



# 14<sup>TH</sup> INTERNATIONAL RESEARCH CONFERENCE

*“ Security, Stability and National Development in the New Normal ”*

09<sup>TH</sup> - 10<sup>TH</sup> SEPTEMBER 2021

COMPUTING

PROCEEDINGS



GENERAL SIR JOHN KOTELAWALA DEFENCE UNIVERSITY





**14<sup>TH</sup> INTERNATIONAL RESEARCH CONFERENCE**  
SECURITY, STABILITY AND NATIONAL DEVELOPMENT IN THE NEW NORMAL

**Computing**  
**PROCEEDINGS**



General Sir John Kotelawala Defence University

Ratmalana, Sri Lanka

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## Welcome Address

Major General Milinda Peiris RWP RSP USP ndc psc

*Vice Chancellor, General Sir John Kotelawala Defence University*

Keynote Speaker, Mr. Lalith Weeratunga Principal Advisor to H.E. President Gotabaya Rajapaksa, Secretary to the Ministry of Defence, General (Retd.) Kamal Gunaratne, DVC Administration and Defense, Brigadier Wipula Chandrasiri, DVC Academic, Prof Sanath Dhammika, Deans of the respective faculties, Centre Directors, Academics, Senior Military Officers, Administrative Staff, Students and all distinguished guests who are connected with us in the cyber space.

Good Morning to you all!

It is indeed with a great sense of responsibility that I deliver the welcome address at this 14<sup>th</sup> consecutive international research conference of General Sir John Kotelawala Defence University held on the timely theme, ‘Security, Stability and National Development in the New Normal’, at one of the most crucial times of our history.

To begin with, let me very warmly welcome our chief guest and keynote speaker, Mr. Lalith Weeratunga, the principal advisor to HE the President Gotabhaya Rajapakse. Of course, Mr. Lalith Weeratunga is not at all a stranger to KDU. He is one of the great personalities who clearly understands the role played by KDU for the betterment of the nation and who has long been assisting us in numerous ways to develop this institution to what it is today. As I remember Mr. Lalith Weeratunga was the keynote speaker of our 6<sup>th</sup> research conference in 2013. Sir, your keynote on our theme, “Sri Lanka as a Hub in Asia: the Way Forward” still reverberate in our minds even after 8 long years.

And it is a remarkable coincidence that I welcome you once again to deliver the keynote address on our current theme, ‘Security,

Stability and National Development in the New Normal”, which highlights the importance of stability created by the development and security nexus in the context of emerging new threats to national, human, and global security. Sir, we are looking forward to listening to your words of wisdom today as well.

Mr Weeratunga, it is also remarkable that eight years ago, you were accompanied by the Secretary Defence during that time, who has been destined to be President of our country today, H.E. Gotabaya Rajapaksa, and today you are accompanied by the present Secretary Defence and the Chairman of our Board of Management, General (Retd.) Kamal Gunarathne, and I am indeed honoured to welcome General Kamal to this conference as the Guest of Honour because he has been a tower of strength for KDU at this crucial time of its history.

Let me also welcome all distinguished invitees including the Tri-Service Commanders and other BOM members including the Chairman of the UGC, distinguished members of the diplomatic corps, Vice Chancellors and academics from other universities, senior tri-service and police officers, and national and international participants joining this event on line.

Ladies and gentlemen, this year’s conference is significant to us at KDU on several accounts. First, 2021 is the year in which we mark the 40<sup>th</sup> year of KDU’s existence in the higher education landscape of Sri Lanka, and we are proud of the role we have been playing therein, whilst continuously growing in its stature as a national university doing its call of

duty towards the nation with fullest commitment and dedication.

Secondly, this year's conference is the one that we hold under the most trying circumstances in our history. Last year too, we conducted our research conference in a hybrid mode due to the first wave of the COVID 19 pandemic that took us all by surprise.

But we hoped that we would be able to conduct the 2021 conference freely and in the usual glamour. But this year, it turned out to be even a worse scenario with the third wave of the pandemic hitting us harder. So we consider that this is a more challenging test of our resilience as the nation's defence university.

Ladies and gentlemen, we always believe in the dictum that a quitter never wins and a winner never quits. So we were determined to challenge the challenges, how hard they may be. And we ensure the continuity of the conference adjusting and amending the circumstances, while taking the highest precautions against the pandemic scenario. We were able to slowly but steadily accept the prevailing danger, assess the situation realistically, and to see the best options for the best interest of our University. Therefore, we finally decided that this year's conference will be a hybrid one with a major virtual orientation.

Ladies and gentlemen, the reason why we conduct this conference somehow or the other is because of our belief that we need to set an example for the nation to stand on its feet at times of crises. We as a nation cannot afford to continue to play the waiting game for ever. As our theme highlights, we need to find ways to ensure security and national development in the new normal adjusting ourselves to the new normal conditions sooner than later.

And thirdly, we believe that this is the time in which a nation's intellectual community must come forward to engage in serious and meaningful research to help overcome

innumerable issues and problems that crop up in diverse fields such as defence and security, economics, science, technology and engineering, medicine and health services, management, social sciences and humanities, law and so on and so forth. It is the responsibility of a university to create the necessary environment and enabling grounds for important research outcomes, which the nation yearns for.

Ladies and gentlemen, we are glad that the intellectual community of the country has very positively responded to our initiative. Despite some adverse comments and criticisms of KDU and its role in higher education in Sri Lanka from certain quarters in recent times, the large majority of fair thinking academics, professionals and ordinary people are with us fully, and that is evident from the large number of research papers submitted by researchers from all over the country representing various higher educational institutions.

Despite the difficulties in adjusting to the online mode, the organizers of the KDU international research conference have done their best to maintain the quality of the conference in the highest level. They intend to set the tone to initiate more collaborative research to face new global challenges. As I always point out these types of research conferences are ideal platforms to make connections nationally and internationally for mutual benefit.

I hope that authors of KDU and various other local and international universities will take the opportunity to interact and develop friendly relationships, establish networks, and explore opportunities to embark on productive research collaborations.

While assuring our commitment to providing best opportunities for research collaborations, I wish all the very best for the presenters and hope you will enjoy every moment of this academic fusion. Thank you.

## Keynote Address

Mr Lalith Weeratunga

*Principal Advisor to His Excellency the President of Sri Lanka*

Secretary, Ministry of Defence, Chief of Defence Staff and Commander of the Army, Commander of the Air Force, Vice Chancellor of the KDU, Distinguished academics, Honoured guests, Friends, *Ayubowan!*

Once again, I am delighted to be with you this morning at this research conference. It gives me much pleasure to be at the KDU because it is one of the best universities we have in Sri Lanka. Since of late, there have been much attack on and criticism of the KDU. That's because the KDU is doing well and has brooked no nonsense. With a village background, my mind goes back to a famous Sinhala saying, which means "only those mango trees that have sweet fruits are attacked."

The entire world is undergoing a massive reorganization with the COVID-19 pandemic, and the traditional themes and arguments in security seems rather irrelevant in the present context. "Security, Stability, National Development in the New Normal" is a timely theme, giving us much food for thought in terms of the advancement of a country like Sri Lanka. If you take the first component, security, the bottom line of security is survival. *Survival*, is based on a number of factors. Barry Buzan, the veteran in international security rejected the practice of restricting security to just one sector and defined it as "a particular type of politics applicable to a wide range of issues."

As eminent representatives of the security sector, you are aware that the concept of security can somewhat vary from one country to another. When Mexico's major national security threat has remained to be organized crime for quite some time, Afghanistan's has been religious extremism. For a country like Somalia, it is the inbuilt corruption into their governance. For some countries, it might change abruptly. A few days ago, we all saw corruption and mismanagement which was the major security

threat of the African nation Guinea, getting substituted by another – an armed unrest. In spite of these differences, almost all countries in the world have developed a commonality during the past year, where the health insecurity assumed a major role over and above all others.

The COVID-19 pandemic has caused the entire world to assume a 'new normal' to fight this common insecurity that is caused by a tiny, microscopic virus. Even during the new normal, however, certain fundamental features of the modern-day security have not changed. Security in the 21<sup>st</sup> Century was, to a great extent, focused on internal factors of a country, rather than external ones. The organization of the threat factor has changed from state militaries to terrorist organizations to even pirates. The underlying motivation for creating insecurities has shifted from being political to one that is economic.

Targets have shifted from soldiers to civilians. The distinction between 'high profiles' of national security and 'low profiles' of economic and social interactions have softened. This has given rise to new sources of global insecurity in the 21<sup>st</sup> Century which are essentially 'soft' in nature.

The 21<sup>st</sup> Century has continued to witness these new sources throughout its first two decades. Donald Rumsfeld, the onetime Defence Secretary of the United States said at a key decision-making point in the history of his country, "there are known knowns; the things we know we know, we also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns—the ones we don't know we don't know." Although stated in relation to a completely different scenario, when recalling this statement, I see that it resonates with the pandemic that we are facing now. In 'security

terms', COVID-19 is a 'wild card', an 'unknown unknown'. It is a security threat without a passport. It caused the 'health security' to assume the prime position in the security landscape of the modern day, surpassing the food security, water security and all other soft securities.

When we view the modern-day threats, we see that none of these is of a purely military nature, as those perhaps were, during the cold-war period. As a result, they also cannot be tackled by purely military means. There is another factor that contributes to the restriction of military means as a response to insecurities. In today's security landscape, States do not have the monopoly that they used to enjoy. Human beings have assumed that role. When the individual is considered as the central point in security rather than the 'State' as before, it gives a new insight into all our security related concerns. This helps us to understand the present-day global vulnerabilities with a new eye.

When the centre of focus in security becomes the individual, it changes the state-centric understanding of national, regional as well as global security. When a pandemic, which cannot be controlled by military means is plaguing the world, the human-centric understanding of security becomes vital to address it in order to ensure development of any country. This is why the 'soft component' of security, or the 'human security' gains more prominence over the 'hard component' of security during this new normal, created by the worst health pandemic in the recent history of the world.

The pandemic has given rise to a number of human security threats. To mention a few, the threat to economic security through unemployment, to health security through the deadly infectious virus and to environmental security through the mass accumulation of the waste generated in the health sector. It has also given a signal on food security as well, which is precisely when the Government declared essential services and appointed an authority to manage the situation in Sri Lanka. So you see, security in the new normal is connected with the

stability of a country, but in a different way from how it did with conventional security under the normal conditions.

National development, as we all know, is an all-encompassing term. It includes both the individual and the nation. Therefore, national development can be considered as the process of development and reconstruction of all dimensions of the nation, along with the development of the individual. This concept is essentially linked with both the growth and the change where *change* can be socio-cultural or economic, tangible or intangible. National development involves activities through a planned national economy, application of modern technology in agriculture to enhance production, application of science and technology in the production sector, improving the human resource and providing education for all among many others.

During a disaster such as the COVID pandemic, it also includes providing facilities and assistance to the poorest segments of the society. In theory, addressing the security needs, especially those of soft security and implementing broad array of the previously mentioned key activities in national development ensures the stability of the country during the new normal. This theory is in practice in Sri Lanka today, in different sectors to different degrees.

Let us consider the vaccination drive for example. Two months ago, Sri Lanka was struggling with the inadequate human resource in the civilian component of the health sector to conduct the vaccination programme at its full length. Health sector employees were getting exhausted with the enhancing demand for services. At this point, the Government employed its military health professionals to assist their civilian component. That accelerated our vaccination drive to such an extent that Sri Lanka became the first country in the world to have the fastest vaccination drive to its population.

H.E. the President had first-hand supervision of this process, at times acting as a 'vaccination planner', which contributed to the success of the



whole programme. This measure addresses our health security, and at the same time contributes to our national development by making the workforce resistant to the pandemic. Together, the two outcomes contribute to enhancing the stability of the country during this new normal.

Now let us consider a few of the numerous initiatives that the Government has introduced to ensure food security. The Government recently decided to take a transition from inorganic agriculture to organic agriculture, in keeping with pledge given to our people by the President, H.E Gotabaya Rajapaksa, in his policy document, 'Vistas of Prosperity and Splendour.' The primary aim was to safeguard the public, and especially the future generations from non-communicable diseases including renal diseases, again ensuring the health security. This also gave an added advantage where the imports of chemical fertilizers became minimal and that saved a considerable amount of money to our Treasury. This also resulted in enhancing organic and bio fertilizer production within the country, opening up new employment opportunities.

Linked with these two activities, the Government also launched 'Wari Saubhagya', a programme to rehabilitate 1000 small tanks across the country. This was to provide water for both irrigation and drinking purposes. These projects ensured irrigation water to a greater area of paddy and other field crop cultivations and also created additional employment opportunities within the country. Overall, those made a noteworthy contribution to the national development as well as to the soft security of the country during the new normal.

National development not only involves the infrastructure development, but also the human development. A developed human resource is a shield against certain soft threats. The programme 'connect Sri Lanka' was launched during the new normal, initially providing four remote areas with 4G connectivity. We are planning to expand it into all 9 provinces.

The pandemic period where schools had to be closed was also used to plan education reforms

aiming at producing future generations that are better equipped with battling their way through the ever-changing global order. These enhance opportunities for the public, especially the children to gain access to knowledge that is amply available to children and citizens of many developed countries, and also to equip themselves better to assist with development initiatives of the Government.

Fruits of this labour will be reaped only in the future, where our country will continue to have a learned, open minded younger generations, and through them, smarter work forces. The activities that the Government has started today contribute to national development in the future on the one hand, security on the other, and to stability of the country, overall.

The last example that I wish to draw has a direct connection with all institutions in the public as well as the private sector, electricity. The Government spent over US\$ 2.3 Bln for oil imports in 2020. We all know that a considerable amount of this is spent for generating electricity. This is an unbearable amount for a developing country like Sri Lanka, to be spent notwithstanding the prevailing health pandemic. It is also a waste of funds considering the vast and untapped potential that Sri Lanka has for renewable energy.

The Government gave due consideration to both these when establishing 'Thambapawani' the first wind power station owned by the Government of Sri Lanka. Another similar plant has been launched in Pooneryn. Use of solar power has been introduced to households. A waste-to-power plant was also declared open at Kerawalapitiya. It is not an easy task for a developing country like Sri Lanka to manage this shift while battling with a pandemic, but amidst all, the Government plans to increase the renewable energy component to 70% of the total consumption of the country by 2030. It is an ambitious target, but it helps the country to reach a higher status in self-sufficiency and also prepares the country to face worse calamities than the present one that might arise in the future. The 'failure to prepare' as the old saying

goes, is 'preparation for failure'. We intend to avoid it.

Moving back to the concept of security with these examples, with special emphasis on human security, it is evident that the national development and security are inter-linked. These cannot be achieved separately. This is probably what caused the formerly known definition of security, 'freedom from fear', to be redefined as 'freedom from want', indicating the link between security and development. Human security, as we all know, is an integral part of State security, which in turn, has an equally strong connection with national development. This is why if you have a closer look at Sustainable Development Goals, you will see that all 17 goals are connected to human security.

In this context, I believe there is something vital that we all need to understand about security, development and the stability that those bring about. The new normal caused by the COVID-19 pandemic is calling us to re-think our actions, plans and concepts on security and development both.

Is it not high time for us to re-think our national security and national development?

Is this not the best time for us to redefine our development-security nexus?

Let me conclude by bringing back to your memory, extracts from a famous speech delivered by Robert F. Kennedy during his run for the Democratic nomination for the

Presidency of the United States. Over 50 years later, his remarks about the measurements of development resonate with something that we need to re-discover with experience we had during this new normal. He said, and I quote,

"... the gross national product does not allow for the health of our children, the quality of their education or the joy of their play. It does not include the beauty of our poetry or the strength of our marriages, the intelligence of our public debate or the integrity of our public officials. It measures neither our wit nor our courage, neither our wisdom nor our learning, neither our compassion nor our devotion to our country, it measures everything in short, except that which makes life worthwhile."

Distinguished scholars, ladies and gentlemen, let us try to fathom the lesson that this global pandemic and the new normal is trying to teach us. Let us acknowledge the all-encompassing nature of national development and pay attention to the vital fact that has evaded our comprehension thus far – the fact that the individual, the human has assumed the central focus in security as well as in national development. Let us use that understanding to re-define our development-security nexus and bring a lasting stability to our country during the new normal.

Stay safe and take care of yourselves.

Thank you.

## Address by Secretary, Ministry of Defence, Sri Lanka

General Kamal Gunaratne (Retd) WWV RWP RSP USP ndc psc MPhil

*Secretary, Ministry of Defence, Sri Lanka*

Chief Guest and Keynote Speaker of the 14<sup>th</sup> International Research Conference of KDU, Principal Advisor to the President Mr. Lalith Weerathunga, Ambassadors and High Commissioners, Foreign Secretary Professor Jayanath Kolombage, Chancellor of KDU General Jerry De Silva (Retd), Chief of Defence Staff and Commander of Army General Shavendra Silva, Commander of the Navy Vice Admiral Nishantha Ulugetenne, Chairman of University Grants Commission Professor Sampath Amarathunga, Vice Chancellors of other Universities, Vice Chancellor of KDU, Chief of Staff of Air Force, Director General at Institute of National Security Studies Professor Rohan Gunarathna, Deputy Vice chancellors, All Deans and Directors, former Chancellors and Commanders at KDU, Eminent Scholars, Senior Officers of the Armed forces and Police, distinguished guests joining us virtually from Sri Lanka and Overseas, Ladies and Gentlemen;

I consider it as a great pleasure and a privilege to be present here today at the inauguration ceremony of General Sir John Kotelawala Defense University's International Research Conference which is taking place for the 14<sup>th</sup> consecutive year and I would like to thank the Vice Chancellor and the conference organizers for the invitation extended for me to be present here to participate in this event. The International Research Conference of KDU is providing the opportunity for academics, professional researchers and practitioners to share their research findings and expertise addressing the mutual challenges in their fields. Therefore, this event has gained tremendous recognition among all interested parties around the world. Further, the provision of a wider interaction and

networking with national and international scholars in respective fields would be absolutely beneficial for all the participants to broaden their horizons of knowledge through intellectual discussions. However, due to the global pandemic situation in effect, most participants may join the event through a virtual platform for this conference as same as the last year. Yet, I'm sure we will be able to achieve the desired objectives in a state amidst this pandemic situation.

Furthermore, I'm extremely pleased that the theme selected by the KDU for the conference this year security, stability, and the national development in the new normal is a timely theme capable of augmenting the significance and focus of the subject of strategic national importance. Further, I firmly believe that the endeavor towards warranting the national development and ensuring national security becomes further from achievement by undermining the routine activities due to the ill effects of the pandemic but becomes attainable by ensuring the adaptability to the new normal as widely accepted by all the countries in the world, today which is implied by the theme that you have selected. In fact, as comprehensively illustrated by the keynote speaker Mr. Lalith Weerathunga it is quite imperative that all of us understand and pursue the ways and means of adopting the circumstances embedded with the new normal. in order to coexist with the Covid 19 pandemic which has not shown any expiry date as of yet.

Ladies and Gentlemen in a context of globalization and further economic integration, in recent decades the relationship between national development and national security of a country has become increasingly

interlinked for Sri Lanka. These connections represent both opportunities and potential threats to the country's national security. The open and interconnected Sri Lankan economy creates vulnerabilities from potential international and external threats. Against this backdrop, national development has emerged as an important strategic priority for the Sri Lankan government with the connection between development and national security which will be orchestrated upon the vistas of prosperity and splendor, the national policy framework of our government headed by his excellency the president Gotabhaya Rajapaksha.

Ladies and gentlemen, the development generally depend on the stability of a country which should be achieved by ensuring national security. Sri Lanka being a country endangered by ruthless terrorism for almost three decades has experienced a lot of hardships during the past and was in the stage of eyeing its development in the last decade. Even though we were able to relieve the country from the menace of terrorism we have found another security threat in the form of a pandemic which has posed a greater threat to the entire world. The threat that we face today is progressing in its second continuous year without any indication of a possible termination we are yet to find a permanent solution for the same. However, we must always work towards reaching our development goals without letting our country at peril. In such a context our endeavor here as Sri Lankans should be to seek possibilities to find ways and means to steer the country towards development goals amidst said difficulties. Sri Lankan government is at the threshold of trying all possible methods to meet its economic growth and objectives yet with lots of empidements while ensuring human security. When the domestic affairs of a country are affected it is extremely difficult for a country to reach its desired end state. Sri Lanka is no exception in

this, regard being a developing country Sri Lanka cannot accept any economic standstills for a protacted time frame. However, any plans to expedite the economic gains should never be at the expense of human lives. Therefore, his excellency the president himself has expressed his keenness on this aspect to see and inspire all possibilities available to ensure the maintenance of momentum in the economic sphere.

On the contrary, we should also note the other contemporary security concerns such as violent extremism, terrorism, piracy, drug, and human trafficking, smuggling, cybercrimes, and other organized crimes and natural disasters pose a grave threat to the stability of a country. Sri Lanka's geostrategic location is susceptible to such threats as it is located in the main sea routes in the Indian ocean. The same geopolitical significance has given a greater recognition to the country, thus it has gained greater demand from the rest of the world. In such an instance, the possibility of Sri Lanka becoming susceptible to threats posed from violent extremism and organized crimes is very high and present the government has initiated several steps to curtail such illegal activities and such measures taken such as the demarcation of maximum security prisons concept and highly effective maritime domination programs launched by the Sri Lankan Navy which have become very effective in restricting such threats. However, the effects of such activities pose a moderate level threat to the stability of our country.

Ladies and gentlemen, a government alone cannot afford to force all these threats that are in concert ruining the stability of a country. Therefore, as responsible citizens, it is our bounded duty to provide novel ideas, suggestions, and proposals to consider in regaining our country's stability and development. I hope the academic events of this nature will undoubtedly serve this national requirement. Such efforts are



arranged to address emerging challenges. Promoting more research and development becomes a task of topmost priority for all of us.

Fortunately, as the Secretary of Defense, I feel tremendously proud and content to say that the Kotelawala Defence University is at the forefront of researching the development of security-related problems in the new normal. The approach adopted by the Kotelawala Defense University to understand the contemporary complex situations concerning the bigger picture rather than dwelling on the narrow passages will become far more effective in resolving the emerging complexity of future challenges. Therefore, I'm well certain that the faculties of General Sir John Kotelawala Defence University with their interest, commitment, dedication, and knowledge in diverse academic disciplines

and outside rich researches inputs would contribute immensely to this year's conference theme. The knowledge that you are going to unearth and share during this conference would be of immense benefit not only to the academic community but to the entire humankind to make their lives better.

In conclusion ladies and gentlemen, I should express my most sincere appreciation to the Vice Chancellor and the organizers of the General Sir John Kotelawala Defense University's 14<sup>th</sup> International Research Conference 2021 for organizing this timely important event amidst the covid 19 pandemic concerns and I wish this event be successful in all way imaginable. Ladies and Gentlemen thank you very much for your patience, thank you.

## Vote of Thanks

Dr Harinda Vidanage

*Conference Chair, 14<sup>th</sup> International Research Conference, General Sir John Kotelawala Defence University*

Mr Lalith Weeratunga, Principal Advisor to HE the President of Sri Lanka, Secretary to the Ministry of Defence, General Kamal Gunaratne, Vice Chancellor – Maj Gen Milind Peiris, Deputy Vice Chancellor (Defence & Administration), Deputy Vice Chancellor (Academics), Rector – Southern Campus, Senior Professors, Deans and Directors, Senior officers representing Tri Forces and Police, Distinguished guests, colleagues, Ladies & Gentlemen, Good morning!

In its 40<sup>th</sup> Anniversary since its inception the flagship academic conference of the KDU, the international research conference progresses to 14 years of continuity. I stand here to reflect and provide my gratitude to a team of individuals who despite every challenge in the form of material and the forces of nature has confronted us with, have managed to successfully bring us to where we are today.

Since 2019, the country has witnessed unprecedented upheavals from violent extremism to microbial threats that have forced a drastic rethinking of every aspect of social life. These challenges have made all of us believe in a reality that long established norms, traditions, beliefs do have their limits and if we are to survive and thrive in the new normal, we must adapt, adopt and innovate. The core fundamentals driving this year's IRC is based on this conviction and that the KDU as a leading force of defiance and a beacon of hope amidst such calamities.

On behalf of KDU, I would first and foremost like to extend a heartfelt appreciation to our Chief Guest and Keynote Speaker, Mr Lalith Weeratunga the Principal advisor to H E President Gotabaya Rajapaksa. Your presence today is a blessing to us as an institution and to the IRC as a process and

your observations made at the keynote enriched us with knowledge and perspective. Your wise words of wisdom will have a bearing on the deliberations of all academic communities within and well beyond this conference. I also would like to thank Secretary to the Ministry of Defence, General Kamal Gunaratne for his presence, his insights and his towering leadership that has seen KDU through fair weather and through some rough storms.

I would like to highlight and appreciate the visionary leadership of the Vice Chancellor, Maj Gen Milinda Peiris and his belief in maintaining continuity of this apex academic event of the KDU. I must then appreciate the critical roles played by Deputy Vice Chancellor (Defence & Administration) Brigadier Wipula Chandrasiri in ensuring that the IRC will take place and in providing the administrative leadership towards the materializing of the conference. The support and blessing of the Deputy Vice Chancellor (Academic) Professor KAS Dhammika is highly appreciated, along with the support of all Deans of faculties who came together to make this event a success.

Even at a time when every institution is careful about its purse, our sponsors have stood by us, let me profoundly thank and appreciate the generosity of our Gold Sponsors, the Bank of Ceylon and the People's Bank and with Huawei Sri Lanka and National lotteries board being our silver partners. There are many more who have chipped in and do not want their names mentioned and a big thank you for all.

I must mention that this year it is the first time the faculty of Defense and Strategic Studies have been tasked with the overall IRC and holds the chair. I must with gratitude mention the hard work of my colleagues in

both departments of Defense and Strategic Studies under the leadership of Col Enoj Herath the Dean of the faculty. The FDSS represents the tip of the Spear of the KDU and bears testimony to the perfect convergence of civic-military relations.

Towards the buildup to the conference the shutdowns became lockdowns and lockdowns became enforced quarantined curfews, yet the main committee of the IRC 2021 managed to work tirelessly around the clock. We knew it was all for a greater cause and I must appreciate the gargantuan task that was handled by the secretary of the IRC committee Ms Lihini De Silva who virtually was my prime buffer and the tremendous work done by the three co secretaries, Maj Ranushka Ferdinandesz, Ms Isuri Uwanthika and Captain Abeetha Athukorala. We were all supported by the dynamic team of faculty coordinators who labored hard and were endowed with patience.

It is with sincere gratitude I appreciate the services of Mr Kithsiri Amaratunga the president of the Editorial committee and Dr Faiz Marikar the deputy editor. I also want to

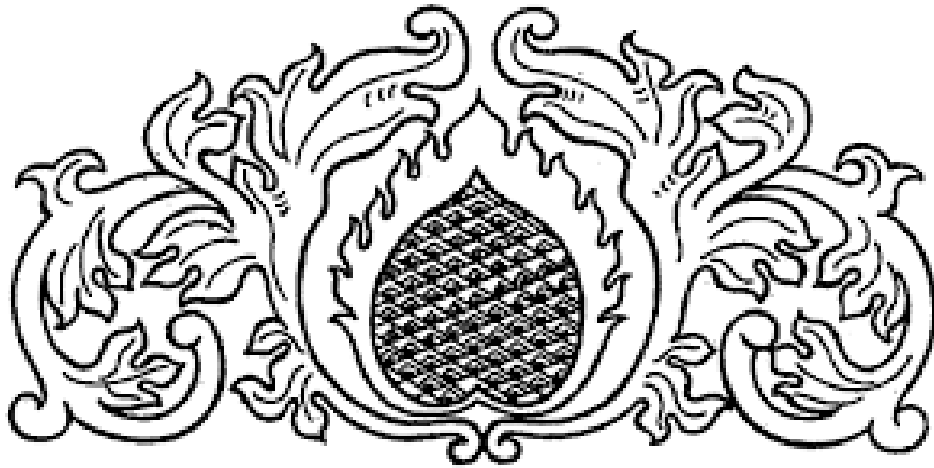
mention the prudent actions taken by Commander Bogahawatte, the president of the publication committee. I would like to thank all committee presidents, committee members, faculty committees, the office of Bursar, Registrar, Adjutant and C/O Admin and the staff at the Vice Chancellor's office.

New normal pushed us to the limits, yet we managed to overcome as we functioned as a collective team. Yet, finally the work would be incomplete if not for the researchers who had put faith in us and submitted papers and reviewers who filtered them. This year's IRC is the most decentralized event out of all IRCs, facilitating intellectual deliberations of this scale is no easy task. To keep this grid alive and robust the contributions made by Director IT and his team needs a special word.

We have truly embraced the new normal. We have not run away from it, instead we have transcended it. Thank you all for accepting and believing in us. We shall prevail and we shall overcome.

Thank you very much!

# COMPUTING



## **PLENARY SESSION**

# Multi-step-ahead Influenza Prediction using Machine Learning Models

Prof. Yukun Bao

*School of Management- Huazhong, University of Science and Technology, China*

Good afternoon!

Respected session chair, and all the conference participants. I'm professor Yukun Bao from Huazhong University of Science and Technology.

I'm glad to take the chance to present one of our recently finished projects titled as Multi-step-ahead influenza prediction using machine learning models: Evidence from China.

This study was conducted by Miss Siyue Yang, one of my PhD students and me and other team members.

In the next 20 minutes or so, I'd like to first introduce the backgrounds. There are research gaps identified. And the motivation behind this study. 2nd, I'm going to come up with some details. I mean some technical details of the methodologies used in this study.

I won't come up with too much detail because this study has already been submitted to the Journal of Applied Soft Computing and was recently accepted. Later, I will share the link to our paper as well as the link to the codes and data used in this study.

3rd, I'm going to come up with some key issues we faced in the experimental design and finally I will come up with some results and conclusions.

Let's come to the backgrounds. As you know that Influenza, known as flu, is contagious respiratory illness caused by influenza virus, which causes a lot of troubles.

There are three to five million severe illness cases and around half million deaths caused by influenza every year.

It is very important to make influenza prediction particularly for public health decision makers. Based on the prediction, we can do something such as medical resources allocation and the planning of vaccination campaigns each year.

The data used in this study is influenza-like illnesses rate. And, this is commonly used in the previous studies, which is a major indicator of influenza activities. We use it to predict the coming influenza in China.

And the ILI is defined as a fever with a temperature more than 37.8 centigrade with the symptom of cough and sore throats, but we don't know the causes other than influenza.

We got the data from Chinese National Influenza Center. This is the website of the center. The data is weekly one. This is the snapshots of ILI from the South and North China in the last 10 years. From this time window of 10 years, we can observe a very strong seasonal pattern with some irregular variations.

And according to the literature review, we get conclusion that there are two sub-categories of prediction models. One is mechanistic models, which mainly was come up with by the community of public health. Another is statistical models and machine learning models. And actually, our study belongs to machine learning models, using some well-established machine learning model such as support vector machines and neural networks. As per the other parts of methodology, he focused one is the prediction horizon. The previous study dominantly focused on one-step-ahead prediction. But there is a trend from one-step-ahead to multi-step-ahead, suggesting that we have to make influenza prediction over a longer time horizon, which can facilitate the decision makings. And there are several research gaps we can find. First of all is that according to the literature review, specific attention on different multi-step-ahead modeling strategies was rarely paid in previous study.

In general, there are three commonly used major modeling strategies. One is iterative strategy; Second, direct one; third, multiple inputs, multiple outputs.

If you have some experience of machine learning modeling. You know that different modeling strategies can significantly achieve different prediction performance while using the same modeler. Yeah, this is common sense, but was ignored in the previous study about the prediction of influenza.

The second gap identified is the measurement of prediction performance during outbreak periods for multi-step-ahead models, which was rarely examined or investigated in the previous study.

Most of the existing models of influenza prediction just use statistical metrics to evaluate performance. But in practice, accurate prediction of outbreak periods including the timing and severity of influenza outbreak peaks is highly concerned and quite important for decision making.

So the contributions of our study are: 1st we conduct a very extensive comparison of different multi-step-ahead modeling strategies with two well-established molders; 2nd we conduct more comprehensive performance evaluations considering the outbreak time and magnitude accuracy; 3rd, we introduce a unified adaptive model tuning framework which can facilitate the prediction performance of the model.

Then we come to the second section about the methodology.

First, let's look at multi-step-ahead modeling strategies. These are the formulas of different strategies. You can find the difference among these three strategies. Let's focus on the first one first. That's iterative strategy. Iterative strategy means that we use available data at time to set up a one-step-ahead prediction model only. By such kind of one-step-ahead prediction model, we can achieve several steps ahead prediction in the iterative way.

And this means that like let's take  $x$  equal to two as an example. If we want to predict  $T + 2$  prediction, we first use this model to predict  $T + 1$ . And then we use the predicted  $T + 1$  as known value and fit it into this model again.

And then we achieve the prediction of  $T + 2$ .

For the direct Strategy, I think it is simple and easy to understand. That you see, we just set

up direct strategy model in the straightforward way. Say we associate the available data and the targets  $t + h$ . Yeah, and then find the relationship.

The third one is a little bit different from the first two. And the different part is the structure of outputs. Output part, let's say we use several inputs and gets the several outputs which covers the time horizon from  $T + 1$  to  $t+h$ .

This means that the function or modeler here must be capable of modeling such kind of multiple inputs multiple output's structure. Then we come to the models.

We use two well-established modelers. One is support Vector Regression, the second is MLP. Yes, two very well-known and commonly used modelers. I don't want to come up with more details about them, so we come to the third part of the methodology that says the modeling framework.

We introduce a comprehensive. Learning PSO machine learning modeling framework. The reason why we introduce. Comprehensive learning. PSO is motivated by the call for the optimization task. While setting up the models one is parameters optimization, the second is feature selection.

This is to say by introducing a binary CLPSO algorithm. We set up a unified framework to tuning parameters and feature selections at the same time. The key part of CLPSO algorithm is the representation of each particle. We use the binary representation to represent features and parameters.

Here is the example; 0 means we don't select that feature. 1 means we select this. By such kind of representation, we can conduct feature selection. Then here we use binary value to represent the real value. Take SVR as an example, the parameters we are going to tune include three. And this is to say, with a unified binary schema to represent features selection and parameters.

And it's easy to make the PSO to work. Here is the formula of updating of velocity. If you have some experience, you might know that what it means by velocity. I don't want to come up more

details to save time. Here is the updating formula of position.

And then we come to the third subsection. About experimental design.

We take data from Chinese National Influenza Center to get 2 ILI series from the Southern China and Northern China. We check multi-step-ahead strategies. Now I mentioned that. And we check 2 machine learning Modelers, one is SVR and the second is MLP. We investigate or examine the performance from two steps ahead to ten steps ahead. We use full evaluation metrics. This is the flow chart of experiments. This is a formula of two statistical metrics. MAPE and RMSE. This is a snapshot of influenza outbreak metrics that you see. We calculate some specific metrics during the outbreak time.

Here is the formula of these two influenza outbreak metrics, PWE and MAE. This is the parameter space of optimization in SVR and MLP. For SVR, we have three to optimize, this is the space. For MLP, we just focus the size, meaning the number of neurons in each layer.

Then we come to the results and conclusions.

Here is the accuracy. I think we could see the results on weekly ILI rates in North China. This column indicates metrics. The second column lists different models. And this is the performance. Of each time horizon from 2 to 10. And then we can get some conclusions. Yeah, these are figures of performance of each model at different strategies. We can get some conclusion by checking the performance metrics. The iterative strategy is also competitive and ranked 1st and PWE outbreak matrix. And the time horizon of four seems to be turning points. Well, the iterative strategy has an edge for short horizons, say two and three, while the MLP is potentially more adaptive for longer time horizon.

These are figures of the performance of the prediction against the real. Yeah, looks great, it looks right, yeah?

And then we come to the performance on weekly ILI rates in Southern China.

And we can get some conclusions by having a closer look at the results. First, the

MLP strategies keeps the most competitive strategy. Just as the findings we get from the ILI in Northern, China. The horizon of four also acts as a turning point. For the ranking of three strategies, in most cases MIMO excels in terms of RMSE, PWD, and outbreak MAE. This is a snapshot of the performance of prediction against the real.

In this, after the extensive experiments, we can get some conclusive remarks. First, the MIMO strategy achieves the best multi-step-ahead prediction. And it is potentially more adaptive for longer time horizon. The reasons behind are because they use the multiple inputs and multiple outputs structure, which can keep the dependency among different time points. Just to say multiple inputs and multiple outputs can recognize the dependency identified by the model.

The second, the iterative strategy has special potential for deriving the least time difference between the occurrence of the predicted peak value and true peak values of an outbreak. This means that the iterative strategy might be a good choice if we want to check the performance during the outbreak period.

This is the end of my presentations, just as I mentioned in the beginning, this work was already accepted for publication in Applied Soft Computing journal.

And then later on I will share links to this paper. And we also will share the code and data to the websites to the journal. And we will also share the links to you. And then you can use the code and data to replicate the study. That means that you can know every detail of this model.

Thanks for listening and I hope can receive emails and inquiries from you. I also look forward to the potential research collaboration between you and my team, or maybe your team.

Thanks very much. This is the end of my presentation, thank you.



# Techno-Socio-Psycho Challenges of National Development in the New Normal

Prof. Tony Sahama

*University of Victoria, Victoria BC V8P 5C2, Canada*

Good afternoon everybody. Thank you very much for having me for this session. Thank you very much for the chair and welcome and good afternoon ladies and gentlemen.

It is my pleasure to be in this session even though we are going through a little bit of a tough time. But, it is good to have some refreshment and sharing the knowledge through this critical time.

As you can see from my screen my topic is techno social psycho challenges of national development in the new normal. Well it is a full blown mouth full of wards, but we need to see how we can understand. Let me see whether we can unpack these complex scenarios.

My name is Tony Sahama. I am located in Brisbane, Australia. I do have several international collaborations, including Sir John Kotelawala Defence University as well. My email address as you can see is available. If anybody would like to reach me, please email me for the further discussion. My personal website and also one of my collaborative websites is open for more details.

This is a research which we did for five years including anecdotal evidence with some empirical evidence. However, I am not going to claim that I am a clinician sociologist or a psychologist. Merely, I am an information scientist, practitioner of information communication technology (ICT) with several years of experience on the same area like computing science, information system and also cybersecurity. As a profession, I am running my independent consultancy at the same time, attached to several universities.

Just to move on, to our unpacking this complex scenario, we need to understand what this new normal is, particularly for national development. Well, there are so many definitions for new normal. However, this is not the time to add additional definitions, rather, we understand

what is this new normal. By the time, depending on the time what we are looking for alternatives. During this difficult time, it is really we are driving to uncertainties through integral integrity and trust issue of our information around us. It fits in the form because the data where we are always dealing with inaccuracies. Leading to policy driven confusions as humankind, we are always looking for socio psycho impact driven by economics and development scenario. Maybe that we are dealing and leading to new classic classifications, which is at the end, it has become our new classification. A different climate. Now this is important to understand how these different new classes are going to entail to understand our new normal.

Let's see this scenario - This scenario particularly what we are going through right now. As you can understand, this is very popular almost everywhere being popped up. Number of cases this is where the COVID-19 cases we used to say by the time. What is going to happen without protective measures? This is going to peak out, out of proportion. Based on our capacity in this particular scenario, it is a health care system capacity. There is no country that can tolerate this situation and can handle and is capable of doing so. With protective measures, this may be able to manage, but this takes a long time. This base is shorter, this base is longer, which means we need more time. Those who are coming from economic background or the policy background, public health background, they all will understand all the implications of these two comments under baseline.

Well, this is the basis of our new normal. Well, of course you need to understand where we end up from this scenario. Based on this scenario, based on our research through information technology and data driven, some decision-making processes we have come up with. What are the different classes we are talking here? More and

more data incentive, data driven and information reach. Everything remote, everything distance we used to call tele-everything. And high tech-innovation and augmentation, different business model, adhoc policies, we are giving away our privacy, eroded privacy and autonomy, perhaps, of course, new legislation according to some of the legal experts. What more, there are more. Well, this is not the time to discuss these new different classes.

Moving on while we conceptualize techno-social-psycho challenges for these different classes or in this so called new normal. If you see this techno-social-psycho classes, if this is going to be an impact from anti clockwise technologically, we have to choose only five factors. There are more than five factors. In fact, there are 18-20 sectors which we may not be able to discuss. Cost, training and complexity, resources then acceptability in contrast to social health, education, occupation income and power, and if we talk about psychological factors involvement, influence, recognition, reward and growth.

Well, of course, how this is going to be intent. Well, we need to see there are three case studies based on our research and experience of data sharing. How are these socio-psycho challenges going to position based on three case studies?

Let's move on to first case study: education: -

When we are talking about this new normal, how the education is providing us new opportunities, new challenges, and new thinking. Under the technology, cost and training is the key for this new education. In contrast, sociologically, education and occupation become the significant factor. In comparison, psychologically involvement and recognition become very significant.

If you see this anticlockwise compared to all other five factors, these two factors, each of this category is very important to understand, which I have highlighted and given in the capital letter format.

Let's move on to our next case study: health: -

In the technological paradigm, complexity and acceptability is the challenge. Sociologically, occupation and income is a challenge. Psychologically, involvement in influence based

the challenge. Let's compare education and health. There are some overlaps.

Next, move on our third study.: Technology: -

Technologically, acceptability is the biggest challenge right now we are facing, which is winning front. Sociologically education is the next challenge. Psychologically, growth in someone somewhere most of us looking for technology. How is this going to be comparatively between technology and health? Like in education, educational technology. Well, as you can see, do we need this overlapping common scenario, where the different classes we are talking about, and also the new normal we are talking about?

How do we position ourselves nationally to tackle this each and every category between this technology, health and education? Repeatedly cost, training, education, occupation, involvement, recognition, income, influence, acceptability and the growth. Of course, this is where we are heading, this is the direction we are heading, which may be the new normal we are defining.

Technologically speaking, these maturity of technology on the Y axis it can be ranked percentile whatever the unit by the time it is natural, which means it is advanced where we are at now we can see artificial intelligence and internet sitting on the top by 2020. See the journey we came through.

By , it is predicted artificial intelligence, virtual reality, and augmented reality, deep learning, machine learning and natural language processing become the tools around the conner, which means this can be easily embedded to technologically driven built-in carry everything remote.

Everything is going to be digital, in other words. How is this going to be helpful for our national goal? OECD countries are progressing; this is the data collected in 2017. We be part of our research; we share the data. As you can see from this bar chart several countries almost 20 countries, which are the countries that are ready for technology, ready for data governance with each bar has two components Those two components are used to magnify which country is ahead, which country is behind. Unfortunately,

we do not have enough data to compare other countries. At this stage, these twenty countries are well placed to see that from 2020 to 2025.

TOR stands for technological readiness, DGR stands for data governance readiness. Each bar first section from X axis to upward is technological readiness next bar is data governance readiness.

Each and every one compared readiness, technologically, readiness and data governance reviews countries are compared we have also predicted which countries are going to be ahead.

Based on our prediction, pretty much spot on where population list or around 5,000,000 countries are ahead. Finland, Singapore and countries like Austria, countries like Slovakia, we are also ahead.

This is giving another level of understanding how these social-psycho-techno factors are confronting!

Key message from previous graph where the technological trend, maturity, the contribution of countrywide when we talk about the technological front where do we see this socio-psycho-techno challenges facing national development, particularly for long term contracts, what is the contributing factor?

If we compare global digital snapshot, which is the source you can see from the slide, table, right. Population in the world, internet users, active social media users, unique mobile users, active mobile users. This was five years ago. Now where are these standing after five years. See the goal? How many million people already since January 2020 to January 2021? How many million people for unique mobile phone users? Internet users, active social media users. So, if you see that five years' growth, if you add them up, we easily show you there is that much of growth for the last five years exponentially.

Having said that if our concept, techno-social-psycho challenges are contributing factors. To education health and technology. How do we see these factors can contribute for our sustainable growth?

Of course, technology can be failure factor will be giving a very good design guideline for the successful develop. Therefore, involvement, influence, and recognition are critical factors based on what we have to conceptualize. Therefore, it is very important to see add on cultural barriers that we have identified to be considered, harnessed, supported, discussed and critiqued for sustainable development. This is the opportunity. We should not miss this opportunity we should carry forward in order to build up our relationships, build up our business, lessons, build up our social events, and build up our economic relationship.

Things are changing the way that we did not expect. Things are happening not that what we expect. That is what the new normal, kind of, teaches us. Therefore, it is very important to see where we are heading. What are the changes we are facing? How these changes can move for our next generation of changes including social changes, psychological contribution and technological intervention.

I hope that I have shared some of the information. Of course, it is not a peer concrete silver evidence. We have a long way to go. This is where we need to understand. How these three factors can contribute to national development and also globally.

Thank you very much for having me. I am sure we should be able to discuss further during our discussion period. I hope that one will be at the end of this session. Thank you very much.

## Making University Education Smart in the New Normal

Dr Shantha Fernando

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Thank you Professor Asoka Karunananda and I also get a lot of inspiration from him.

So, I was told that the theme of this particular session is digital resilience and innovation in the new normal. And then, when I was asked to select a topic what I thought was rather than going into some theoretical discussions, I selected the topic of making university education smart in the new normal. Knowing that this is a research conference, I wanted to bring in some theoretical aspects and the research aspect but what I thought was considering the situation to focus more on the practical side, and then do some insights from the experiences that I had not only myself together with our colleagues, mostly in our university, and then I hope that it will be good for KDU as well because I have been sharing this with many of the colleagues at KDU university. I also teach some of the batches.

So, making university education smart in the new normal. If I just present to you what I hope to discuss today. I would like to briefly look at how things have evolved in the university education, not looking at all the sites but some of the things that are relevant for my topic, some of the research findings, specifically some of the ways that I got involved. And then, how in the past, probably over the period of maybe 18, 19 years, how the things were improved, or the preparatory work was done, and then how we have come to the state today, and some of the challenges that we faced, and then how we overcame and then how we could face the current situation what is called the new normal, and then some conclusive remarks. In fact, I'm happy that the session by Prof. Tony, the previous session, set a good platform for me and several definitions and the way that we should look at was discussed, and some of the aspects will have some level of overlapping. But looking at from a different angle of course. But we will see it kind of a parallelism and similarity as well.

So if you look at university education and trends and some of the research findings. Now if you look at this, now my topic is on smart university education, and if we talk about this smart university education, I don't think that we can get rid of the topic of E-learning. Now people may use, you know different terms, use of learning management systems or learning and content management systems, etc. Those are the system side, but the learning side separately looked at and then there are a lot of ambiguity is that may be there. So I thought, you know, just to give you some kind of a definition for E-learning. So what does it actually mean because the reason that I want to talk about E-learning is that today during this pandemic situation even the educational institutions that did not consider E-learning as a means of education earlier, now they have been sort of forced into that. Sometimes whether they like it or not they had to select it, because otherwise there was no survival for them. But I would like to bring a kind of a definition, the definition that I would use, in fact different people may use different definitions. It is up to you to either agree or disagree with me. That's okay, perfectly okay. I would define it as something referring to electronically facilitated, enhanced and managed learning. Now, just because something is there in the internet, some learning contents are there in the YouTube, or a lot of Wikipedia articles are there. Just because all the resources are available in the internet, we don't call it E-learning. But when it is, of course facilitated to electronic means to systems and communications and tools and various other things. If it contributes to the enhancement of the learning experience, and not just the learning experience. If it provides a management platform, the learners are you know not just left for their own courses of actions, but they are guided through, and their activities are managed, their performance is evaluated, the tasks done by the teachers or the lectures or the tutors or the facilitators, those are managed, all the resources are managed. So, this management aspect is very

important when it comes to the E-learning. So, it is something very much beyond mere hosting of application services. So, I do not generally consider just because you have a learning management system that you really have E-learning. You can simply have a learning management system and you can have a lot of contents there as well. You can put a lot of links to various other. We know that today we have a lot of what is called the MOOCs, massively open online courses and there are a lot of universities who are offering them. Of course, if we enrolled to a course and if you follow, then of course yes, it is managed learning. Then so there will be somebody who's managing that, and then we will be guided through a particular process. So, learning is also process. So, it goes just very much beyond the mere hosting of the application services. And in fact, I would like to say there are three use that matter that we can consider, one is the usefulness, the other is the usage and the usability. That is one aspect, then the other aspect is that the learner engagement. So, the learner engagement matters a lot. So, in fact this is one of the challenges that we face today during this pandemic, how to get the learners engaged. In fact, more than the university level and the postgraduate level, we know that as parents, how much trouble that the parents have to take to keep the students, specifically the primary and secondary school level students engaged with the activity. Because it's very difficult for them to stay in one place. Engagement has become a kind of issue. But it is true, up to some level, even from the undergraduate and postgraduate learners as well.

Now one aspect that we have to look at, from a theoretical point of view that I have considered even in my PhD time with that the designing useful content, and then whether it will be really suitable for our new normal. Now If you look at this usefulness of learning content, E-learning content or whatever the content that we use for our learning process that will depend on several other factors, we can't disregard them. For example, if you have a particular academic program, it is offered within a particular course. So, we have take that context into consideration, then it is in a particular field or discipline within which the academic program is run. And then, in many universities today we have, specifically

when it comes to the technology based or technical education, there's a particular target industry, it may not be a kind of a niche area, but some form of target industries considered. And also, it is very important that we can't keep on producing new content always, the reusability, sometimes certain content may become obsolete, some new content may be developed, but then we have to see whenever we put some effort into that, whether it can be reused, and then the feasibility of cooperation or the delivery of the courses in the target learner environment. Now, that is quite important today, specifically in today's context, because depending on the target learner environment, now the early days in our full-time concept of university education, the learners came into the university, so then most of the facilities were available in the university. So, they are there was a particular environment. Now what has happened is, the target learning environment has become different. It is not the same environment today. So then how can we take this learning process forward successfully considering that new normal environment that the learners are having. Then of course we can't forget about the people who involved with this learning process, there are a lot of actors. Generally, that's the place where we talked about the learning management system where the actors come together. So, the effective use of e-learning depends on how well the particular platform or a learning management system is used by these actors. The actors can be the learners, academics, content developers and various other stakeholders, even the industry participants can be there, local as well as foreign experts, and then the students also can be, learners also can be both local and foreign. And, whenever we deliver a particular course, which is generally referred to as engaging in a learning experience, and synergy matters, how we do it together. It is not only the subject matter experts, even the students. Today of course in the era of internet, even the students bring in a lot of expertise. Sometimes in certain areas, they may outperform the lecturer even, and that is to be expected. So, it is a two-way education process. While I am teaching a particular subject, I also did learn a lot of things from the students in today's context. This synergy, doing things together, that matters. So, I generally refer this as the usage



aspect of the e-learning content and the systems, and that has to operate in the new normal. Then of course we come to the usability aspect the appropriate use of technology. Because this e-learning content depends on various things, one is the supportive IT infrastructure in the learning environment. So, it maybe the university, it can be the working place, it can be the residence. Because some people are accessing, some of the learning content, or they are conducting the courses from there are working places, some are industry experts. And then the learners, the students are sometimes in their residencies, or in some cases, some people have got even COVID, and they were in the hospital and they were still engaging in the learning process. Now this is something that was not there before. Of course, if they were in a serious situation they may not do that but I know personally, you know several students who were while in the hospital, how they got engaged with the learning process. And then, we also have to consider the systems we have, the facilities, the functions, tools. So, lot of things that are provided in a learning system environment. Now the question that we have is whether these are appropriate to cater for the new normal.

Now, early days before this pandemic came in, there was a particular environment that we operated, but now of course we have to consider lot of other factors, the bandwidth requirements, the charges, the policies that the government may have regarding the data volumes and the charges by the ISPs, the income levels, we know that some people had faced the issue of the income level going down. So all these factors need to be taken into account. But yet, we have to take the learning process forward. Now, what should we focus on because of this, some of the research that we did identified that interactivities very important and the learner contribution is very important. So, this is something that we keep them engaged and the process will go forward, Right! So, the interactivity may be defined as the activities carried out between multiple parties with each other. So, when it comes to the learning process, interactions can be between the learners and the learner, and between the content of the system and the learner, and then between the tutors and the learners.

Now, the most important but neglected part has been the interaction between human role players, that is the learner-learner and the learner-tutor. So, why this is important is because this is where the different ideas, different arguments. So, all those are generated in this human interaction situation. Because of that, it is quite important. Now, I got involved with a project called Distance Education Partnership Program which was under the distance education modernization project under the Ministry of Higher Education sometime back. Also Prof. Asoka Karunananda knows about it, we were working together. In one of the research, we got involved, our objective was to find the highest contributor for the learner satisfaction. So that was the dependent variable that we used.

So, based on the qualitative and quantitative analysis, we looked at independent variables, the community building, interaction, learner support, course design, etc. And, we carried out the research using some online instructors who are undergoing training, and some educational and tutor mentor specialists who conducted the courses. The highest contributor for the learner satisfaction was the interaction. This is what we found. So, if I show it using a graph, the interaction contributed about 50% or over 50%. And then the other factors like community building, learner support, course design, all of them had lower percentages. Of course, there was various other factors, you can see that this does not add up to 100%. So, the learner satisfaction dependent heavily on the interaction. So, what is the implication for the new normal. So, if we want the learners to learn, they need to engage in the books. If we are to keep the learner engagement, interactivity is important. The challenge is to facilitate the interaction, while the learners are keeping social distance. So, to make the education smart. we need to be smart enough to maintain the interaction in the context of new normal. So, our challenge is you know, how can we facilitate this, what kind of tools that we use, how can we ensure that the interaction will go forward in the way that is expected or that is desirable, right? So, this is something that we need to keep in mind.

So, then we will come to the preparation and gradual improvement, some of the experiences we have from the past. So, if you look at this the

preparation and the gradual improvement, why I want to focus on this gradual improvement aspect is, today we can see that the effort is to do things as fast as possible, because all of the sudden this pandemic came, and then institutions were clueless. But then of course many people faced lot of problems as well. I'm not sure whether I have a direct answer to say, whenever particular institution needs to get into this, whether they have any other choice than you know getting into some rapid course of actions. But of course, for our own advantage we have been doing this for quite a long time. So therefore, we could have some gradual preparation and an advancement than having a lot of ad-hoc initiatives. We started way back in 2003. Now it is almost 18 years. So then, what we observed was the steady and the knowledge construction could be achieved when we had the learner participation included. And also, we have seen that there's a lower dropout rate. Now I'm not talking about the fully virtual or traditional learning. So, this is kind of a blended learning activity that we started. Then we figured out that there was a kind of a satisfaction and a motivation that we could observe among the students. And also, there was a kind of a bit higher volume of knowledge sharing because it is not only the lecture who was engaged in the learning process, it was also the participants.

In fact, we tested this mostly the PG courses. I have to admit that some of the courses for the undergraduates at the quite early stages, in the first year, the first semester and the second semester, didn't have that much of a success but as it went along the academic years, there was quite a good improvement and when they came to the third and the fourth years or semesters 6, 7, 8, ... etc, we could see the advantages. So, in this case, when we look at the knowledge sharing, We were able to manage multiple resource persons and better planning, and then there were so many subject matter experts that could be brought in. So, we didn't have to depend purely on our own university, we could have a lot of collaborations with many other universities. And then, even to face unavoidable circumstances like, such as the COVID situation. It was quite equivalent to having lecturers who do not fall sick, right now as human beings we fall sick. But of course, here, there's a kind of opportunity for

us to have a situation where the learning activities go uninterrupted continuously. So, this was one advantage, of course in some areas there might be a situation that we are unable to find that many expertise, but still we could use lot of other collaborations with many other universities and then MOOCs and various other things to fill the gaps. So that was a quite good opportunity for us.

Because of that, instead. Now, in fact what I'm talking about here is not the fully virtual learning, but to have a lot of interactions, and then use the system to facilitate that, humaneness also needs to come in. So, therefore building learning communities with enhanced relationships, that was quite important. Today we talk about the social distancing, right! Now, while the social distancing is happening, whether we have ways of bringing closeness, right! Now, that is something that we could facilitate through many of these learning management systems and get them to engage in activities, and then work on the subject matter in a different way than becoming just the mere listeners, right! Now if you consider how we remember the some of things that we learned during our university time. Now, that is because of lot of activities we had, the engagements, the things we did, rather than listening to a lecture, right!

So, I'm not going to talk about this Bloom's Taxonomy and all that, but then we know that when we apply the things together, that's where the projects are also quite important, right! So, because of this the new normal calls us for a new way of building relationships in the learning process, and also it's very important. Due to the time restrictions I will skip this particular slide but one thing that I want to highlight is that the institution need to get involved in this. Now we can't have, you know just individuals trying the things. Now, we have to bring this together in a formalized manner, right! Sometimes you know, we may not be able to wait for the perfect solution, but however we will have to work on certain things and then we had to build our own thing as well, because each university works in a different way. And therefore, there need to be certain things that can be developed within the university itself, so that their processes can be facilitated. They may not be kind of in a huge system you can do a lot of integration.

So, if you look at, you know how we did from the past experiences, it's mostly the integration and automation, right! So those are the main technical tasks. In fact, when COVID came, we were COVID ready. So, we were ready for it even well before the COVID pandemic. Of course, we didn't know that it was coming. So, why was that, we already had some centralized authentication systems implemented, now these are not learning things, but that facilitated, and integration of applications to the single sign-on, all our learning administrative portals, Moodle like learning management systems, document management systems, WIFI facilities, email, web, and there were so many other things. And also, we had built as a team, of course there was a team of people who work together with various online live session platforms like not only zoom. There was a something called BigBlueButton and then there was various other platforms. We had a situation where the zoom capacity was not sufficient for us, and then for that we used something like, called the BigBlueButton, for an example, right! And most importantly, they were not isolated solutions, they were integrated. They were integrated through the centralized systems. And, also we had automation of examination related processes, automation of undergraduate studies, automation of postgraduate research related things. And then, even facilitating the research, and various other works through the virtualization and hosting, because now people have to work from home, these facilities have to be there.

So, there was this gradual improvement of all of these from time to time, and then that helped us during this. Now, of course I'm sure many universities already have these things. It's only a matter of using them in the appropriate way, right. And also, we had this policy development, which was very important. Because otherwise in the remote mode of operation, we can't cater for some of the issues that may come up. So, the IT policies, acceptable use policies, managing the user accounts and social media, because that we need a lot in the educational learning process today. And then how the services, IT services arm should be restructured to cater for this new normal, and most importantly the Help Desk. Because the users will be facing a lot of issues. And then, the only way that they may ask for the

help is through a Help Desk. So, we should have a kind of very efficient Help Desk. I am not saying that our help-desk in a quite up to the level that we expect, but some form of help desk is there. Because that importance was very much felt when the situation happened. And, not only that, the people who are authorized to do things, who are the responsible parties, may not be the technical people but the people who have the authority, they have to do engage in lot of virtual meetings, so that they can decide on what to be done and then communicate properly to the systems engineers and the technical people. So, some of these meetings had all these parties together. So early of course, always you know, different parties have their separate levels of meetings, but now all things were brought together and all the people were together in decision making. And that is something that came up during this time.

So, in conclusion, I would like to say, one is, the university education needs to be adaptive whatever the circumstances maybe. It can be some industry revolution that is happening, that happened in the past, and the technology enhancements that are taking place around, and the widespread use of the internet and speeding of that to all the corners of our country, the IoT driven environments that are coming up. Always, even in the occurrence of a pandemic like this, right, whatever the circumstances maybe, the university needs to be adaptive.

So now, in order to do that, unless the underlying facilitation that happens, if unless that is smart, the processes, the university education will not be smart. So, we need to focus on that, and then to have all these things facilitating this education environment. Otherwise, the coping with the challenges of the new normal will be far from the success. How many people think just the delivery of the content is the education, but that is not the education. The mere content delivery, you know somebody may read it or may not read it, but the students or the learners need to get engaged. So, we will see whether we have provided the proper university education when they go out of the university, and then when they go to the society. So, because of that, an innovative learning environment that drives the learners towards achieving these objectives need to be created. So, it refers not only to the use of technology, but also



to redesign the academic processes with an integration of the automation, the automation has to be brought in.

So, I'm not saying that we have done it in the level that we should do it, but we are somewhere there. So, because of that we are surviving today and then we can face it. And then that sir, that was

for our advantage because even before the pandemic we could do it. But even today, the universities who have not started can start on it, and I hope that it will help.

So, with that, I would like to wrap up. So, I would like to wish you a meaningful learning time, amidst the pandemic and take care!

## The Opportunity: ICT for a Sustainable Post- Covid Future in Sri Lanka

Mr Diyath Ariyaratne

*General Manager, Pearson Lanka (Pvt) Ltd*

Poverty and inequality are universal. They undermine every society everywhere. But poverty is not natural. It is man-made. So, poverty is inevitable. It's an area where the world has made huge progress in the past few decades. Just 30 years ago there were 1.9 billion people living in extreme poverty, but that number has been transformed. In 2015, it fell to 734 million people. That's over a billion people lifted out of poverty. Billion people out of poverty was amazing. It was across the world. We lifted people out of poverty across the world. More kids got into education as across the world maternal mortality was reduced across the world today. Not many people will be left without access to a mobile phone, and what that has done to empower them to access to education, to a livelihood is huge, but still almost 10% of the human race is living unbelievably harsh lives. This is largely determined by their circumstances at birth, and these high levels of inequality work against better opportunities for all – opportunities that could change the world.

I want to tell you a story. About 1999, I used to teach people how to write computer programmes. And I had a very, you know, plush office and everything. And just outside of this office, there was this large, sprawling, urban slum, full of children. So, one day, I tried an experiment. I made an opening in the boundary wall that separated my office from the slum. And then I fixed a computer so that from the other side of the wall you could see the computer and a touch pad. On the first day we saw this 8-year-old boy teaching a 6-year-old girl, how to surf. How on earth did he figure that out? How did he know what the computer was doing? Three months after I had first put their computer in the wall, the children said they wanted a faster processor and a better mouse. I asked them “how on earth do you know these words? Where did you learn this from?” And they said. Well, you you've left a machine here that speaks only in English, so we had no option but to learn the language. Easy, isn't it? I

repeated the hole in the wall experiment for five years across the length and breadth of India. In a village 300 miles away from Delhi, one girl is explaining to the other girl what a neuron is. They were just 12 years old. We have hopes we have an enormous potential of what children can achieve together. If we let them.

Good afternoon, good morning, good evening depending on wherever you are joining from.

I thank the Vice Chancellor Major General Melinda Peiris, Dean, Faculty of Computing Dr. Asela Gunasekara, Major RMM Pradeep and Mr Ashen Wanniarachchi and the faculty of computing at KDU, for inviting me to speak at this annual international research conference. I'm truly humbled to be a speaker here amongst such an eminent group of academic and industry professionals.

I commend the Faculty of Computing for coming up with such a fitting theme this year. Smart integration of technology to sustain and national development in the new normal. Along the same theme, I would like to share some of my thoughts around the opportunity we have as a country to use it to create a sustainable post COVID Sri Lanka. Some of what I am going to talk about will have some overlap with what you just heard from Professor Tony and Doctor Shanta. Nevertheless, my perspectives are purely as an industry stakeholder that contribute to creating more opportunities in the information technology space in Sri Lanka. A fun fact about the photo you see here on the cover page. This was taken when Pearson donated a computer lab to a rural school just before the onset of COVID about 20 minutes' drive from Colombo City in Gampaha District. You can see the wonder of the boys, especially the one that's in the middle who has never sat on a rotating computer chair, not touched a laptop in their lives. The time of this one teacher that's here has shared amongst two schools in the area during a week. So, this is reality, just in the outskirts of Colombo.

Today, amidst the COVID-19 pandemic, everyone understands the need to grow their economies and develop countries, but not everyone gives due attention to the negatives that unbalanced economic growth can have on our planet and people's wellbeing. It is time to change that by looking at the world in a different way and sustainable development will help us do just that. Sustainable development is about the big picture. I am sure this illustration is familiar to a lot of you. It is development that meets the needs of the present without compromising the ability of future generations to meet their own needs in natural, social, and economic resource. In 2015, 193 countries of the United Nations, including Sri Lanka met and agreed to adopt 17 global sustainable development goals as a universal call to action to end poverty, protect the planet, and ensure that by 2030 all people enjoy peace and prosperity. Enough is said about the environment these days as climate change is the next biggest challenge humanity will face. I will focus on the opportunity we have with ICT that can help education and employment which in turn can have a direct impact on economic and social aspects of sustainable development.

World population today is around 7.8 billion. There are over 264 million children that don't go to school. 250 million children worldwide, are in school but not learning. They might not be having the basic facilities or having learning disabilities. Lack of trained teachers, inadequate infrastructure and learning materials, makeshift classrooms and poor sanitation facilities make learning difficult for many children. 617 million children across the world don't have basic reading and mathematics skills. Another interesting fact is 65% of children aged 12 in year 2015 will do jobs that don't exist today. As you know, COVID-19 further deepens the inequalities in access to education. You have witnessed on media how our own sons and daughters climb trees and mountains to get access to their online class. On the other hand, if you look at some other social and economic indicators specific to Sri Lanka listed here. While there is a clear and present danger in a straining economic environment, we still have some great opportunities as well. As a country, we have made progress in some of the issues concerning poverty over the past decade and a half. We have

a high literacy rate at 92.5 percent, 99.1% of primary aged children are in school. Our service sector contribution to the GDP is around 60%. From our employment aged, only 50% are in active labour force participation. I share these indicators with you because while global view looks grim, we do have a solid Education Foundation that most of our peer countries in the region don't have that we can use to rebound despite the setbacks from the pandemic.

Now let's look at some of the world trends that we see in education against the backdrop of the pandemic over the past 18 months. There was an accelerated adoption and rise of online and digital tools for schools and education. There is a massive demand to fill large number of high skilled jobs.

In the market today, government and private organizations have increased attention on employee training, upskilling and reskilling to meet evolving labor market needs. With a growing need for accreditation and certification, colleges and universities are demanded to offer shorter courses or lower cost options to help those who are unemployed.

A growing global middle class which is also true for Sri Lanka and longer careers are also driving lifelong and informal learning, particularly for reskilling and upskilling. A trend that has accelerated over the past year. Few things are for certain, world will not return to pre COVID status quo of education and we'll show permanent changes as a result of the crisis and adaptations to it. As Dr. Shanta rightly said, today learning can take place anywhere. Parents, students and teachers seek profound changes in the way education operates in the future.

Looking at the opportunity, what reforms should we focus on in Sri Lankan education system? As per the United Nations, COVID-19 has wiped out 20 years of education gains just in the year 2020. Just think about that – 20 years of education gains just in a year. Inequality in education deepened with COVID, and learners demand equity now. Every child, every student in our country has the right to go to school and learn, regardless of who they are, where they live, or how much money their family has. We need

more investment in use of technology for learning to stop falling behind further as a country. Sri Lanka's government education expenditure as a share of GDP is 2.1% and has been consistently lower than that of our regional and income peers. We must address this. We need to update curriculums often and move away from outdated rote learning methods that have, I'm sorry to say, plagued of education systems for many years. Especially in the remote or blended learning mode we have today, Sri Lankan students are fatigued as the curriculum content is not tailored towards online delivery. We need to fix that. It is encouraging to see those institutions such as KDU constantly reaching out to industry experts and adjusting their curriculum and course material relevant to today's market and modernizing the delivery of education. I recall Commodore Janaka Gunaseela of KDU stating in a review board in the recent past that KDU graduates secure 100% employment almost immediately after they pass out. This is the outcome that Dr. Shantha also mentioned, I think, that is what is expected when someone graduates through our universities. This should continue to be the case in both state and private education institutions in Sri Lanka. We should look beyond the traditional four-year degree and in addition, look at offering adult learning, shorter courses, soft skills training so that we can help the unemployed, which is a problem for our part of the world as well. There is a 14% drop out rate of students from O' levels to A' levels in Sri Lanka, and I believe this would help that population as well as the group that don't make it to the universities. We should promote more students and girls into STEM, science, technology, engineering, and mathematics subject streams in our part of the world, that is an untapped talent pool for tech jobs. Also, today seven countries, including some of our peers in the region, have adapted coding as a subject. To educate children technically and make their skills applicable for the upcoming future jobs. We all understand the value learning brings to people's lives in helping them progress and achieve their goals. We must ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. Everyone should have the opportunity to learn because learning transforms lives and

societies. Nelson Mandela once said, education is the most powerful weapon you can use to change the world.

The IT-BPM industry provides a golden opportunity for accelerating economic growth in post-pandemic Sri Lanka. Accelerated digitalization and hybrid, remote work models have disrupted the industry, creating great prospects for skilled tech talent to join a global workforce from our own country. IT-BPM industry in Sri Lanka grew rapidly over the past two decades and today the government of Sri Lanka identifies the sector as a thrust industry. It is a high value job industry with a smaller workforce can have a massive impact on the country's economy through steady inflow of foreign revenue. Today IT/BPM industry generates over 1.5Bn of revenue and a great forex earner for the country IT/BPM being the 4th largest exporter. With over 680 ICT/BPM companies are there with nearly 114,000 skilled professionals that contribute to 29% of the services exports of the country. Sri Lanka has fast emerged as a global destination of choice for IT/BPM and knowledge solutions industry. Global brands are powered by Sri Lankan talent and getting recognized as an "Island of Ingenuity" for our high-end software engineering and technology services backed by ingenuity, quality, and world-class people practices. Today, as an example, the world's leading digital learning and media company Pearson that has over 22,000 employees worldwide, the company that I am part of have made Sri Lanka their largest technology center for software product engineering and infrastructure services employing over 850 Sri Lankan technical talent. IT-BPM industry require very few imported inputs that thus making it resilient industry. If you are in IT-BPM now, you can technically work from anywhere. The industry is less vulnerable than other industry is struggling in a vuca world, volatile, uncertain, complex and ambiguous world, and also more interestingly, IT-BPM sector is less vulnerable even to government stupidity and outdated policies. While we have made huge strides and progress in digital and physical infrastructure development across the island, we are at great danger of falling behind our competitors in our competitive edge as a location due to lack of

quality and quantity of talent for the IT-BPM sector coming out of our universities and higher education institutions. Higher education institutions must help the industry to scale up, producing more tech talent to meet the current growing demand. We must act now and take remedial action because we are falling behind among our peer countries like Bangladesh and Pakistan in global outsourcing indexes.

Last but not least, I believe for us to rebound as a country and develop. We should also create a vision for our country because my personal, humble opinion, view is that one does not exist. One might ask, we have election manifestos. That get dangled at us every couple of years with prospects of development that never get fulfilled. Sorry to disappoint, but typically those visions are just to merely get them elected. Even during the pandemic impacting the entire human race, topics like business ethics, accumulation of wealth, values, equity or question, development of a country should be holistic and integrated. And like Professor Tony said, whatever you do with technology should ultimately contribute to the vision you have for the country. It might work in a certain country, or it might not. Remember, technology is only an enabler and it's not the silver bullet, for all

problems of development, especially in our country's context where over 60% of our population is strictly rural. There are sophisticated definitions on sustainable development, that is all encompassing, holistic and integrated, but all these are modern expressions of deeper values we already had in our country in the past. Perhaps going back to the vision of our great leaders in the past for our nation has the answers for the kind of development we need today. And that is the vision our great kings and leaders had for this nation for thousands of years, which was, Danyagara Dharma dweepa – land of plenty, land of righteousness. I would like to close with an excerpt from a book written in 1999 by my father, who in fact was a close associate of the great General Sir John Kotelawala. And I quote, "There should be a spiritual-cultural and socio-economic content in all development processes. Development should start from the grass-roots from the village up. People should fully participate in planning for development and in the implementation of such plans. It should first strive to satisfy the basic needs of the people and not artificially create the wants that are a blind imitation from materialistic cultures" Thank you & Stay Safe!

## Use of Blockchain Proofs for Building Trust in Business

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Blockchain has been identified as a revolutionary technology even before the pandemic. But in the new normal blockchain has extra significance as a way of building trust in communities in business and in international transactions where we will not have access to the traditional means of building the trust in this new normal. I'm the co-founder of a blockchain based supply chain traceability company. Most of my presentation will be centered around a practical experience in using blockchain for tracking supply chains for the past four years. Let me start with the supply chain example. This is an Agri supply chain, and as you can see, there are farmers and field workers in the supply chain producing things and recording things and government authorities who try to make sure that the production happens in compliance to the regulations. business owners who coordinate everything and ultimately sell this product to the consumer and ultimately the end consumer who consumes these purchases and consumes this.

But now if we take a picture like this, the economic intentions of these various parties are very much different from each other. They are misaligned basically. The producers and field workers will want to get a maximum payout for their produce and the government authorities will be interested on flagging these businesses for the regulations and the business owners will try to project a very beautiful picture about the product, sometimes pretty much deceptive and the end consumer wants to consume a very high-quality product for a very low price. So, the economic intentions are very much different. So, the blockchain's goal here is to ensure trustworthy exchange of information in a setup like this where no one actually fully trusts each other.

So, the blockchain's challenge is how to maintain information authenticity when different parties are involved have misaligned economic interests. And to analyze a situation like this we can investigate a theory like the game theory, which

is a branch of mathematics. And this is a well known theory in game theory, which is called prisoners dilemma. Let's say cops taking into custody two people in suspicion for a murder. Let's see. Now the cops are confident that at least one of them is guilty of this offence. Now the COP strategy is this. Put these prisoners into two prisons and cut off all the communication channels between them and give each of them an offer. The offer is this. If you defect your colleague, which means if you say that your colleague is guilty, then, if your colleague also says you are guilty, then each of you end up having a sentence of two years in prison. The numbers are given negative because the guys are trying to minimize it. You should try to minimize your prison sentence.

Now if you defect and your colleague cooperates, which means that your colleague says you are not guilty. Then you will be freed straight away, and your colleague gets a three-year sentence. So that is the zero and minus 3. And if you cooperate, and if your colleague also cooperates, each one ends up getting a sentence of one year in prison, and if you cooperate, and if your colleague defects, you get a sentence of three years while your colleague will be freed straight away. And here if you think from a rational perspective from one prisoner, if he cooperates, he gets either minus one or minus 3, that's his output, and if it defects, what is expected output 0 minus 2? And what is better out of the two? It's obvious, right? 0 minus 2 is better than minus 1 minus 3. And each prisoner, of course, rationally picks this option, which is to defect, and betray each other. And ultimately, they end up here. Rational behaviour with self-interest leads to this equilibrium. This is called Nash equilibrium in game theory. But it's not difficult to recognize that this is not the optimal position here. The optimal position is minus 1 minus 1, where the prisoners cooperate and end up with only one years of sentence each, but they never end up there because of the rational behaviour,



So this is what happens when people have misaligning economic interests. They always end up in suboptimal positions, and this is the unfortunate predicament of most of our social relationships.

So now because of that, it's very difficult to do transactions between people because of these misalignments, and this is one of the answers that human civilization has come up with using money for transactions. Here you see, A is heading a product to B, and B pays to A with money. And you can see that the product has a value. It's obvious, but looking at money, it's just pieces of paper. How to ensure that money has value? For that you have centralized power, the centralized political power with government, which operates this setup using central banks as a centralized economic power using jurisdiction and so on. But history has taught us that the moment you centralize power, you end up with a lot of corruption, deception, and lot of bad things. But the catch is still money is an excellent mechanism.

Money is one of the best inventions of human history, and it is an excellent way of exchanging value. So, the question here is that can we kick the bad guys out here and keep the good guy. The good guy's money, right? And this is the idea of Bitcoin, which brought the first blockchain you have here. You have the money. But you don't have a government. You don't have a central bank. Instead, you run something what is called a crypto economic model according to a free-market mechanism which is decentralized without any centralized power based on economic rewards and penalties. And this is how it happens. So, what you see here is a blockchain of all the transactions. Transactions mean I have a wallet, and you have a wallet, and when I pay from my wallet to your wallet, the amount will be deducted from my wallet and the same amount will be added to your wallet, simple as that. So that is called the wallet balance rule, which is the number one rule in blockchain which is extremely simple. And these transactions are grouped into what is called blocks, and then you have a sequence of such blocks. So that's how the term blockchain comes in. But the catch is this. There's no single government or single company with any kind of single authority to keep this record. This record is kept in a

decentralized network like what you see in the top right. Everyone keeps their own record, and everyone keeps communicating with a lot of other people in the network, each one of these dots is called a node, and each one participates in an activity called mining, which is basically you construct a block and then you do conduct a calculation which only makes sense in the blockchain, and it doesn't have any sense or any value outside the blockchain. Effectively what you do is you take the block content, add some random value to it, and get the hash. And then you repeat that operation until a certain bit pattern is yielded. And you will have to do that iteration, maybe many trillions of times until you end up successfully mining a block, and while doing that, you're spending your resources. You're spending your hardware, you are spending your electricity, so you're basically making an economic commitment on the chain.

So, that is a number two rule, economic commitment rule. And then, the moment you complete a block, you communicate that to the network and go to the next block and so on. So, you ultimately end up with a chain like this, and when you work with a network like this at any given point of time, you can have many such chains running in. And the number three rule is always the longest chain wins, and that's why you should get your truth. So, now here we can see three competing chains and two out of them have the same link, but one of them will win soon. Now the moment you learn about the existence of a longer chain, the best strategy is to switch all your mining resources into the longest chain because otherwise you are just wasting your resources on a chain which is anyway losing. Now when you mine a block you get a reward for that, which comes in terms of the coin in this blockchain. If it is the Bitcoin blockchain you get your reward in terms of coins and that's how you encourage people to get engaged in this activity.

So with this, ultimately, blockchain achieves a way of enabling authentic transactions without the need for any centralized power. So, this is a historic achievement. The potential of blockchain, the impact it can have in the world is usually compared with the impact Internet had on the world.



So, it has a lot of applications in many domains. Yeah, the engine value is economic commitment on a chain which is paid back later only through the blockchain. Now in the previous slide we saw many chains like this, and they are usually called soft forks. Soft forks usually happen due to network imperfections.

The picture I have in my node may be different from the picture you have because I have not received certain information by now because my network is slow or something like that. But a blockchain like this previous one will always converge into one chain, which is the longest chain. But there's another way where the chain can be changed. That is by changing the protocol. So, if we go back to the previous slide, the protocol is basically this square you see in the top right. And if you change the protocol, you can change the chain as well, so this is not a soft fork. This is called a hard fork, and if the protocol changed proposal is accepted by the majority, this happens in a very democratic way. If you want to change the protocol you need to bring in a proposal and the majority of the community has to agree, which is a very difficult process and that can go through several debates, campaigns and so on. And if that happens then everyone switches their mining power into this new protocol, and the old chain may or may not continue.

I'll give you an example. This is from Ethereum, which is one of the most popular blockchains. The Ethereum blockchain was hacked in 2016 and something like \$60 million were stolen due to a vulnerability in one of the decentralized apps, which is called DAO, which was based on Ethereum. So if it was a small amount then you could have continued with that, but 60 million is something that you will have to consider significantly. So the Ethereum community discussed what to do to deal with this situation. And then the majority agreed to create a hard fork, change the protocol so that they bypass the block which contains the hacker's transaction and take all the other transactions and create another block called Block 4A and proceed from there, but a minority disagreed to this because tampering, changing things, changing transactions is basically opposed to the original blockchain ideology, so they continued the original blockchain. Now today, both these

both these are continuing as blockchains, and the hard fork is now Ethereum. It's the main Ethereum, but the other chain is also continuing under a new name called Ethereum classic because Ethereum has the majority of the community support. The value of Ether is much higher than the value of Ether classic. And one interesting point is this. Now, let's say if you had the transaction here in block two, which moved 100 ether to your wallet. Then when you have two chains, suddenly you end up with 100 Ethereum and 100 Ethereum classic. So you have just got luck. And another interesting factor which was revealed here is there's nothing called hacking a blockchain. Now this hacker, these hackers, they were a group. They are walking in daylight. They didn't get prosecuted or anything because remember there's no jurisdiction or government in blockchain. The only rule is what is said in the code.

So if the code has a vulnerability, that vulnerability is a part of the rule, so exploiting the vulnerability is not an offence. And the nature of truth in blockchain is like this. The truth in blockchain is like wine. It is more credible when it gets older and to think blockchain is arranged like a story. So, it is a very easy to audit it. So auditing is one of the domains which is predicted to be disrupted in near future by blockchain.

So the previous blockchain category is called chain-based consensus blockchains. There's another type of blockchains which is named as semi-trusted blockchains. We in classified also use one of the semi-trusted blockchains. No activity called mining here. For a block chain of this kind to work, you have to have some kind of trust between the players, and you always have your floating growth only with respect to the final block. Until the final block, everything is cement truth, and it cannot be changed. So you don't have soft forks here. Smart contract is basically logic executed on a blockchain. The original Bitcoin blockchain had some basic level of smart contracts enabled, but then Ethereum came, and it made it possible to write any kind of logic that you would write in another programme to be executed in the blockchain.

So, accordingly, Ethereum is called the world computer. Just like other entries in the blockchain, smart contracts also are

immutable. They cannot be changed, so it's not like your code. When you are in a typical code, when you figure out a bug, you can go ahead and fix it and release it to the code repository. But in a blockchain, the moment you commit a piece of code, that's it. You can never change it. And this is the blockchain ecosystem. Some are in a summary, layer one is basically the truth building layer, which comprises the protocol, consensus mining and those stuff I described. And there's a layer zero as well, which is the invisible layer, where all those debates, discussions, and all those democratic mechanisms take place. And blockchain governance is a topic in its own right and on top of layer one you have what is called DAP. So decentralized DAPs, which is basically applications running on top of blockchain. So Tracify also has a depth on blockchain. And this is an example for a DAP we have developed which is called block event, a very simple DAP. This is for selling event tickets on blockchain. So, you have the public blockchain here and we develop a DAP for that event participant and event organizer. Event organizer creates a bunch of what is called assets in the blockchain, like coin and then sets the ticket price, and the event participant makes the payment for one ticket and the DAP confirms to the blockchain that the payment is legitimate. So, the blockchain releases one asset to the event participant. So, on the day the event, the participant walks into the event location and generates a QR code which represents that asset and requests event entrance from the deck and the DAP confirms the event entrance request to the public blockchain, and the block chain takes the asset back from the event participant and confirms the participant's ownership that the ticket is a legitimate one.

And the DAP authenticates the user, and it tells the event organizer that OK, this is a participant who has a legit ticket and let him in. So that's a pretty basic DAP, a very simple kind of a DAP that you can have. But intensified for supply chains, we have a much more complex blockchains due to this fact. Now if we go back to the previous transaction, now what the blockchain deals with is money. but money is plain value.

If you take 100 rupee note, even if the rupee note is worn out, the value of it is still 100 rupees. But the value of commodity, the value of products is

much more complex. So assuring complex value transfer in blockchain is a difficult, but still achievable. So, if you take a supply chain, what you see in the middle as grey boxes are the row data in the supply chain and they are hashed into the blockchain as black boxes like this, and what you have is information, so when you derive information out of row data, you may have to do some slicing and dicing, which you achieve through smart contracts. And for dealing with the complexity of the supply chain data, instead of just one proof, like in block event, tracefied comes up with the metrics of numerous kinds of different proofs regarding the supply chain, like this. So that's how we deal with this complexity of information here. And ultimately, you end up with this. Now before purchasing a product as end consumer, you scan a QR code and the blockchain tells you that the claims that the producer is giving you are credible. However, not every proof is a direct proof. Some proofs take an application of complex logic on many transactions which come to this topic of long running transactions, which is sort of a complex topic, so I will skip that part.

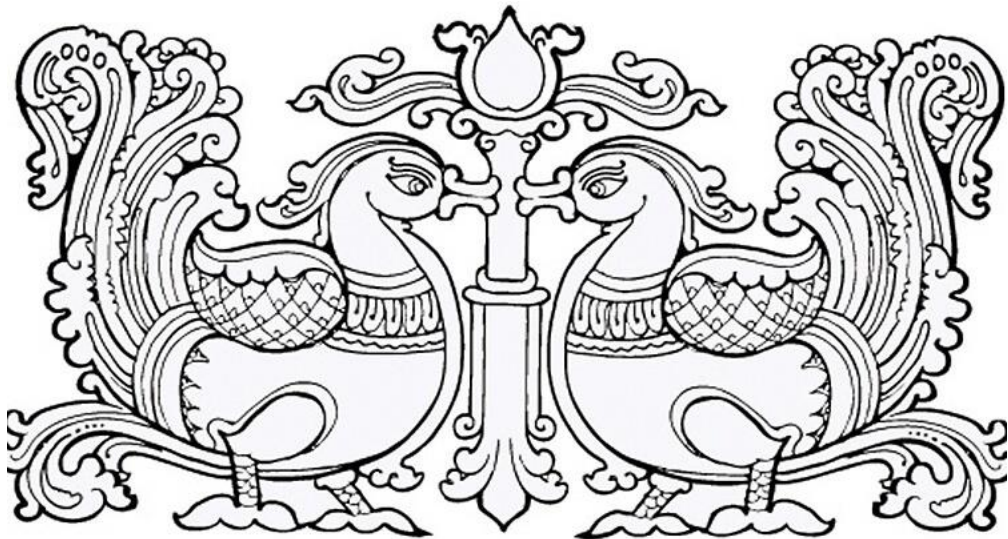
But I can provide you if you want to learn these long running transactions, you can have a look at this blockchain which is called OGRE which introduced this concept. And, dealing with real world facts in the blockchain – because blockchain is clueless about real world facts. Blockchain only knows about digital records – you need actors code or a curse, which is another concept in the block chain.

For example, in a supply chain, you can have a Agri field officer recording certain things in a farm and reporting that information back to the blockchain or a sensor, a device like a sensor recording temperatures in a warehouse and reporting it to the blockchain. And privacy in the blockchain is also another emerging area because one of the problems is when you go to the public blockchain, everything is there; everyone can see everything. And, there is a solution, a pretty much new solution named Zero Knowledge Proofs which enables you to guarantee things without exposing your information. So, you can search for the technology in the Internet. I don't have time to explain it right now. An example blockchain for that is 0 cash or Zcash where you have all the

blocks in your blockchain, like pretty much in another blockchain, but every block looks like a black box. The only thing it tells you is that all the transactions in this block are legitimate, that's it. You can't see any other information beyond that. Efficiency in blockchain is also another topic. There are a lot of solutions emerging, which have been emerging for the past couple of years. There are solutions like sidechains, layer two solutions and layer one solutions, and you can search for them, and these are sort of advanced topics with the blockchain. And in addition to the public blockchains, there are two others types of blockchains. One is consortium blockchain which you form by the cooperation of a number of organizations. Facebooks' DM is an example for that earlier known as Libre. What Facebook has

done here is that they have partnered with several very reliable large companies and these companies do the mining. So there's no public mining there and a private blockchain is a blockchain which is governed by just one organization and Hyperledger is a very good example for that. OK, for learning, I can recommend these two books mastering Bitcoin and mastering Ethereum by Andreas Chrono Poulos, and a good blog to have a look is Vitalik Buterin blog, who is the Ethereum founder, and if you guys are interested in the local discussions that are happening around blockchain, you can join this meet up, Colombo blockchain meet up which we run. We usually have a meet up every quarter.

Thank you.



# Technical Sessions

# Hatred Comments Detection in Twitter using Deep Learning

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**Abstract** - Social media applications are the most popular web and mobile applications across the globe. In the meantime, however, this has resulted in the emergence of conflict and hatred by making online environments, particularly Twitter, uninviting for users. This issue typically affects individuals, organizations and governments because it can have a reasonable or unreasonable impact on someone's reputation, as well as could trigger discrimination, hostility and violence, which can lead to or include terrorism or atrocious crimes in society. Therefore, an accurate, efficient automatic model to detect and classify hate speech on Twitter is a particularly useful tool for the relevant authorities. This paper describes the detection and classification of hate speech on Twitter by using deep learning. This can fill in the gaps between current models with higher accuracy and reliability. Thus, this research is beneficial in several ways, such as the detection of hate speech in distinct categories, such as in toxic, severe toxic, obscene, threat, insult and identity hate. The developed application used deep-learning algorithms to find the number of occurrences of the words and semantic words. The LSTM model is used to train the data set and to get the probability values. The classes of hate speech were calculated against the training data set and were found to be above 72%. In conclusion, the developed method can help to detect and classify hate speech into six classes on Twitter.

**Keywords:** *social media, Twitter, hate speech*

## I. INTRODUCTION

Social media is any digital tool that allows users to quickly create and share or exchange ideas with the public by building up virtual networks and communities. Social media applications are the most used web and mobile applications

across the globe. There are different types of social media networks that are popular at the present time that can be categorized as social networks (Facebook, Twitter, LinkedIn.), Media Sharing Networks (Instagram, Snapchat, YouTube), Discussion Forums (Reddit, Quora, Digg), Bookmarking and Content Curation Networks (Pinterest, Flipboard), Consumer Review Networks (Yelp, Zomato, TripAdvisor) etc. People are spending more time than ever before on their smartphones. People are able to communicate with other people and share all the media, like messages, images, audio and videos, worldwide at their fingertips through the use of social media. It can assist users in interacting with one another, raising their voices against an unjust act or issue, sharing valuable information, spending free time, and many other identified uses. Getting informed about the latest news around the world, marketing/purchasing products and services, making friends are some advantages of social media. Other disadvantages are failing to classify good and bad, inappropriate postings/content, cyberbullying, spreading of gossip, rumors, publishing, racism, spreading terrorism, hate speech. In Sri Lanka, viral postings and news on social media occasionally contain disgrace and hate speech, frequently targeting political parties, politicians, celebrities, and reputable companies. Twitter has information that is considered important by users. Messages (tweets) from other users who follow them will appear on the home page to read. Users can not retweet or resend messages sent by other users. Twitter, as a microblogging platform, has a large and growing user base on Twitter, users publish short messages using 140 or fewer characters to "tweet" about their opinions on various topics and to share information or to have conversations with their followers. Promote violence against others or personally harass or assault them because of



their race, nationality, national origin, caste, sexual orientation, gender, gender identification, religious belief, age, disability, or serious illness. For example, targeting may be done in a variety of ways. Mentions, including a screenshot of a person, referring to someone by their full name, and so on, are all examples of targeting. It poses serious threats to democratic society's stability, civil rights security, and the rule of law. If left unaddressed, it may escalate to larger-scale incidents of aggression and confrontation. Hate speech is, in this context, an intense expression of intolerance that leads to crimes.

Hate speech has an effect on a number of current United Nations areas of operations, including human rights security, atrocity crime prevention, genocide prevention, and counter-terrorism. The root causes of violent extremism and terrorism; avoiding and responding to gender-based violence; improving civilian protection; refugee protection; combating all types of bigotry and discrimination; minorities must be protected, unity must be maintained, and women, girls, and young people must be engaged. As a result, combating hate speech necessitates a concerted effort that addresses the origins and generators of hate speech, as well as the broader consequences for victims and communities. Therefore, hate speech detection is critical on Twitter. Uther, there are various classes of hate speech in the twitter. *The comments of toxic class* are harsh, insulting, or likely to cause someone to quit a conversation. The severe toxic class means severe stage of the toxic comments. The comments of obscene class are appealing primarily to a voyeuristic interest in sexual activity show or describe sexual action in a plainly objectionable manner and lack genuine literary, aesthetic, political, or scientific. The comments belong to threat class means a statement of the desire to do harm, hurt, or damage. The insult *class* is contemptuous or sneering. The comments of in the identity hate class belongs to someone's sexual orientation or identity, aggressive or antagonistic towards them.

## II. RELATED WORK AND MOTIVATION

(Ginting, 2019) recommended a method for detecting hate speech on Twitter. This method is built on the automated collection of unigrams and patterns from the training set. These patterns and unigrams are later used as functions of a machine learning algorithm, among other things. (Gitari,2015) employed the paper to develop a model classifier that employs sentiment analysis techniques, specifically subjectivity detection, to not only recognize and rank the polarity of sentiment expressions, but also to detect that a given sentence is subjective. (He,2013) presented a paper on an in-depth case study that uses text mining to analyze social media data in order to teach businesses how to conduct a social media strategic analysis and turn social media data into information for decision makers and e-marketers. Furthermore, this paper highlights that more enterprises are moving to social media sites like Facebook and Twitter to offer services and connect with consumers. (Jiang, 2013) developed a statistical method for mining Twitter data for drug effects. Adverse drug reactions have been one of the leading causes of death. This research has developed a statistical method for mining Twitter data for drug effects. The attempt to create an automatic method to derive possible drug effects from Twitter data is discussed in this article. This research has established a statistical framework for gathering, sorting, and evaluating Twitter data to search for drug effects. (Jianqiang, 2017) presented a study on sentiment analysis, which is the method of automatically identifying emotional or opinionated content in a text fragment, as well as determining the polarity of the text.

The aim of Twitter sentiment classification is to categorize a tweet's polarity as positive, negative, or neutral. (Kurniawan,2016) presented a research study to create a real-time traffic classification system using social network data. Preprocessing, feature extraction, and tweet classification are all stages of Twitter data processing based on text mining that employ three machine learning algorithms: Naive Bayes (NB), Support Vector Machine (SVM), and Decision Tree (DT).In recent years, the utility of excluding stop words in the form of Twitter sentiment classification has been called into

question (Saif, 2014). Using pre-compiled stop word lists or more advanced methods for dynamic stop word detection, removing stop words from textual data is a common technique for reducing noise. However, in recent years, the utility of excluding stop words in the form of Twitter sentiment classification has been questioned. One of the major challenges that Twitter sentiment analysis approaches must overcome is the noisy design of the data provided by Twitter. Singh (2016) presented a paper based on text mining. To check the meaning and sentiment translation of the slang terms, the proposed preprocessing approach relies on the binding of slang words to other coexisting words. To find the bindings, this paper used n-grams and conditional random fields to verify the meaning of slang words. (Wakade, 2016) showed how to use Weka data mining software to retrieve valuable information for classifying sentiment in Twitter tweets. Introduce a new system for pre-processing tweets to practice decision trees. (Watanabe, 2018) demonstrated how to use a computer to classify elements of hate speech in a text so that the speech can be understood later. Using the form of Multinomial Logistic Regression words. Wakade (2016) showed how to use Weka data mining software to retrieve valuable information for classifying sentiment in Twitter tweets. Introduce a new system for pre-processing tweets to practice decision trees. Watanabe (2018) demonstrated about the usage of a computer to classify elements of hate speech in a text therefore, the speech can be understood later using the form of Multinomial Logistic Regression. According to the existing studies summarized above consider only the detection of the hate speech in the social media. On the other hand, the accuracy of the previous researches are low. These observations on existing research triggered our motivation to detect and identify the hate speech into six categories with high accuracy in Twitter.

### III. METHODOLOGY AND EXPERIMENTAL DESIGN.

The proposed model is capable of detecting various types of hate speech, such as toxic, severe toxic, obscene, threats, insults, and identity hate using deep learning algorithms. The labeled data

set was gathered from Twitter. Thereafter, a set of deep learning operations has been applied to detect different types of hate speech if any as illustrated in the figure [1].

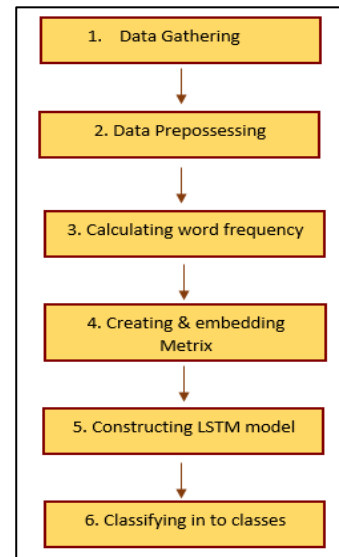


Figure 1. Methodology

The imported data set was preprocessed and tokenized by dropping unnecessary features which are not important for future processes. Following that, the number of clean and unclean entries was computed. Additionally, the distribution of the tag over the data set was counted and plotted on the data by using a bar chart. Furthermore, the frequency of the words was calculated in the clean and unclean data comments. Thereafter, the words frequented in clean and unclean data comments were displayed in a graphical way by appearing as the most frequented words, larger. The embedding matrix was constructed to find semantic words with the help of the Global Vectors for Word Representing (GLOVE) vector. An embedding matrix is a low-dimensional space into which high-dimensional vectors can be translated. Machine learning on big inputs, representing words, is made easier via embedding. An embedding should, in theory, capture some of the input's semantics by clustering semantically related inputs together in the embedding space. Next, the example for each category was displayed for the training purpose of the model. The Long Short-Term Memory (LSTM) model was used to train the proposed model because there might be lags of undetermined duration between critical occurrences in a time



series, LSTM networks are well-suited to categorizing, processing, and making predictions based on time series data. The LSTM model can learn a function that transfers a series of previous observations as input to a new observation as output. As a result, the series of observations must be converted into several examples for the LSTM to learn from. A probability of containing each category of hate speech was calculated for each uncleaned data comment in the dataset and finally taken to its apex.

#### IV. RESULTS AND DISCUSSION

In this section, the results of the proposed models are discussed. Jupiter 6.0 was used to create the model. About 15,957 data has been gathered from Twitter to detect the different types of hate speech based comments. The collected data was divided into two categories for the training and validation purposes in this research. The data preprocessing techniques were applied to the gathered data to remove hashes, tags, digits, punctuations, and id columns as illustrated in the figures [2] and [3].

```
In [4]: #Dropping the unnecessary features
train_data.or.drop(['id'],axis=1,inplace=True)
# test_data.drop(['id'],axis=1,inplace=True)
```

Figure 2.Removing id column.

```
In [10]: #defining a function to clean the data
def clean_text(text):
    text = text.lower()
    text = re.sub(r'http[s]?://(?:[a-z]|[0-9]|[$_%&]|[*~'"])|(?!(?:[a-z0-9+@-])|[-+@-])', '', text) # clean url
    text = re.sub(r'@\w+', '', text) # clean hashes
    text = re.sub(r'@\w+', '', text) # clean @
    text = re.sub(r'#[a-z]+', '', text) # clean tags
    text = re.sub(r'\d+', '', text) # clean digits
    text = re.sub(r'[^\w\s]','',text) # clean punctuation
    text = re.sub(r'[\p{L}]{4,5}\s', '', text) # clean punctuation
    text = [APP[word] if word in APP else word for word in text.split()] #
    return text
```

Figure 3. Removing special characters and URLs

The general distribution of the data set was checked and plotted on bar charts as figures [4] and [5]. Firstly, the amount of comments for each category were plotted as in the figure 4 and the percentage of each category were calculated and plotted as in the figure 5.

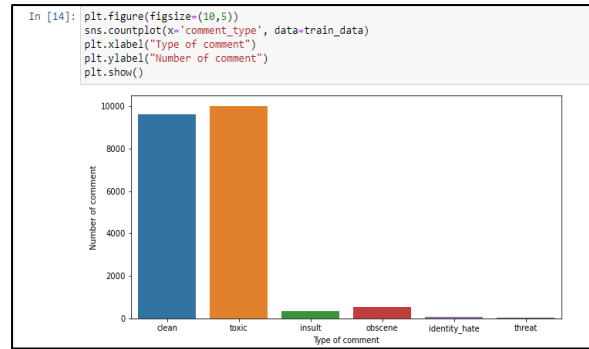


Figure 4. Amount of comments under each class



Figure 5. Percentage over the database

The frequency of word count for each category was calculated for the collected data set by making the most frequently occurring words larger, as shown in Figure [6]. Furthermore, as shown in Figure [7], the frequency of clean data counts was calculated.



Figure 6. Wordcloud for comments based on hate

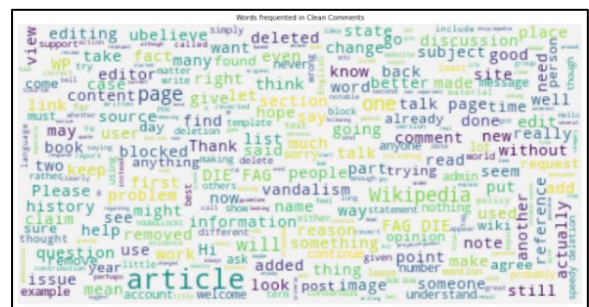


Figure 7. Wordcloud for clean comments



democratic society, the protection of human liberties, and the rule of law. It can escalate to larger-scale outbreaks of violence and conflict if left unaddressed. In this case, hate speech refers to an outburst of intolerance that contributes to hate crimes. Terrorist networks use social media to carry out large-scale, covert or overt ideological activities. In particular, this will have a negative impact on someone's ability to use and be on Twitter. This has a negative impact on someone's ability to use and be on Twitter. Deep learning algorithms are used to detect six types of hate speech on Twitter. This may help to encourage people to think before making statements that may embarrass other parties or have an impact on their future, personal, or professional lives. There has been a lot of research done on the detection of hate speech using deep learning with low accuracy. This study differs from previous studies in that it focuses on detecting and classifying data into six different classes of hate speech with greater accuracy. Hate speech can be detected and classified into classes with an accuracy of above 72% by using this model. However, it is necessary to carry out further studies to enhance the accuracy of the system and the usability.

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# Investor Oriented Stock Market Portfolio Management and Stock Prices Prediction Platform for Colombo Stock Exchange of Sri Lanka

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**Abstract** — Over the past few years, various studies have been conducted to develop an optimum stock market-related portfolio management platform that will assist investors to actively perform the portfolio management process. Risk and level of investor participation are considered to be challenging aspects identified for optimum portfolio management. Along with portfolio management, stock price prediction is one of the key contributing factors that help an investor to arrive at mid-and long-term strategic investment decisions. Various deep learning concepts are evaluated to determine the most accurate algorithm to implement the stock price-based prediction system. Currently, Colombo Stock Exchange (CSE) has identified a desperate requirement of a portfolio management system with prediction capabilities to support local and foreign investors to actively engage in trading activities among different stock exchanges in different countries. A critical study has been conducted using supportive research papers, similar applications developed and using various requirement elicitation techniques to determine matters such as the functional requirements, non-functional requirements, investor requirements, and UI/UX considerations. The paper further describes various technological mechanisms implemented and system architectures used to develop the portfolio management and stock price prediction system. Accordingly, the implementation of the Brownian Motion algorithm-based model and LSTM (Long Short-Term Memory) model are in detail presented by the author. Finally, evaluation and testing results of the completed system and stock price prediction models are presented to prove the successfulness of the completed application and the accuracy of the models implemented.

**Keywords:** *stock, portfolio, prediction, LSTM, CSE*

## I. INTRODUCTION

(Hayes, n.d.) Stock market portfolio management is a technique or art of analysing or overseeing, selected number of an interested group of shares in order to achieve long-term financial goals and objectives. The ultimate requirement of portfolio management is to weigh the strength, weaknesses, opportunities, and potential threats over a selected number of stocks. The requirement an investor is intended to be achieved from portfolio management is to increase the investment returns under a deuterated risk level within a specific period. In the non-automated process, an investor requires to re-balance his/her stock portfolio manually according to the trading activities conducted over time. Following are the actions or tasks that needed to be performed by an investor in the manual process to manage the stock market-related investments- Reevaluate the financial value of the current stocks if purchased before, Revaluating the investor depending on investment strategy by analysing the stock selection criteria used previously such as stock purchasing sectors e.g.-health care, leisure and entertainment, business, etc. Manually analysing the current market value of stocks preferred to purchase in each public listed company, summing up the total investment and deciding the percentages of possible returns expected, Calculating and evaluating the expected returns with real returns and deciding sectors to add or drop based on returns (Chen, n.d.). Stock prices prediction is an act of forecasting the future stock prices of a particular public listed company. Currently, many countries including NYSE (New York Stock Exchange) provide predictions to the investors to increase the profits or return of investors by investing at present. Although there



are various arguments related to the success of prediction since there could be various macro and microeconomic factors influencing to fluctuate the stock prices. Stock market-related operations are uncertain in nature and most of the investors feel insecure and unconfident when managing their investment portfolio on stock exchanges among different countries. One of the prime concerns of investors, stakeholders, and any other individual in the financial market is to successfully manage the stock market portfolio. On other hand, investors face various difficulties in identifying public listed companies that have a sound growth prospects for investment.

In the current situation, Colombo Stock Exchange would not offer a feasible platform for the investors to manage, view, analyse and forecast the future behaviour of the stocks purchased by an investor. Currently many investors driven stock purchasing platforms are introduced in Srilanka and international where investor could directly engage in buy/sell actions without any assistance from stockbroker or brokerage firm. With the development of said platforms a need of a stock portfolio management and prediction platform is identified. Web and mobile responsive application is developed to facilitate the investors to manage and analyse local and foreign stock portfolio by including stock prices prediction module which support the investors to obtain decisions based on predicted behaviour of a particular stock.

## II. PROBLEM DOMAIN

Currently, in Sri Lanka, investors obtain assistance from various stock-brokering firms where stock broking advisors would assist an investor by advising, predicting the market, and managing the portfolio for the best investment return. On each transaction conducted on behalf of the investor, a certain amount of brokerage is charged by the stock- brokering firm. If a local investor is interested to invest in the international stock market either an investor could start purchasing stocks through an online platform using an E-wallet with a dollar account or through a stock-brokering firm that specializes in the international stock market transactions ("Homepage," n.d.). On considering the local/international situations if an investor needs to obtain a quick analysis or update of the

current portfolio status, gains, loss, or any other information, he/she needs to request a portfolio summary through the broker or through the portfolio management access granted by the stockbroker firms. ("How stockbrokers misled investors in 2011," n.d.) CSE and Central bank of Sri Lanka have identified various frauds or illegal attempts actioned by stockbrokers due to lack of proper concertation, lack of knowledge on share market activities, or lack of updated portfolio analysis knowledge with the investor. Due to the continuous fraud, malpractices, and untransparent actions conducted by stockbrokers, CSE has identified a reluctance of potential investors to invest in the share market and actively engage in large volumes of shares. One of the most popular incidents is Securities and Exchange Commission (SEC) filing a court case against four well-known stock brokering firms that have been operating over the past few years. According to the SEC, these stock brokering firms had been involved in certain manipulation or creating abnormal/misleading situations regarding a share price named "Radiant Gems International PLC" in 2011 which have interfered with the smooth functioning of the share market and losing the credibility regarding the share among investors who have currently purchased shares or intended to purchase in the future.

At present Colombo Stock Exchange does not facilitate investors with an official Stock market portfolio management platform with prediction capabilities. In order to avoid or minimize the above-mentioned problems, one of the drawbacks CSE has identified is the unavailability of a fully responsive, functional, user-friendly, ubiquitous, and free platform to add and manage the stocks owned by an investor in his/her local or international portfolio. Stock prices prediction system would also assist an investor to obtain the most accurate financial strategic decisions before investing in a particular share according to the predicted data. This development will be the first official Stock market portfolio management and prediction system for CSE in Sri Lanka.

### III. LITRETURE REVIEW

A study has been conducted prior to the design and development of the system to obtain in-depth knowledge on related theories, concepts through research papers that are related to the study.

#### A. *Stock Market Portfolio Management:*

A Walk-through (“(PDF) Stock Market Portfolio Management A Walk-through,” n.d.) Stock portfolio refers to purchasing and overseeing several different stocks under various volumes from different or same stock exchanges. When purchasing stocks, the investor may come across two different perspectives such as risk stocks and risk-free stocks according to the investment return factor. Risk stocks are a type of stocks that consist of the uncertainty of investment return with the certainty of today. Risk-free stocks are the shares that have no doubt of the possible return along with the investment. According to the paper some of the advantages of SMPM (stock market portfolio management) are maximizing the investment returns with minimum risk, ensure investor receives profit sufficient for the investment, real-time tracking and notifying profits and losses. The aim/objective of SMPM is to maximize the return along with the minimum possible risk. The relationship between return and risk is contradictory. Certain factors are influencing to affect the performance of stock such as stability of the public listed company, government rules and policies, regulations on business activities, policies implemented on the financial market, current inflation rate, and crude prices. Risk analysis related to portfolio management is one of the main aspects concerned by the author. Accordingly, various factors affect the stock performance and due to the uncertain nature of stocks, the return values could vary, and due to the fluctuating nature of stock prices, the returns vary. Therefore, the paper emphasizes this as a main challenging factor to develop an SMPM. The Paper has further elaborated three categories of portfolio management techniques that an investor would follow when handling the portfolio. Active Management, Passive management, and Hybrid strategy (Combination of active and passive). Active management strategy involves constantly checking, analysing the portfolio for any profit or

losses incurred, purchasing stocks when selling prices are low, selling stocks when prices start dropping are few important activities an investor would perform in the active strategy. Market timing is considered a critical activity when following active management. Passive management is followed usually by the investors when the investor believes that the financial market is running at a stable level smoothly. On passive management, investors would not constantly check or analyse the market activities or transactions. The level of returns might drop in the long term since a lack of consideration on individual share sell and buy prices. Hybrid strategy management is considered the modern approach that is developed as a combination of active and passive management strategies.

When considering the paper, the risk and returns/profits consist of opposite relationships. From Srilanka's perspective since there is no feasible, automated way of managing the stock portfolio the proposed system would provide a significant contribution to minimize the risk and maximize the returns on the investments. Either an investor follows an active, passive, or hybrid management process based on the functionalities proposed or delivered by the system (including prediction system) system would try to stick the investor on active management strategy using certain technological implementations such as constant pop-up reminder notifications, detailed summary reports generations, etc.

#### B. *Stock Price Prediction Using LSTM, RNN AND CNN- Sliding Window Model*

(Selvin et al., 2017) Forecasting could be defined as predicting future behaviour or trends based on analysing past related historic data. Predictions are used in various systems in the industry such as in the business sector, health care, education, time-related activities, etc. According to the paper, forecasting could be divided into three types- short-term, medium-term, and long-term forecasting. The main difference between forecasting types is the duration predicted in the future. To provide prediction a variable is considered, in the paper “price” is considered as an important variable. Stock price forecasting could be performed using various methods such as technical analysis, fundamental analysis, and Time series-based forecasting. In Fundamental

analysis the investment on a particular stock price decision is based upon the analysis of profits/returns, sales, and other economic (micro and macro) factors. Mainly suited for long-term forecasting. Technical analysis uses the previous data (past stock prices) in order to predict the possible future price. Average/Mean is the main algorithm used to provide the predictions on the said type of analysis. Mainly suited for short-term forecasting. Time series-based forecasting mainly involves two types of algorithms namely, the Linear model and non-linear model. Series of time-related data are analysed and studied along with algorithms to predict the future. Based on the two types of algorithms the paper has stated linear models are not capable to identify a pattern or trend in a set of considered data. The inability to identify the latent dynamics within the data is the main reason for the above-said drawback. The nonlinear model utilizes methods such as deep learning, Neural networks, and various other algorithms in order to provide predictions. The Paper further evaluates concepts such as multi-layer perceptron (MLP), Recursive Neural Networks (RNN), Convolutional Neural Network (CNN), and other types of machine learning techniques such as image processing, natural language processing on testing the suitability to stock price predictions. One of the most feasible and proven methods suggested by the paper is algorithms based on deep learning concepts. After completing several levels of the self-learning process, deep learning has been able to identify a pattern, hidden trend, and dynamics underlying within the data analysed.

Based on the results of an experiment conducted by the author the paper recommends Convolutional Neural Network (CNN) predictions are more accurate when compared with the predictions from Recursive Neural Networks (RNN) and Long Short-Term Memory networks (LSTM). Since CNN does not rely on previous/historic data or information for prediction CNN model has been able to provide proven results. The CNN prediction process understands the patterns/dynamic changes in the current window. This is considered as one of the prime reasons for providing more accurate prediction results. LSTM and RNN depend on historic/past information or data to predict the

instances of the future. However, for short-term predictions, RNN and LSTM models were able to provide more accurate predictions according to the results of experiments concluded by the author.

### C. *MobiMine-Stock market monitoring platform*

(“[PDF] MobiMine: monitoring the stock market from a PDA | Semantic Scholar,” n.d.) MobiMine is an intelligent cross-platform accessible system for monitoring and analysing stock market-related data through a distributed data mining process. Investors could store the current portfolio-related data on the application to manage and monitor the stocks. One of the important factors identified through the research paper is the watchlist feature that allows investors to concentrate on the stocks that are interested to buy soon. The application can construct relationships using the data collected from various finance-related data sources with the ultimate objective of identifying specific focus areas of the investor to provide an enhanced analysis process based on one’s interest. Using the data mining process, a customized wish stock list details will be delivered through the application. The existing portfolio management system depends on the manual input of wish stocks (stocks that are expected to purchase in the future). Manual-based construction of watch list features using the predefined focus area of the investor is often cumbersome and unpractical since the investor cannot watch and analyse the market for a longer period when on the move. Investor-based customize focus area development is the main requirement addressed through the application and focused on improving the watch stock list feature. Challenges faced by the author on developing the above process are- Difficulties in handling the continuous flow of data from many incoming data streams, Managing the limited wireless/GSM network bandwidth when conducting the data mining process, Representation of highly informative data within a limited small screen, Managing the battery consumption when conducting high computational and processing tasks. The application has been developed according to the client-server architecture where investors run the application on any type of handheld device where a Mobile server sources



the financial data streams. To ensure the smooth functioning of the application it is designed to work without any issues on wireless low bandwidth network connections.

The main functional requirements addressed by the MobiMine application are as follow-Portfolio management- Each investor is provided with a dashboard to manage, analyse stocks, and evaluate between different stocks' performance, gains, losses, etc. The investor could edit or delete their stored portfolio-related details from the application.

Area of Focus/Interest- The application delivers a more unique approach to track and monitor changes in the market by dividing the selected events as "interested to investor". The following are delivered through the focus area of the application- Watchlist feature- Each stock added by the investor on this section is assigned with a score. A higher score means more interesting and a lower score means less interesting. The higher score-marked stock is given more priority when delivering related data specific to that stock. Modules such as Stock connection, Stock nuggets, and reporting module are a different collection of services provided by the application to understand the dynamic and volatility nature of the market. MobiMine application employs various data mining techniques to collect and deliver stock market-related data from a variety of sources. One of the main functions performed by the MobiMine server is, it collects related financial data from various related data sources over the internet and stores them in the database in order to be used in the data mining process. The server receives the data feed in XML format. In order to perform the data mining various techniques such as clustering, statistical-based algorithms, decision trees, and Bayesian nets are used.

#### *D. Predicting Stock Prices Using LSTM*

("(PDF) Predicting Stock Prices Using LSTM," n.d.) Due to the changing nature of various financial indicators, the prices of stock prices would fluctuate unexpectedly. This has been a difficult and challenging factor for many stock analysts, investors, and researchers who are keen on knowing the future behaviour or situation of the stock prices ("(PDF) Stock Price

Prediction Using Machine Learning and Deep Learning Frameworks," n.d.). With the rapid development of technology and correct utilization of important and informative indicators, behavioural predictions could be performed up to certain aspects. According to the author, a significant explanation has been provided on the RNN (Recurrent Neural Networks) which is explained as one of the powerful and well-proved models on processing sequential related data. On the in-depth analysis of RNN, LSTM (Long Short-Term Memory) is identified as the highest successful RNN's architecture. LSTM consist of memory cells which could be explained as a computational unit that replaces hidden layer artificial related neurons among the networks. This structure helps to dynamically identify the data structure and associated patterns to provide more accurate high-capacity predictions. The overall paper is focused on presenting an in-depth idea on developing a prediction system for predicting the returns of NIFTY (50) using an LSTM model. Using a historic dataset that contains 5 years of past stock prices the model training and validation activities are conducted (Ghosh et al., 2019).

The methodology section of the paper is explained using the background research activities conducted on experimenting prediction activities of the NIFTY (50) stock prices. The following series of activities are conducted by the author when developing RNN and LSTM based models. Step 1 -Preparation activities of the historic stock prices data. The window size of the dataset according to the paper is 22 days and stock prices related data ranging between 01/01/2011 and 31/12/2016. Step 2- Pre-processing stage of data- At the pre-processing stage the following activities are conducted as Discretization of data- sorting filtering and determining the important features to be used when developing the prediction model, transformation of data, cleaning, and integration of data. After the pre-processing stage, the dataset is divided into testing data and training data. When selecting data for training most recent data values are used. Step 3- Extraction of features-In feature extraction process more refined and most relevant features are selected in order to be used as input for the neural network.

Step 4- Neural Network Training process- By assigning random weights and biases the neural network is trained in order to conduct the experiments. According to the paper, the author has developed an LSTM model with a sequential input layer. Along with the sequential input layer, two dense layers and LSTM layers are used. Further LSTM model consists of Activation named “ReLU” and linear activation function with output dense layer. Step 5- Prediction of results- In this final step the author evaluates the model by cross comparing the targeted values with the outputted values generated from the RNN output layer. Backpropagation algorithm could be identified as a significant action conducted by the author to reduce the difference between the derived results from the final model and targeted results. Here the initial biases and weights of the network set at earlier steps are readjusted to reduce the difference between the results. The paper signifies analysis phase by which the efficiency of the model is evaluated. In order to test the efficiency of the model a statistical equation namely Root Mean Square Error (RMSE) is used. Using the value of the said equation the difference or error between the derived results and targeted results could be minimized. Accordingly, the table below is extracted directly from the research paper to demonstrate the experimental results of the model outcomes. Various test cases with different parameter numbers and EPOCHS are stimulated by the author. By which the stimulation conducted with selected features such as High, Low, Open, and Close along with 500 EPOCHS has provided the best result of 0.00983 and 0.00859 (testing with RMSE). Results of different parameters and EPOCHs are shown in Table 1.

**Table 1:** Comparative Results Using Different Parameters and Epochs.

Parameters	No. of Epochs	Training RMSE	Testing RMSE
Open/ Close	250	0.01491	0.01358
Open/ Close	500	0.01027	0.00918
High/Low/Close	250	0.01511	0.014
High/Low/Close	500	0.01133	0.01059
High/Low/Open/ Close	250	0.0133	0.01236
High/Low/Open/ Close	500	0.00983	0.00859

Source: Predicting Stock Prices Using LSTM

In concluding the paper, the author proposes Long Short- Term Memory (LSTM) and Recurrent Neural Network (RNN) as successful approaches to predict more accurate stock prices.

#### IV. METHODOLOGY

As the primary data source research papers were critically studied, analysed, and evaluated to understand the functionalities, challenges, theories, and concepts to obtain in-depth knowledge on the research area. Along with the critical literature review various requirement elicitation techniques were used as secondary data sources to identify the functional and non-functional requirements from investors/users and officials of the Colombo stock exchange.

Several interviews were conducted to obtain detailed information from the CSE officials since the ultimate development is intended to be developed on behalf of CSE. By conducting an interview informative and detailed information from a broad perspective was collected from different types of stakeholders within the CSE. Several officials of CSE including the head of R&D (research and development), head of Public Relations Department, and Chief Information Officer (CIO) of CSE were interviewed to obtain in-depth information on investor behaviours, legal factors, functional requirements, and non-functional requirements are mainly discussed and focused.

Questionnaires are used as the medium of collecting data from the investors. The questionnaire comprises 17 questions covering a broad context regarding system development including functional requirements, non-functional requirements, visual design aspects, UI/UX (User Interface/User Experience), and content management. The questionnaire was presented to a sample of 23 respondents and obtained their responses. As the sample space investors who are currently engaged in various professions are selected such as doctors, engineers, judges, businessmen, teachers, accountants, architects, etc. Responses from the questionnaire are subjected to a statistical analysis, which helped to determine functional requirements, non-functional requirements, important designing aspects considerations, and

user requirements. The responses from the questionnaire and information gathered from interviews are mainly considered when developing the proposed portfolio management and prediction system. After a comprehensive gap analysis, the following requirements and processes are identified as essential to the proposed system in addressing the important requirements identified.

#### A. Functional requirements

Initially, an investor could sign up and log in to the system. The first user could add stocks details by entering the stock code name and selecting the Stock Exchange (New York stock exchange, Colombo Stock exchange). Along with the stock code, the user can input the bought price and the volume of the share. Similarly, the user could add the entire portfolio to the system which could be diversified between different shares belonging to various countries. Once the system is updated, each user will be provided an analysis of profit returns/losses, updated stock price details, etc. The portfolio will automatically be updated once the market transaction goes online country-wise/stock marketwise.

- Live and summarized stock market transaction dashboard presented based on user's selection.
- Ability to generate a detailed summary report on the current portfolio in PDF format.
- Delivery of E-mail and SMS-text messages notifications on profits and losses incurred on current portfolio.
- The ability to add and remove stocks of different countries/stock exchanges and portfolio-based customization.
- Informative analysis of a particular share using Candlestick chart filtered according to different time slots such as Monthly, weekly, 30 days, 90 days, 180 days, and 360 days.
- "Wish Stocklist feature" is integrated to analyse the stocks that are intended to invest in soon.

- Future Stock prices prediction using line graph representations provided on each share based on user selection.
- Ability to update and change user/investor account-related details such as personal information and password.

#### Administrator-

- Ability to obtain detailed analytics on the investors/users who are currently enrolled with the platform.
- Ability to obtain an overview of currently logged and active users.
- Ability to create new users and update the personal information of existing users.

#### B. Non-Functional requirements

Availability (24x7), User-friendly and highly interactive platform, Privacy/Security, and High performance in large workloads.

#### C. Design and Development of the Application

The following section of the paper provides a thorough insight into the developed application as a proposed solution to the stated problem. This section deeply justifies various technological mechanisms implemented in order to develop and embed the previously identified requirements into the system.

The web-based platform is developed using HyperText Markup Language (HTML), Materialize CSS, Bootstrap, and React.js as frontend framework and back-ended using PHP with required 3rd party libraries. MySQL relational databases will be used for managing and storing data. The whole application runs on the base of four API endpoints. Two JSON-based APIs will be used to retrieve data on the international stock exchange and another XML-based API is used to retrieve data from Colombo Stock Exchange (Officially provided by CSE to fulfill the current development purposes). The logic behind the portfolio management and stock analyser goes along with the data return in JSON format. Relevant data will be retrieved and passed to data structures where manipulation activities will be carried out and then stored in the database.

Machine learning-based prediction systems will be developed and implemented using API-driven data sets. Two types of models are developed to provide price prediction categories based on short-term (1-7 days) and midterm (15-30 days). For short-term predictions stacked Long Short-Term Memory cell (LSTM) model is used to provide the predictions since LSTM is extremely powerful on sequence-based prediction problems with the analysis of past information. As well as for long-term predictions Brownian Motion algorithm-based model is developed. Both models will be trained and deployed on Azure Machine learning studio to avoid any difficulties or delays in model processing and rendering. Python language along with supportive libraries such as MatPlot libraries, Tensor Flow (Keras), Pandas Data reader will be used to implement the model training and other model-based manipulation tasks. One of the challenges identified when developing the stock price prediction module is the update factor of the dataset used to train the model. For example, if a particular investor uses the stock prices prediction system today, the dataset should contain yesterday stock prices related data when training the model that is used for forecasting the future stock price of a particular stock based on the perspective of today.

(Agustini et al., 2018) In order to perform long-term stock price prediction Brownian motion model is developed using hyperparameters. When conducting the expected formulation of stock prices, a confidence level of 95% is determined. Initially, the dataset is retrieved using the Pandas yahoo finance Data Reader by specifying the Stock symbol of the stock which is required to be predicted. In order to specify the range of the time period the current date is fetched using `current=datetime.now()` function. Along with the current date and time details, `current.year-3` is used to specify the starting year of dataset and `current.Month` and `current.Day` is used to specify the latest time period which the particular stock-related dataset needs to contain. As the main parameter from the dataset the "Adjust Close" is mainly used to train the model. After the fetching process, the data normalization is performed using the logarithm function. On completing the normalization process the following calculations are conducted -Mean,

Standard deviation, Variance, Volatility, and Drift value are calculated. The Brownian motion algorithm along with hyperparameter is applied in order to forecast the stock price after completing the previous computational step. In order to obtain meaningful representations using the Mat plot library a graph is plotted and saved in .PNG format in order to render and display in the portfolio management system once an investor/user requires prediction results. Final graph generated using Brownian Motion algorithm on APPLE Inc (AAPL) stock original stock price and Predicted Output is represented using the Fig 1.

For short-term stock price prediction Deep Learning Artificial Recurrent Neural Network (RNN) architecture based Long Short-Term Memory (LSTM) model is developed. On elaborating the process of prediction initially using an API driven endpoint data source named Tiingo the relevant stock related dataset is downloaded in .CSV format. Every dataset downloaded from Tiingo consist of stock prices related information ranging from 2016 to the present. Accordingly, the following column attributes are provided from the dataset-symbol, date, close, high, low, open, volume, adjClose, adjHigh, adjLow, adjOpen, adjVolume, divCash, and splitFactor. As the main parameter "close" value of the concerned share is used to train the model. In the next step, the dataset is split as training data and test data in order to avoid overfitting. This will also help to determine the model generalization ability as well. After implementing the splitting process feature scaling process is implemented since the LSTM are sensitive to the scale of data, therefore before model fitting the data are normalized using scikit-learn pre-processing package named Min-Max Scaler and NumPy. One of the advantages of feature scaling could be an increase of performance. Since LSTM expects all the data to be in one specific arrangement using NumPy the data are transformed into 3D dimension array. Once all the above-mentioned steps are fulfilled the LSTM model could be build using the following Keras imports, Sequential-neural network initialization, Dense- to add a densely connected neural network layer, LSTM- to add a Long Short Term Memory layer. After importing the required modules, the model is compiled



using popular optimizer named adam, and the loss is set as mean\_squared\_error in order to calculate the squared errors mean. Next, the model is fit to run 100 Epochs with a batch size of 64 and verbose 1. Epoch is specified here to define the number of times the learning algorithms would work on the entire training dataset. After completing the model compiling process, the future stock prices could be predicted using the test data set. Here some of the actions performed earlier are conducted again such as transforming the new dataset using MinMaxScaler and Reshaping the dataset. inverse\_transform function is used here to obtain the readable format of the stock prices after completing the predictions. Finally using Matplotlib predicted stock prices are visualized. LSTM model prediction developed for Microsoft Corporation (MSFT) stock is shown using Fig 2.



Figure 1. Apple Stock prediction using Brownian Motion Algorithm  
Source: Author



Figure 2. MSFT Stock prediction using LSTM.  
Source: Author

After completing the development and testing phases the entire project is hosted on the Microsoft Azure platform (IaaS, PaaS) deployed and implemented on a virtual machine to ensure

the platform performances are guaranteed on peak workloads. The finalized system architecture is represented using Fig 3.

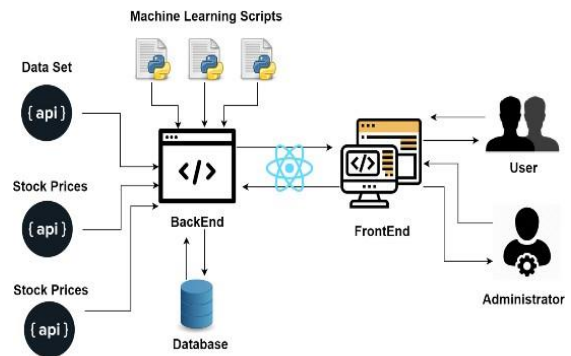


Figure 3. System Architecture  
Source: Author

## V. RESULTS AND DISCUSSION

A comprehensive system testing and evaluation were conducted to verify the results/output of the finally developed system. System testing and user acceptance testing are conducted on the 95% completed system by the author as well as from the higher officials of CSE. The Fig 4. provides the results of testing conducted on every functional component developed in the system using the manual as well as automation testing mechanisms (e.g.- Selenium and Katalan Studio tools). The sole purpose of system testing and evaluation is to ensure the exactness of the system and the arrangement of functionalities newly developed.

On deeply evaluating the stock price prediction module the Long Short-Term Model (LSTM) and Brownian Motion algorithm-based stock price prediction model have outcome more than 85% of accuracy when forecasting future stock prices. According to the testing conducted on Brownian motion algorithm-based model with different types of Stocks, On Microsoft Corporation (MSFT) stock the difference between the original stock price and predicted stock price was 4.88%. When evaluating the model on Nike Inc (NKE) stock the difference between the original stock price and predicted stock price was 12.1%. On APPLE Inc (AAPL) stock the difference between the original stock price and the predicted stock price was 18.51%. As a conclusion of the testing phase conducted on the Brownian motion algorithm, it clearly justifies that based on

various types of stocks considered the difference between the original stock price and predicted stock price value vary. Finally based on the test cases conducted on the Brownian motion algorithm with different stocks it generally outcomes more than 80% level of accuracy.

Functional Requirements	Pass/Fail	Score
<b>Investor/User</b>		
Login and Sign-up Function	Pass	98%
Live and summarized stock market transaction dashboard	Pass	97%
Summary report generated in PDF format	Pass	95%
Delivery of E-mail and SMS-text notifications on profits and losses incurred	Pass	92%
Ability of adding and removing stocks from portfolio	Pass	100%
Informative analysis of a particular share using Candle stick chart	Pass	100%
Wish Stock list feature	Pass	96%
Future Stock prices prediction using line graph representations, provided on each share based on user selection	Pass	97%
Ability to modify user/investor account related details	Pass	97%
<b>Administrator</b>		
Detailed analytics on the investors/users who are currently enrolled with the platform	Pass	95%
Ability to obtain an overview of currently logged and active users	Pass	95%
Ability to create new users and update personal information of existing users	Pass	98%

Figure 4. Test Case Results

## VI. CONCLUSION

In concluding the paper, a highly interactive, more analysis capable, and fully functional portfolio management system with prediction capabilities is developed and implemented along with results of the testing and performance evaluation on independent modules including the stock price prediction. The system would be beneficial for the highly engaged investors to actively participate in the stock market transactions with high volumes of investments at low-risk levels and obtain maximum possible returns from the investments. Higher levels of investor participation in stock market activities would ultimately lead to achieving the goals and objectives of the CSE. Accordingly, this would contribute to boosting the overall volume of market transactions. This will ultimately contribute to improving the country's GDP (Gross Domestic Production) in the mid and long terms.

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# Automated Hospital Clinic Management System for Private Hospitals

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**Abstract**— The most essential aspect in the country's development is its healthcare system. Long-term disease treatments are one part of treatment. Private hospitals conduct different clinics to treat these long-term diseases. These clinics are separated into groups based on the types of diseases. Some people suffer from one or more diseases, and need to choose doctors for each disease type for their treatments in private hospitals in Sri Lanka. However, there are still several major issues in private clinic management systems, for which no effective solution has been found. The existing system's huge problem is poor coordination between doctors, patients and medical staff. The other problem is patients face lots of difficulties in maintaining their medical record books for each relevant clinic. Accordingly, this research paper mainly provides an effective solution to the issues highlighted in order to improve the efficiency of Sri Lankan private hospital clinic management systems. The proposed system will connect patients, doctors, pharmacy staff and medical staff into one platform and store information about patients, doctors, appointment details and all medical records. The research is based on the automated clinic management system for private hospitals and has updated it to a computerized automated system. The clinic management system for private hospitals will allow efficient creation and management of patient data, as well as management of doctor's schedules, seamless flow of information from one department to another, handling of the health center's accounting, and accurate archiving of patient information and diagnosis data.

**Keywords:** *manual, automated, clinics, private, disease*

## I. INTRODUCTION

Year after year, technological advancements become the valuable resource for future professional lives. Apart from that, the digital environment has the power to transform our reality by infusing it with a new scenario and with this development comes the ability to effectively channel patients into contact with this expanding technology, which has resulted in a variety of benefits and prospects. So, clinic systems play a significant part in the healthcare system.

In the developing country, the healthcare system is the main factor. When it comes to healthcare, the role of hospitals is invaluable. Two types of hospitals exist in Sri Lanka. Government hospitals and private hospitals are available in Sri Lanka. The lots of people in this country do their treatments at private hospitals because of they can choose relevant doctors, date, and time due their preference for their treatments. In finding the problems of existing private hospital clinic maintain systems and upgrade that manual system to automated computerized system, this program allows the manual record book system to be replaced and can accelerate information processing, storage, and retrieval. Therefore, reduce the difficulty of the current manual system and make it convenient for users to use. Usually, one private hospital conducts more than one clinic. In these clinics they record patient's day-to-day status in small books. Sometimes these medical record books can usually be the major problem for clinic systems. These record books are lost, misplaced, or destroyed and sometimes patient forgets to bring them. Doctors are unable to determine a patient's true status. As a result of these reasons allergic reactions can be occur, patient privacy may be compromised, and patients may pass away due to these reasons.



However, with the use of information technology current practicing clinic system may be improved. In the healthcare sector, the clinic system will continue to expand and grow. Therefore, in this research computer system implemented with the functions to automated clinic management system for overcome those barriers and difficulties. As a result, this research will discuss the effective clinic management process of doctor, pharmacy staff, patient and medical staff through the automated system and how the process is done through this system in an effective way.

## II. LITERATURE REVIEW

This research focused on reviewing the problems with the current private hospital clinic system and how to convert it to an automated computerized hospital clinic system. There are several kinds of existing systems and experiments that may be used to get a better picture of the technologies that have been adopted by other researchers for use in this proposed system. New features have also been explored to improve this system. This literature survey will provide insight into how other researchers approached their study and applied their findings.

Demirel (2017) presented paper under the topic "Hospital Management Information Systems in Health Sector and Development in Turkey". The aim of this research is to examine the how private hospital clinic management systems have evolved and what function they provide in the health-care sector using Turkey as a case study. The study began with an examination of the evolution and several types of hospital clinic management systems. The thesis has been applied to various systems to determine their usage and advantages. The evolution and features of private hospital clinic management systems in Turkey are reviewed in the study's second section. Hospital management information systems (HMIS) provide a framework for storing data relevant to a hospital's financial, management activities and medical processes. The primary implementations of the clinic management systems are confined for patient data monitoring and payment for health management services supplied.

Khan and Saber (2010) the following are the steps to implement this paper solution for a successful hospital management information system; Patients, healthcare workers, managers, and system designers should all be able to use hospital information management systems. The health-care system's stakeholders should have access to it 24 hours a day, regardless of their profession or location. The administrative priorities should be clearly defined by the system administrators. It is essential to standardize primary and secondary health-care records. The processes for obtaining and using information technology should be streamlined. Information system criteria should be decided at the institutional level. At the national level, the Ministry of Health should organize and oversee the hospital management system. During institutional decision-making, political interventions should be avoided. Users of clinic management system must be encouraged to engage in and share to the clinic management system. Healthcare industry professionals must also participate actively in the planning activities process and notify private hospital clinic management of any flaws that might change because of the system in use.

Yahaya et al., (2019) Presented paper under the topic of "Development of an Automated Healthcare Record Management System". According to the authors, this project has focused on improving the University of Ilorin's clinic management service by developing a clinic record management system with a smartcard. This needs to be differentiated away from the manual paper-based patient's medical record system and toward a computer-based system.

According to the Abraham and Joyce (2016) paper under the topic of "Designing a Web Based Hospital Management System for MOUAU Clinic". This paper proposes an effective web-based framework to improve the analysis on medical research as well as making it easier to access medical records and receive care. Today, certain issues in hospitals remain, such as the disappearance of patients' medical records and other vital files. This research study will identify these problems. This proposed system will assist medical personnel in conducting their duties by replacing the manual method and speeding up

the encoding, storage, and retrieval of information. Hospitals can save money over time because of improved productivity and overall performance.

Edmund, Ramaiah and Gulla (2009) presented a paper under the topic of "Electronic Medical Records Management Systems". This research paper has focused to review the existing Medical Records Clinic Management Systems (MRCMS) and on the healthcare industry assess the impact of medical record clinic management systems. The research study also addresses the benefits and drawbacks of medical record clinic management systems as well as the challenges that various groups of users face when implementing and utilizing them. A good MRCMS will not only store, collect and handle data efficiently but will enable authorized staff to assign the system at the same time, ensuring that everyone gets the most out of the system.

According to the research paper of "Hospital Patient Database Management System", Asabe, S. A, Oye, N. D and Monday Goji (2013) they investigated a hospital patient data management system that was created to replace the manual method of scanning, sorting, storing, and accessing private hospital's patient medical records with a medical clinic record due to remove the problems associated with the existing clinic method. The existing clinic management system was investigated, and a computerized program was developed to change it. The existing hospital clinic management system has been investigated, and a computerized application has been developed to replace it. When patients check in and out of the hospital, these computer-based systems produce patient reports. This paper aims to find a more accurate, dependable, and effective computer system for maintaining patient records in general hospitals to ensure an efficient result that is less time consuming. According to the report, the building of a hospital patient database record would be a solution to the difficulty that the current manual system of storing patient medical records has.

The study investigates the problems with the hospital's manual patient records system and proposes solutions by building an online clinic management system. Interviews were the

primary tool used in this study. Two doctors, three nurses, and medical staffs were interviewed. Several numbers of fifty outpatient records were sampled. The webpage was designed, and data was entered using a combination of PHP, MySQL, and Macromedia Dreamweaver. The records were generated into the configured clinic management system. The records were generated after the records were entered into the configured outpatient management system. The findings demonstrate the difficulties that the manual inventory control system faces. The changing of a patient's medical folder and the complexity of scanning a patient's medical folder, the complexity of concerning prior complaints to current complaints due to the folder's capacity, quick access for patient's medical diagnosis histories during an emergency, the lack of backup when data is lost, and the compilation of trustworthy. This research study focuses potential solutions for above problems based on the results. To keep track of outpatient records and enhance medical care delivery, an online clinic database management system was developed. (Abisoye, Abisoye and Ojonuba, 2016)

The focus of Mamra et al., (2017) is on the elements that influence clinic record technology acceptability. The factors studied in this study are the UTAUT2 technology adoption factors and the factors introduced by this study, as well as how they influence user acceptance and behavioural purpose toward the Clinic Record System.

The research by Sawaneh et al., (2018) on a patient database management system aims to replace the conventional system by converting the manual process of scanning, sorting, and gaining access to patient medical data in an electronic medical record (EMR). Existing platforms (manual systems) have been scrutinized, and a computer-based system is now needed for the best results. The computer-based software generates patient records, allowing doctors to keep track of their patients in and out of the hospital on a regular basis. The research aimed a more dependable and efficient method to process patient health records using computer technology, providing a proficient outcome that is cost-effective, saves time, and speeds up treatment. The study proposed a patient

database as an alternative solution to the world's growing population, especially in third-world countries. The device would act as a coordination mechanism, facilitating the efficient transmission of patient medical data to healthcare professionals for accurate monitoring both inside and outside the hospital. It also speeds up the transition of patient healthcare data to medical repositories or individuals such as insurance companies or employers. Accurate diagnosis is enhanced by efficient medical record storage, which leads to more accurate and detailed prescriptions that can be referred to as required.

### III. METHODOLOGY

To appropriately determine the processes and communication of hospital clinic management system users' requirements, quantitative and qualitative methodologies are applied. Finding data on private hospital centres is the major focus of data collection, and most knowledge is gained through both organized and unstructured interviews with domain experts by solving the problem, discover relevant documents utilizing the documents analysis method. All the details and requirements of all other relevant data was collected by interviewing doctors and pharmacy staffs at the private hospital to gain a comprehensive concept of the proposed clinic management system. To get patient's requirement distributed a google form with required information. And developer refers books, the internet, case studies and research papers of current clinic systems as key data sources. The collection of quantitative and qualitative data is accomplished using a combination of these strategies. One of the key approaches used in this study is Client Server Architecture. As technologies has been used for the proposed system is PHP, HTML, CSS, JavaScript, Bootstrap framework, and SMS gateway.

#### A. Requirement Analysis

There are four main login interfaces in this system. This proposed system may be accessed by the administrator (receptionist), doctor, pharmacy staff, and patient using those four unique logins. Furthermore, each doctor and pharmacy staff have a unique username and password provided by the system when they

register. Patients can login with their username and password, which they created when they first registered with the system. There are major functional requirements are listed below.

Admin(receptionist) able to,

- Add clinic categories
- Add doctors and pharmacy staff to the system
- Add doctors under the clinic categories
- View doctors, patients, and pharmacy staff
- Remove doctors and pharmacy staff
- Add available date and time for each doctor
- Sending username and password to each doctor and pharmacy staff
- View appointments of patients under relevant doctors and date wise

Doctor should be able to,

- View appointments of patients
- Enter description of disease and prescriptions
- Search patient medical histories
- Change own profile details and password
- Send prescription to the pharmacy department

Patients should be able to,

- Make an appointment for doctors
- View appointment histories
- View medical histories
- Change own profile details and password

Pharmacy staff should be able to,

- View prescriptions of patients
- Change own profile details and password
- View prescriptions details date wise

#### B. Conceptual model

Private hospital clinic management system uses proposed hospital clinic management system.

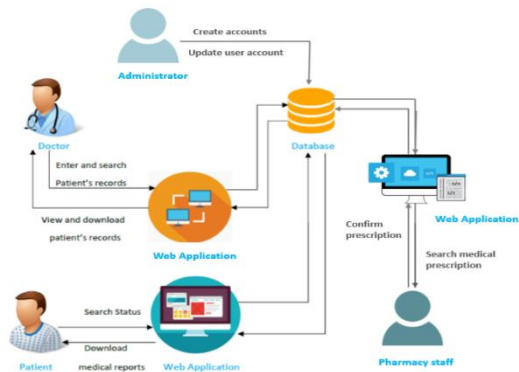


Figure 1. Proposed Clinic Management System

This proposed web-based system will send patient's appointment details to the relevant doctors and admin of the hospital center and when patient make an appointment, the confirmation Email and SMS will send to the relevant patient with relevant appointment details. All patients can make an appointment registering to this system and able to cancel those appointments if required.

In doctor side, doctors can print or send medical prescription to the pharmacy department without any issue. This is a less time-wasting process because of patients cannot waiting in a queue to get their medicines and it reduces inconveniences of pharmacy staffs because of it is not written prescription note; some handwritten is not clear for pharmacy staffs.

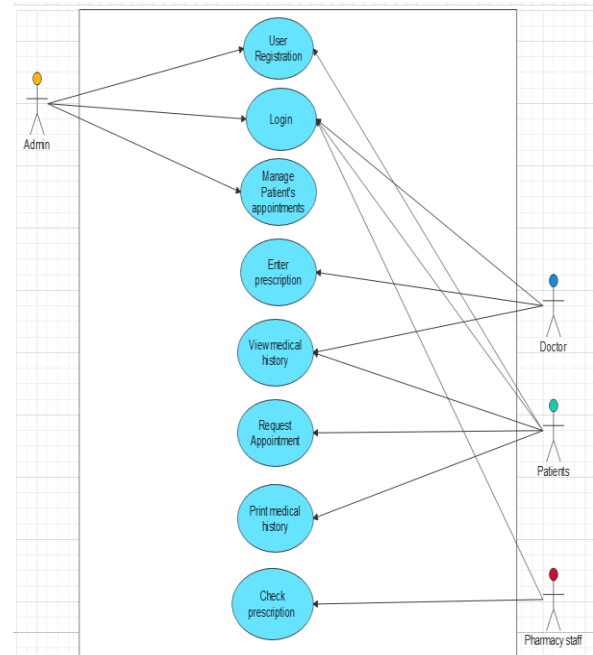


Figure 2. Use Case Diagram

### C. Implementation.

The Private Hospital Clinic Management System consists with four main modules.

#### Registration Module

Only patients must register to this system by themselves. For register to this system, patients must enter username and password as they preferred. Those username and passwords use for login to this system. If required patient can change their passwords after login to their account.

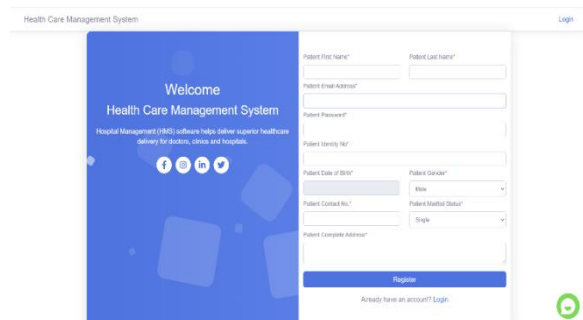


Figure 3. Patient registration

#### Login Module

The login function should be used to access system's users. To log into the system, users should already have usernames and passwords.

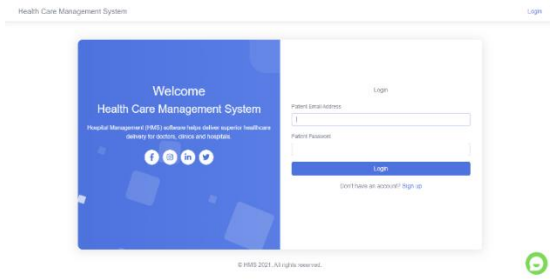


Figure 4. User Login for doctors

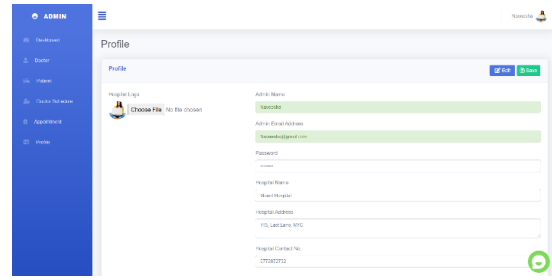


Figure 7. Admin profile details

### Administration (Receptionist) Module

Admins must create user accounts and register with the system. One of the most key aspects of hospital clinic system is the administrator's role. End-users will be added to this proposed clinic system by the admin of the private hospital. The administrator has authority to access to the information adding, editing, deleting and or removing users. Also, the admin(receptionist) can add clinic categories, available data, and times, remove and update doctors and pharmacy staffs apart from that administrator can view the appointments of patients under each doctor and then admin can decide who has the maximum number of appointments as daily, weekly, or monthly then admin can request to each doctor for an additional date. As an analysis part, this is one of the system's main functional requirement for admin.

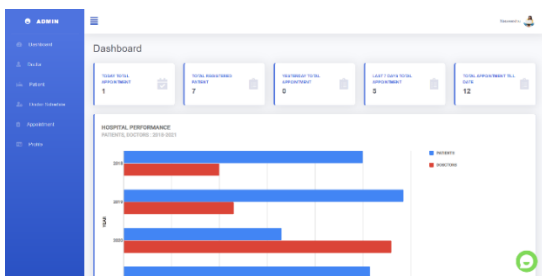


Figure 5. Admin dashboard

### SMS Module

Each patient will receive an SMS and email from the system confirming their appointment and reminding them of the next clinic date. The unique feature of this system is that it can generate alerts in all three languages for basic mobile phones. If patient required to contact admin (receptionist), the system has provided the SMS facility to contact the admin of the hospital through this system.

### Appointment Module

All patients able to make appointments after registering to this system. Patient can pick doctors by searching under clinic categories. After submitting the appointment, the confirmation Email and SMS notification will send to each patient about their appointment details with channel number. These appointment details will send to the dashboard of receptionist of the hospital and doctor.

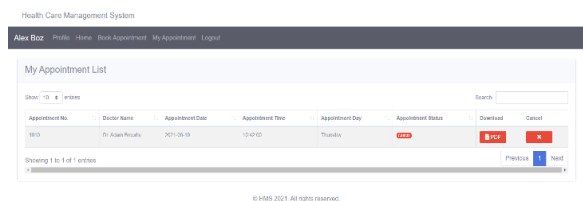


Figure 8. Patient appointment list

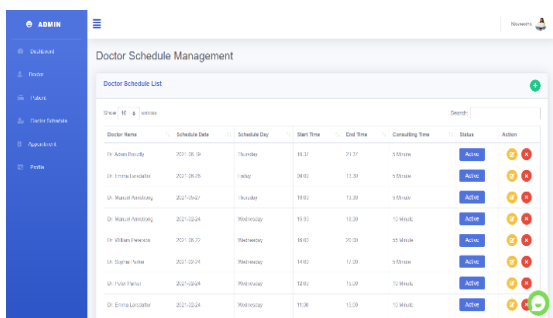


Figure 6. Admin (receptionist) dashboard registered doctors

### Getting Medicine Module

After channelling patient, doctor enter medicine for a particular patient through the doctor dashboard. Then medical staff can view medicine orders of patients through the pharmacy staff dashboard.

Pharmacy staff also able to add new products to this system, view inventories and can view this process as a report.

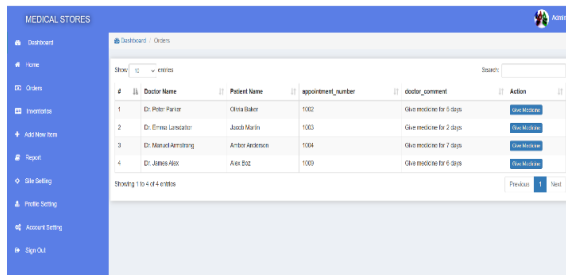


Figure 9. Pharmacy staff dashboard

#### IV. TESTING AND EVALUATION

During the testing phase, the current private hospital clinic management system to be applied as data analysis tools to ensure that all requirements have been met. Through the management process of certain modules, the system's features tested as modules. In addition, the system accuracy was evaluated using 50 patients. During the evaluation test appointments sample send to private hospital through this system and system is instructed to send automatic reply mail for their confirmation appointments.

According to the pie chart below, 38 patients provide correct appointment information, whereas 12 patients give incorrect information. The system's overall accuracy is 76%.

Accuracy Of The Reply Message of Farmers  
50 responses

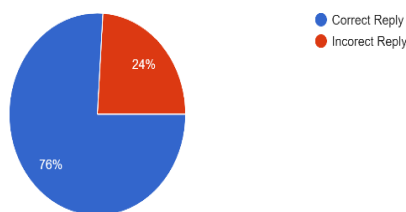


Figure 10. User Accuracy Chart

The automated private hospital clinic administration system appears to have been well adopted, according to the feedback.

Do you think it would be better that implementing automated clinic management system for private hospitals?  
66 responses

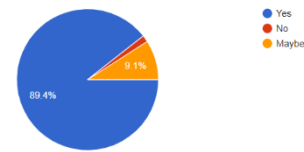


Figure 11. Accuracy pie chart

#### V. CONCLUSION AND DISCUSSION

Sri Lanka must go forward with technology as a developing country. As a result, private hospital clinic systems that are currently manual must be digitized and automated. According to result obtained by this research, the private's hospital clinic system must be automated. The focus of this study was on one aspect of the private hospital system. As a result, this research is focused on hospital clinic management. If a patient registers for more clinics, the patient must keep separate medical record books for the separate clinics in which they are registered and, they cannot choose a particular doctor as they preferred. Because of the manual approach, it can be the problem of many other issues. According to my study, many consumers are unsatisfied with the current manual system. People need to update their current system to one that is automated and computerized. Most people are dissatisfied with the current system due to several problems. The enhanced automated private hospital clinic management system provides alerts for the next clinic date, appointment's confirmation Email and SMS, simply to understand GUI and it must be simple to use for elder people who are not familiar with IT (Information Technology) knowledge. Hence, to be successful, it must be given to an appropriate time management system; otherwise, more time is spent because of poor management.

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# Comparison of Trilateration and Supervised Learning Techniques for BLE Based Indoor Localization

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**Abstract**— Location-based service is one of the primary services with high demand on the Internet of Things (IoT) applications. However, indoor position estimation is challenging due to interference and the inability to use GPS in indoor environments. Among few feasible solutions for this problem are Received Signal Strength Indicator (RSSI)-based indoor position estimation, one of the emerging best contenders. This research conducts a comparative study on trilateration techniques versus supervised learning models for estimating the position of a mobile node in an indoor environment. For the experiment, an existing dataset available publicly is used. The experiment testbed consists of three beacon sensor nodes designed using Bluetooth Low Energy (BLE) wireless technology and one mobile node. The RSSI readings at the mobile node from three stationary beacon wireless access nodes are used. Three popular regression models, namely, Decision Tree Regression (DTR), Random Forest Regression (RFR), and Support Vector Regression (SVR) algorithms were trained using the dataset. Also, trilateration techniques were performed to obtain the estimated location. The Mean Square Error (MSE) was utilized to analyse the model performance. Out of the three regression models and Trilateration tested, RFR showed better position estimation in indoor environments.

**Keywords:** *indoor localization, trilateration, bluetooth low energy, supervised machine learning*

## I. INTRODUCTION

The indoor localization problem in a complex propagation environment has aroused interest in researchers and developers in recent years. The Internet of Things (IoT) enables the increase in the processing capacity of embedded systems, mobile devices, and the recent development of

new wireless communication networks. Nowadays, the IoT applications that use location-based services (LBS) in different solutions and areas, such as security, mobile robot navigation, ambient assisted living, Smart-cities, elderly care, etc. (Narasinghe et al., 2020), (S. Büyükçorak et al., 2014), (A. Yassin et al., 2017). Furthermore, location-based services are used in conjunction with other technologies such as IoT. This is made possible due to information retrieved from Radio Received Signal Strength (RSS). RSS-based indoor position systems supplement the Global Positioning System (GPS) in indoor environments because GPS cannot be used indoors due to poor signal strength and signals being blocked/ reflected by walls.

The IoT systems could be deployed using many wireless technologies to communicate within the sensor nodes in their networks, such as Bluetooth, infrared, LoRaWAN, Zigbee, Wi-Fi, GPRS, and 3G (M. Sikimić *et al.*, 2020). Though Wi-Fi has been widely used for most IoT designs, all mention technologies have pros and cons in terms of range, protocols, cost, and device compatibility. Various wireless technologies have been proposed and tested when performing indoor positioning in literature. The most common technologies are Wi-Fi, Bluetooth, Zigbee, Radio Frequency Identification (RFID), Bluetooth Low Energy (BLE), and LoRaWAN. But each of them has its strengths and weaknesses. Due to the high availability of access points in buildings, Wi-Fi has become the easiest option. However, Wi-Fi access points are usually placed to have maximization coverage for its internet users. In this case, signal coverage is not sufficient for a localization application.

Further, Wi-Fi is also consumed a lot of power from its batteries. Compare to Wi-Fi, Zigbee and LoRaWAN have excellent sensing ranges. But

implementation costs using these devices are pretty high] (M. Sikimić et al., 2020).

Among available contributions to RSSI-based indoor localization, most of the investigated algorithms are deterministic, and such systems need more hardware devices. Moreover, many indoor localization solutions are not generalized and can not use one specific solution for another application. Many developed algorithms for sensor node localization are statistical and may be inefficient and have difficulties implementing them on real IoT devices (Maduranga & Taparugssanagorn, 2014).

In this work, we compare the accuracy of localization obtained through trilateration techniques and supervised learning. The data set used the works of S. Sadowski and P. Spachos (2018), which contain RSSI values received from three BLE beacon nodes at three different known geographical locations in an indoor environment.

## II. EXPERIMENTAL SETUP AND DATA SET

The dataset for RSSI values was obtained from the research conducted by Sadowski & Spachos (2018). They have performed their experiment to determine the localization location of a mobile sensor node with RSSI values receiving from its three beacon nodes. The room for experimentation was conducted at a research lab with dimensions 10.8m x 7.3m. This lab had a large floor area, few computers, chairs, desks, some active Wi-Fi devices, and BLE devices. The environment was considered a very noisy and controlled environment for experimenting due to the possible significant interferences caused by the above devices. To minimize the interference of other wireless devices, they have switched off mobile phones and other Wi-Fi devices, which do not belong to the experiment.



Figure 1 Experimentation Testbed  
(S. Sadowski and P. Spachos, 2018)

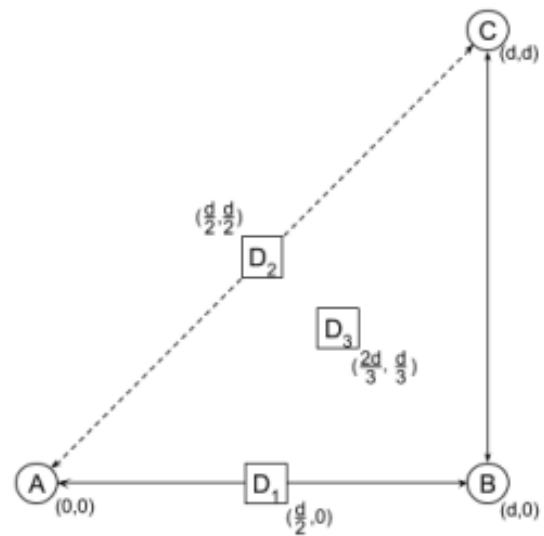


Figure 2 Arrangement of sensors with coordinates  
(S. Sadowski and P. Spachos, 2018)

Experiments to obtain RSSI values were conducted in the afternoon so that a minimal amount of different transmitting device which attempts to communicate using the same medium is ensured. Since RSSI values tend to interfere, all tests were conducted in a controlled environment to ensure consistent readings. Approximately 100 readings were taken from D1, D2, and D3, as shown in figure 2, and averaged to ensure that an appropriate RSSI was used in the calculations.

The transmitters for the experiment had been three Gimbal Series 10 Beacons developed by Qualcomm. The Gimbal Beacons had been configured using the iBeacon protocol developed by Apple (S. Sadowski and P. Spachos, 2018). The receiving device that read beacons was a Raspberry Pi 3 Model B with the capacity to pick up any beacon signals and their RSSI values and store the information in the area.

## III. LOCALIZATION USING TRILATERATION

Trilateration is a type of deterministic algorithm used to find an unknown location of a mobile sensor node with RSSI values received from its beacon nodes. Trilateration required at least three beacon nodes to calculate the unknown location of the mobile node. To calculate the position of the mobile devices through the trilateration technique, (1)-(2) and (3)-(5) were used.

$$\text{RSSI} = -(10n\log_{10} d + A) \quad (1)$$

$$\log_{10} d = (1/10n[-\text{RSSI} + A]) \quad (2)$$

The value  $n$  is the signal propagation constant,  $d$  is the distance between the mobile phone and the access point, and  $A$  is the received signal strength in 1 meter from the beacon node. The value  $A$  is obtained experimentally at a distance of 1 meter to the beacon. The geographical location arrangement of three beacon nodes concerning the mobile node is shown in Figure 3. The equation (1) can further arrange as follows;

Equation (2) shows the relationship between the distance vs. RSSI on a log scale. (Y. S. P. Weerasinghe and M. B. Dissanayake, 2019)

$$(x - x_1)^2 + (y - y_1)^2 = d_1^2 \quad (3)$$

$$(x - x_2)^2 + (y - y_2)^2 = d_2^2 \quad (4)$$

$$(x - x_3)^2 + (y - y_3)^2 = d_3^2 \quad (5)$$

The Euclidian distance is used to calculate the position of the mobile node. In eq (3) to (5), the coordinates  $(x_1, y_1)$ ,  $(x_2, y_2)$ , and  $(x_3, y_3)$  are fixed coordinates of the three beacon nodes, respectively, whereas  $(x, y)$  is the unknown coordinate of the mobile node. By substituting the preprocessed RSSI values in equations (3)-(5), able to estimate the unknown location of the mobile node.

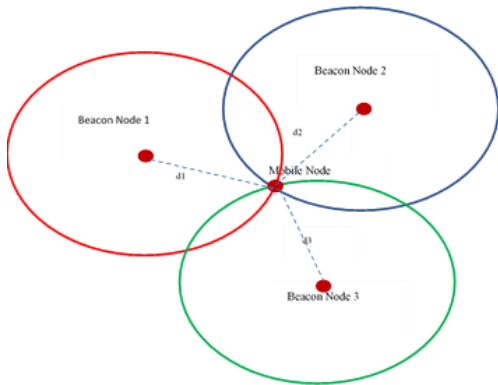


Figure 3 Positioning in Trilateration

#### IV. LOCALIZATION USING SUPERVISED LEARNING

Recent works are existing on applying supervised learning for indoor localization problems (Roy et al., 2021), (Maduranga & Abeysekara, 2020), (Y. Cheng et al., 2016). The regressor variable is the RSSI value, and the predictor variable(target) is the  $x$  &  $y$  location coordinators.

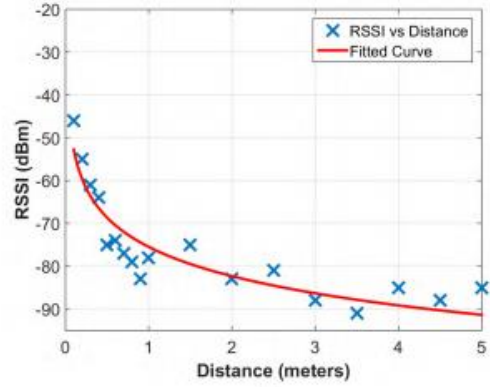


Figure 4 Fitted curve for RSSI vs. Distance [6]

##### A. Decision Tree Regression (DTR) algorithm

This supervised learning algorithm constructs a tree structure through the core algorithm Iterative Dichotomiser 3 (ID3). This follows a greedy approach in creating the branches in the decision tree by selecting the highest yield of standard deviation reduction in the regression approach. Further, standard deviation is used to calculate the homogeneity of a numerical sample. Standard deviation reduction is the reduction in standard deviation after a dataset split on an attribute. The decision tree regression algorithm will decide on ceasing branching by the coefficient of variation. (Weerasinghe & Dissanayake, 2019)

##### B. Random Forest Regression

This is a supervised ensemble learning algorithm. The random forest algorithm utilizes the bootstrap aggregation (bagging) technique as its ensemble model. This is a technique to reduce the variance of the predictions. Random Forest Regression algorithm constructs multitudes of decision trees during model training. It will generate the output in a meta-estimator by aggregating multiple decision trees to generate the regression output. The algorithm involves random sampling of the input variables to improve the variance reduction of bagging by minimizing the correlation between the trees, which allows providing a better understanding of the variance of the dataset. Variance is the statistical measure of the variability of the data points from its average (Maduranga & Abeysekara, 2020), (Y. Cheng et al., 2016), (Weerasinghe, Maduranga & Abeysekara, 2019),

(Loh et al., 2014).

### C. Support Vector Regression (SVR)

SVR applies the similar algorithm principles of Support Vector Machine (SVM) for classification problems with few minor changes. SVR algorithm also maintains the feature of maximal margin of SVM, however in the regression approach, SVR maintains an epsilon, the margin of tolerance (Maduranga & Abeysekara, 2020), (Y. Cheng et al., 2016).

## V. SIMULATIONS AND RESULTS

The above three selected algorithms were fitted into three separate datasets, which consisted of RSSI values obtained from each node (A, B, C) and the x & y coordinates of D, D2 D3 distances at 5m.

Feature scaling & normalization were performed as feature preprocessing for regression. 5 - fold cross-validation was implemented. All models were subjected to hyperparameter tuning before model training and test set prediction.

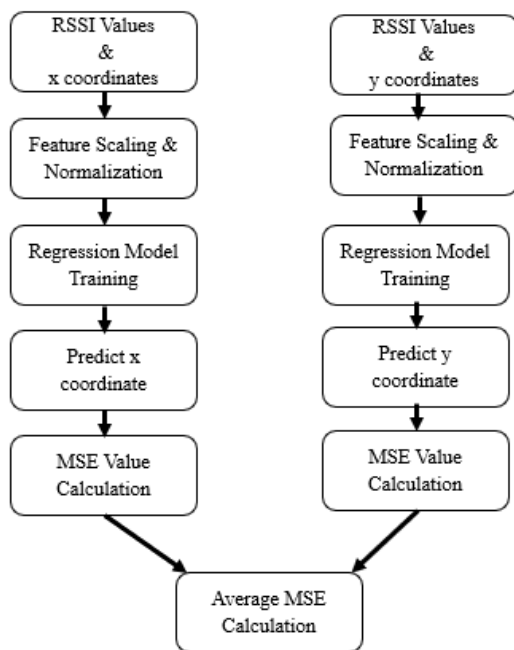


Figure 5. ML model methodology

Table 1: Error between actual and predicted values (for Node A)

MSE value	Decision Tree	Random Forest	Support Vector Regression
x coordinate	0.4232	0.3266	0.5372
y coordinate	0.3930	0.3945	0.0852
Average	0.4081	0.3605	0.3113

Table 2: Error between actual and predicted values (from Node B)

MSE value	Decision Tree	Random Forest	Support Vector Regression
x coordinate	0.4691	0.2562	0.5373
y coordinate	0.1300	0.2088	0.2088
Average	0.2995	0.2325	0.3733

Table 3: Error between actual and predicted values (Node C)

MSE value	Decision Tree	Random Forest	Support Vector Regression
x coordinate	0.4525	0.3531	0.5373
y coordinate	0.2413	0.4307	0.0048
Average	0.3469	0.3919	0.2713

Table 4: Averaged MSE values for each algorithm

Average MSE value	Decision Tree	Random Forest	Support Vector Regression
	0.3515	0.4925	0.3186

Table 5: Comparison of accuracy of Trilateration approach and supervised learning approach.

Average MSE value in supervised learning approach (Support Vector Regression)	0.3186
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Average MSE value in Trilateration approach	1.100

The accuracy between predicted coordinates and the actual coordinates, Mean Square Error (MSE), was calculated. MSE is the statistical measure of the averaged squares of errors which are then averaged squared difference between actual result and the predicted results. MSE values were calculated for x & y coordinates separately and averaged to obtain a mean MSE value of the algorithm prediction results. Table 1,2, & 3 depicts the MSE values rounded off to 4 decimal places. Table 5 shows the comparison of the accuracy of localization implemented through Trilateration and supervised learning. The MSE value of the trilateration approach was obtained from Sadowski & Spachos (2018).

## VI. DISCUSSION

It was observed that the supervised machine learning approach yielded accurate results with minimal errors when compared to the conventional method, the trilateration approach (MSE value of 03186 in supervised Machine Learning while the traditional approach yield 1.100). This is potential because machine learning algorithms learn effectively from the input data with known or unknown statistics while conventional methods such as Trilateration heavily rely on a mathematical formulation.

## VII. CONCLUSION

In this paper, a comparison of the accuracies of localization obtained through trilateration techniques and supervised machine learning techniques was made. Regression-based supervised learning algorithms (Decision Tree, Random Forest Regression & Support Vector Regression) were deployed for model training. Accuracy of localization was measured by obtaining the Mean Square Value (MSE), a statistical measure of the error made during prediction. All machine learning algorithms yielded an MSE error much lower than that of the error made during the Trilateration approach.

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# Factors Causing Less Student-Teacher Interaction in Virtual Classrooms and Video Conferencing in Distance Learning: A Review

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**Abstract** — As the Covid-19 epidemic forced people to stay in their homes, the field of education faced a major problem of conducting classes according to the same educational style. Although distance learning provided the first solution, it could not replace physical education methods. Synchronous distance learning is the most used and effective method, with video conferencing and virtual classes taking precedence. A survey was conducted to identify issues of effective interaction between students and lecturers with the participation of 243 individuals, including lecturers and students. Feedback reveals how lecturers and students experience systems and how satisfied they are. Both parties have a positive feedback average on the use of such systems. The research is concluded by proposing to develop additional features in current online learning platforms.

**Keywords:** *Synchronous distance learning, distance learning systems, student-lecturer interaction, video conferencing, virtual classrooms.*

## I. INTRODUCTION

With the advent of the Covid-19 epidemic, people had to restrict behavior in their homes. In every part of the world where the epidemic is rampant, unfortunately, the number of human activities per day has dropped. Education took a large part of it as teachers and students could not meet face to face in the classroom for effective education. In this situation, distance learning comes to the point of meeting the need for education. Distance learning is a way of educating students online. Lectures, learning materials, assignments, and activities are posted online. Students are more likely to receive education from home than to attend physical classrooms. Distance learning methods can be divided into two main categories,

synchronous distance learning, and asynchronous distance learning.

**Synchronous distance learning** - The meaning of the phrase "at the same time" is very well explained in the term synchronous distance learning. This means providing education while it is going on. This is necessary for the live communication of the Internet and technology. Examples of this method are video conferences, live chats, live discussions, and virtual classrooms. In synchronous distance learning, students must meet with their instructors, lecturers, and teachers at the same time as scheduled. Considering several aspects such as technical issues and students who love asynchronous classrooms, this approach takes the disadvantage of limiting some students to their own ability to learn fast. Synchronous distance learning depends on the quality of the lecturer and how the lecturer interacts with students. Some students may feel that they are not getting enough attention during lectures. Also, students may not have access to the content when they like or need it. If they missed the schedule, they would have to decide that they missed it. Lecturers can receive immediate feedback.

**Asynchronous distance learning** - The opposite side of synchronous distance learning. Students do not need to attend classrooms "at the same time". They receive a cluster of works daily, weekly, or monthly for a specified period, including due dates. They can learn at their own place and take advantage of self-learning mechanisms. Students have access to the syllabus content beyond the designated sync classroom. Online conversations, quizzes, games, pre-recorded videos or webinars, tutorials, and blogs are asynchronous distance learning methods. Since the asynchronous distance learning method is a more learner-

centered approach, students can complete their course content in their own time and regardless of location. But as disadvantages, the contact course content in their own time and regardless of location. But as disadvantages, the contact between lecturer and students may be limited. This causes the students to leave if they feel isolated during learning periods. That means in asynchronous distance learning students need to be self-disciplined and motivated to complete their contents.

Considering both distance learning methods, both methods have advantages and disadvantages. Between them, synchronous distance learning is the most used distance learning method in the Covid-19 epidemic situation. In AACSB quick-take survey on COVID-19 which took a survey by covering major regions which are Oceania, Middle East, USA, Africa, and Canada for discussing how far those regions converted their education mechanism and by which methods. This survey showed that 79% of respondents had converted face-to-face courses to online or virtual formats that mean synchronous distance learning methods and the rest of them which is 21% of respondents had converted their face-to-face courses to online courses that mean asynchronous distance learning. Although distance learning helps to solve the major problem which is the inability of maintaining face-to-face physical classrooms, it could not complete the authentic experience and efficiency of a physical classroom. This is due to the lack of important features such as enhanced student-lecturer interaction, task monitoring mechanism, real-time student activity monitoring mechanism, methods of improving attendance, and generating reports for further analysis to understand student active participation.

As a lecturer, he/she always faces the problem of keeping students' attention and active participation in lecturing in synchronous distance learning systems. This happens when using virtual classrooms and video conferencing. Sometimes, students attend but they do not sit in front of the computer. Students turn off their mics and cameras and go to sleep or do something else that is not related to the subject. This problem causes many lecturers to be

frustrated that they are not able to conduct their studies like physical lectures. Given the current situation, we will have to live with the Covid-19 epidemic for many years. But education should not fall, it should be conducted physically and effectively. Therefore, it is important to address the problems that exist in synchronous distance learning systems when considering those needs and the future of students.

## II. LITERATURE REVIEW

Since online distance learning comes as a trending technology for solving learning problems which were occurred during the Covid-19 epidemic, teachers and students tended to use a bunch of e-learning applications which are Microsoft teams, Zoom meetings, Cisco WebEx, Google Meet, GoToMeeting, and join.me. Each of them has unique features that are helping for distance learning.

Using Moodle, Microsoft Teams, and Zoom Platform has a huge positive impact on student self-study. For some academic achievements, it was very effectively linked. Moodle, Microsoft Teams, and Zoom platforms greatly influence student activities such as creating visual presentations, presenting papers, and viewing topics for their assignments. The researcher researched by activating Moodle, Microsoft Teams, and Zoom platforms at Jordan University. In activism, students express their motivation for self-employment. Moodle, Microsoft Teams, or Zoom platforms can be used as full-time, part-time, or traditional learning methods, so they are ready to receive additional educational material through those platforms. It also has a huge impact on students' friendships and attitudes about positive self-esteem. Those platforms motivate students to focus and learn independently. (Jehad, Raja, Elham, Haifa and Hussam, 2020)

When analyzing the effectiveness productivity of Google Classroom, by considering the message recipients, it is consistent with the expected recipients. The lecturer publishes information directly on the accounts of students who are involved in the learning process. Considering the effectiveness and effectiveness of the content, the lecturers need more information and clarification about the information published in

Google Classroom. Not every student was able to understand at first reading, they just wanted to comment and ask for a better understanding. Considering the effectiveness and effectiveness of the communication medium, not every student can take advantage of the Google classroom, as students with technical problems such as internet connection may not have adequate hardware requirements for smartphones or laptops and computer literacy. (Nur, Wa, Fahmi and Mohd, 2019)

WebEx allows students to send face-to-face, PowerPoint environments, and text messages. Shared whiteboards, screen sharing, and desktop screen sharing enhance the learning experience at a key level. Voting, testing, and group work features are very effective when considering student active involvement in online lectures. The WebEx platform gives students the ability to see the time and effort that instructors use for content. Active student participation is very important when doing online learning. It should be explored to identify how to improve student activism using WebEx teaching group sessions. (Levette, Chadwick and Kyla, 2016)

E-learning is a trending teaching style that uses electronic media such as CD-ROM, Internet, Internal, External, or satellite. Distance learning is important when discussing e-learning. This is because, in distance learning, the main method of transferring learning materials over networks is electronic learning. Cisco WebEx is a distance learning platform that provides a full conference experience for students and mentors. When the WebEx conference is applied to DLIT (Distance Learning Information Technology), it has the ability to share data files within groups, share presentations, share desktop, share files, whiteboard features, and discuss with private chat groups. Users are satisfied with the features that WebEx offers to them. (Jirayu and Khanista, 2017)

Distance learning methods also be analyzed for quality assurance. It is very important for delivering high-quality learning methods to students in academics. Among them students have chosen Zoom as the most effective e-learning platform. That is because more interaction of the learning process of Zoom video

conferencing. It was able to create more positive satisfaction for the students for having a better experience in their learning journey. And it can enhance the positive outcomes of students and encouraging them to access remotely the learning materials while reducing the workload for lecturers and teachers. (Abu, Benjamin, Mitchell and Umme, 2017)

In higher education, online education is a milestone in changing all components of teaching and learning. But comparing physical education in real classrooms, it has several problems that affect the quality of education. Students may have inappropriate expectations in lectures, such as expecting instant feedback on their assignments and online comments. And when considering the readiness of attending online courses of students, not all students can be able to participate in the lectures. Most students must be self-motivated and self-directed to participate in lectures. Some students may feel isolated and disconnected in online lectures. Therefore, the participation of some students in online lectures comes to a major problem. And transitioning from physical face-to-face lectures to online lectures is impacted on disconnecting the face-to-face interaction between lecturer and student, and it causes communication barriers, conducting classes focusing on faculty classes, lack of interest in lectures, and requiring much time to adopting to necessary teaching style. (Mansureh, Angie and Lilia, 2017)

Distance learning can be described as a great ability to set a high standard for valuable learning experiences. The research team surveyed with 1250 students between the ages of 20 and 22 from 12 departments at Kazan Federal University. Among them, 90% of students responded positively to the impact of distance learning. This experiment may reveal that students participate significantly in online lectures, but there are some issues with distance learning about the interaction between the lecturer and the students. It should consider the problem of distance learning when assessing modern distance learning technologies, marketing advantages, inappropriate administrative control, and access control problems. (Irina, 2018)

Online distance learning must be reviewed by examining the effectiveness of each country's cultural and educational characteristics. And then it must be explored by considering the potential of online classrooms which are linked to face-to-face physical education. Distance learning methods must be established in a theoretical framework in the future. The online classrooms are also conducted by teachers who conducted physical classrooms before. Therefore, future studies must be examined the efficiency and affordances of different online distance learning platforms, and especially the novel tools must be developed for the systems to increase the efficiency through it. (Hyun and Wi, 2020)

There are many challenges in distance learning which are faced by learners. When speaking about efficiency concerns learners must balance it as well as balancing proximal goals with distal ones. And they need to balance intrinsic and extrinsic requirements. If any student is asked to take personal responsibility for their education, it becomes a huge internal conflict for them. The tools must be implemented to keep their attraction to studies well. It should help students to understand their responsibilities and they must inspire by the learning methods. For encouraging active collaboration among students, they should manage their accounts individually and their attitudes must be improved with interdependence. (Philip, Robert, Eva, and Eugene, 2011)

Video conferencing can be discussed as an approach of giving more responsibility to students for their learning, group workings, doing tasks that help conventional teaching. Video conferencing does not cause to replace print or other methods, which means it does not affect the conceptual processes of learning. This provides the facility to get both students and tutors to a central location virtually. This method helps to make demonstrations easier to digest and supplementing discussions with guest speakers. Teachers have the opportunity of sending lectures in a flexible way as they can do it without boundaries of distance. (Rop and Nelson, 2012).

### III. METHODOLOGY

The purpose of this research is to provide a solution to the problems of online distance learning methods, especially video conferencing and virtual classroom interaction between students and teachers. A survey was created to get adequate feedback from teachers, lecturers, and students. The survey included a specific questionnaire to gather separate responses from the students' learning side and the teachers' and lecturers' side of the education provider.

In the beginning, it was done by studying the objective, citing several resources. Then end the flow of the distance learning methodology. Identifying the base area is the most important part of the study period. The next step is to create a questionnaire to survey with the participation of students and teachers/lecturers. The questionnaire was prepared for the two main sections for students and lecturers. The next step is to review research papers on distance learning methods, especially covering video conferencing and virtual classes. The following is an analysis of the responses collected regarding the reviewed research papers. As a final step in concluding a conclusion based on the survey and review.

When the student-instructor ratio reached 1:23, responses to the survey had to be stopped. The student-instructor ratio in higher education can be between 1: 15-30(Nizamettin and Bekir, 2014). The researcher had to use online methods because of the difficulty of getting feedback without meeting the lecturers.

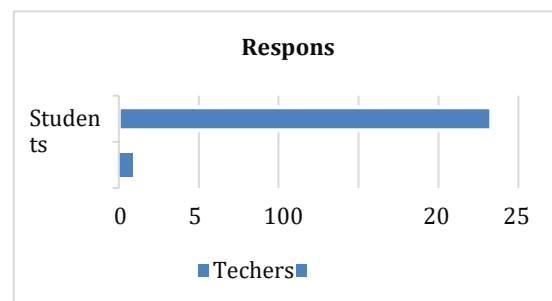


Figure 1. A bar chart of the number of responses distribution

Areas of focus, Approach to visual and auditory impairment, active participation in video conferencing and virtual classes, attendance, participation in extra activities, objectives of participation, support for each other, effectiveness productivity Multimedia use. The conclusion is concluded by proposing methods of meeting continuous requirements for a better distance learning experience.

#### IV. RESULTS & DISCUSSION

Many research papers do not discuss ideas for video conferencing and problem-solving in virtual classes regarding the effectiveness and effectiveness of interaction between lecturers and students. The Covid-19 epidemic is forcing everyone to take online classes, and since then they have begun to face several issues that directly affect the patterns and quality of education mechanisms. Reviewing research articles shows that platforms such as Microsoft Teams, Zoom Video Conferences, Cisco WebEx, Google Classroom, Google Meet do a better job of synchronizing distance learning mechanisms. There are many prizes for video conferencing and virtual classrooms in an epidemic like Covid-19. But there are some problems with those systems. It is good to analyze what they are and to what extent they can be solved.

From the survey, the researcher was able to obtain 243 responses from students and lecturers. 233 of them were students and the rest were lecturers. The balance of feedback meets the requirements of the average student-mentor ratio.

Learning should be done by students without coercion and they should be motivated to learn effectively. Looking at student responses, 86.7% of students participate for learning purposes and 30.9% for attendance, with 9.9% due to lecturer coercion. Others responded for a different reason.

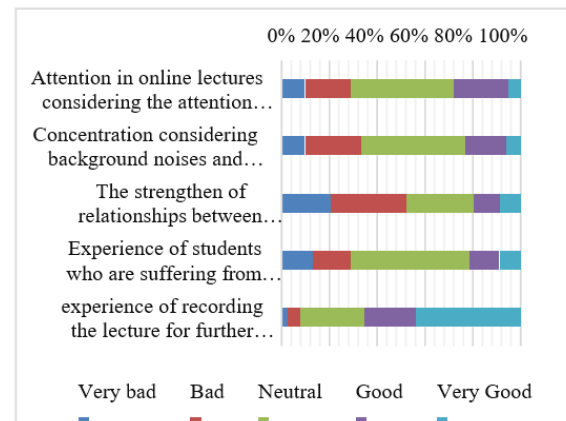
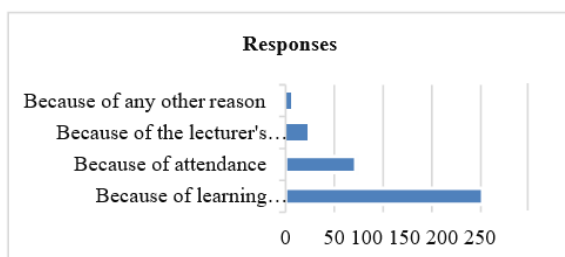


Figure 2. A bar chart of student responses with respect to the reason of attending lectures.

(Figure 2) The distribution of responses indicates that a significant number of students are not involved with online lectures for learning. The table below covers some aspects of response.

(Figure 3) Most students are in a neutral position when considering attention rather than physical lectures, and the distribution of general responses is very similar. Many students may have similar experiences in online lectures as in physical lectures. But distribution puts more weight on bad experiences than good experiences. Strengthening relationships between students does not seem to be as good as physical lectures. 52.4% of students say it is not as good as expected. It shows that student interaction is not good during a video conference or a virtual class. Of the 159 visually or hearing-impaired students, 79% responded moderately. This means that they may have similar experiences to physical lectures. Considering the rest, distribution adds more weight to a bad experience. A major advantage of video conferencing and virtual classrooms is the recording facility. 65.4% of students say it is good and 27% have a neutral opinion. Overall responses to the experience show that the average percentage of visually or hearing-impaired students' attention, environmental disturbances, and experience retention were taken into account. The recording facility is a great feature. It also minimizes the benefits of relationships between students during online lectures.



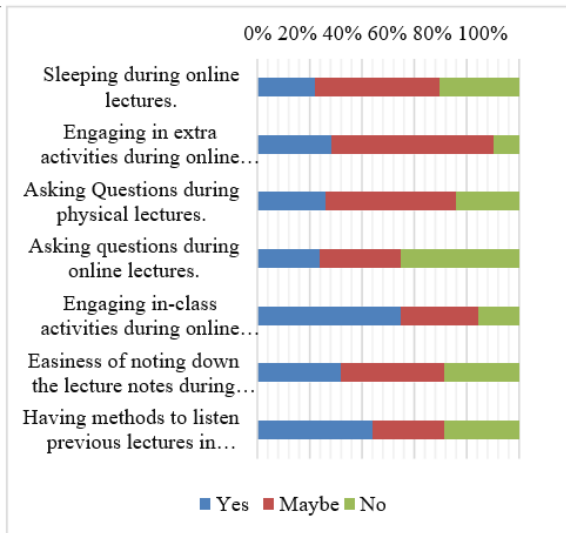


Figure 2. A bar chart of student responses with respect to the reason of attending lectures.

While analyzing the responses to these questions, the questions are simply yes-no-sometimes questions. These questions were posed to analyze the activities performed by the students during the lectures. The first chart shows how students fall asleep during lectures. 69.1% of students are accustomed to collecting yes responses and sometimes sleeping during responsive online lectures. This is because students are free to distort their mics and keep them on their cameras. They take advantage of this feature to skip lectures and only 30.5% of students interact effectively with lectures. According to the second chart, 90.1% of students engage in extracurricular activities during online lectures. This is not good because they do not focus on lectures. Considering the next two charts, there is a big gap between asking questions in physics lectures and online lectures. Probably 49.8% of the students in the 'Ask Questions During Physical Lectures' response responded. However, only 30.9% of the students responded to the 'Ask Questions During Online Lectures' statement. Sometimes students who ask questions in physical lectures show a decrease in the probability of asking online lectures. The response to the yes response has been similar. Engaging in-class activities received 54.9% of yes responses. And 29.6% of Maybe responses. It shows that engaging in-class activities during online lectures are in good condition. Online lectures are quite good when considering taking notes during lectures. It received 72.3 and positive

responses. In physical lectures, students can discuss groups, further learning methods, so 71.2% of respondents received a positive response to having methods to listen to previous lectures in physical lectures. But recording lectures are not provided everywhere in physical lectures. But in online lectures, it is easier to do because this feature is provided in the software used for video conferencing and virtual classrooms. It has been discussed earlier.

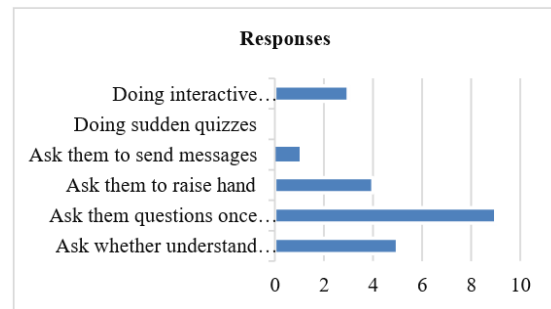


Figure 4. A bar chart of responses of lecturers on how they keep attention on lectures

Only 10 lecturers and teachers were involved in responding to the survey. All lecturers and teachers need to do things like asking students if they understand often, asking them to raise their hands almost, asking them to send messages in chat boxes, emergency quizzes, and interactive educational games to keep them focused. They should all be done by advising or asking students. It prevents the lecturer from continuing the lecture.

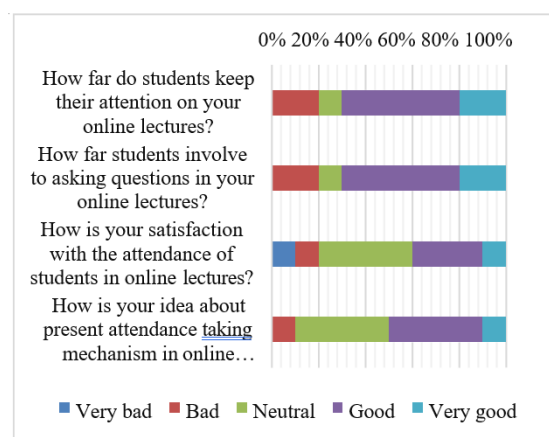


Figure 3. A stack 100% bar chart of responses of lecturers on satisfaction.

The chart shows the lecturers' satisfaction with some aspects of online lectures. Satisfactory data were collected with simple yes-no-perhaps



questions. The first chart shows the lecturer's satisfaction with the students' attention. The distribution of the first graph gives 80% more weight to the positive side. The second is also distributed as the first. It shows the involvement of students in asking questions during online lectures. Looking at the results, the lecturers are also satisfied with that. Considering student attendance satisfaction, 80% of the third graph responds positively. This means that the average attendance of students for online lectures is good. Feedback is balanced by looking at the final chart and giving 50% of the feedback as positive and negative. That is, some lecturers do not accept the attendance mechanisms currently in use.

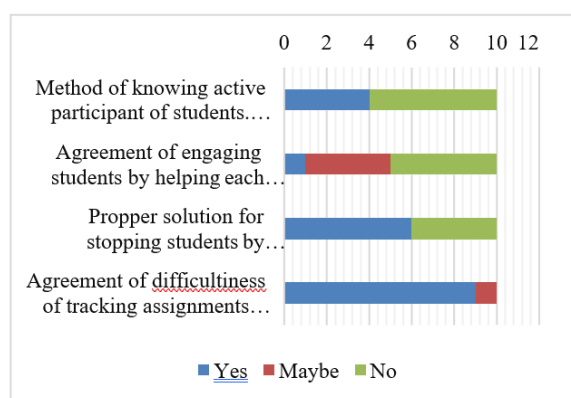


Figure 5. A stack 100% bar chart of lecturers on experiences

The first graph shows that there is a method for knowing the active participation of students in online lectures. 60% of respondents say no. This means that lecturers have a problem with whether students listen to lectures. It is because of their freedom to avoid mics and cameras. When looking at the analysis of student-based questionnaires, both the results give the same answer. Considering the relationship between students, the second chart shows that the relationship between students does not take place during online lectures to help each other and they may not know it. More than 60% of lecturers have solutions to stop students from engaging in extracurricular activities. They mentioned some of the solutions they use in online lectures, such as asking frequently asked questions, giving some activities, and assigning students tasks to complete during lecture time based on what the lecturer covered. All those solutions are done by the lecturer and if they are not able to do such things the students may lose

their focus. The final chart shows that 90% of lecturers have difficulty monitoring assignments and class activities during lectures using computer software. As a discussion of the students' questionnaire-based analysis, many students agreed to sleep and do extra activity during lecture hours. Activities include playing computer games, watching movies, and other activities not related to the current lecture. Both problems must have the same solution.

It should develop with many advanced features when considering student-lecturer interaction in distance learning, especially video conferencing and virtual classrooms. Both students and lecturers have the same type of problems that greatly affect teaching and learning patterns. To maintain the effectiveness of distance learning methods, the active participation of all students in special video conferencing and virtual classroom lectures, and the effective interaction between lectures and students are very important.

## V. CONCLUSION

The student-lecturer interaction in lectures is very important. In online distance learning methods considering video conferencing and virtual classrooms, it is very difficult to conduct. The attention, efficiency of learning, and teaching patterns depend on giving an effective education for students. The research shows that in synchronous distance learning concerning video conferencing and virtual classrooms, most distance learning methods have so many advantages. Its most important advantages are the ability to record, zero interruptions such as a physical classroom, self-learning, access to multimedia resources, and the ability to focus on lectures individually. But the freedom of synchronous distance learning to video conferencing and virtual classrooms has led students to miss lectures while sleeping, doing extra activities that are not related to continuous lectures, attending only on arrival, and much more. Lecturers have a positive outlook on these methods, making it easier to teach in an important way. They both deal with their confidence as they choose to embark on their play activities. The proposed solution is developing the systems to monitor and inform

students' activities (sleeping, not sitting in front of a computer), computer activity monitoring, and generate statistical data of student activity participants concluded by the researcher. The existing systems provide many features to conduct meetings for the purpose of conducting online classrooms. But the main requirement "keeping the positive learning outcome of students" is not covered considering some sensitive areas like student-teacher/lecturer interaction. The researcher recommends, when developing and improving other distance learning systems, to use education-oriented requirements such as the identified requirements in discussion field. For having a good learning outcome in online distance learning systems, it is recommended to add student-lecturer/teacher interactive features within the systems. The developers can use real-time behavior tracking features and task monitoring features for decreasing the cheating possibility in online classrooms. And throughout the time period of the meeting, it can be used to take an accurate attendance by analyzing the actual participation (students who actually participated to the lectures without doing nonrelated activities to lectures) of students. Because the motive must be to have a positive learning outcome by using online learning systems.

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# Cloud-Based Realtime Emergency Medical Service Platform

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**Abstract**— In emergencies such as accidents, natural disasters and epidemics, immediate medical treatment is necessary, where patients need to be transported to the hospital from their location. In such situations, Emergency Medical Services (EMSs) as well as ambulances play an important role in saving people's precious lives. Presently, there are several systems in Sri Lanka to direct ambulance drivers to reach the patient's location in minimal time and to send the patient to the nearest hospital as soon as possible. But there are some limitations in these systems, such as the nearest hospital may not have the facilities to treat the patient, limited number of ambulances available for each of these systems, hospitals' difficulties in tracking ambulances and the fact that existing systems do not maintain patient health records. Therefore, the need for a Cloud-based Real-time Emergency medical service Platform that can be used across the country is essential to address the said issues. The aim of this research is to provide a mechanism to reduce the latency of finding a suitable hospital for an emergency patient. The proposed platform is built using a Web application and an Android application that serve as the admin panel and user panel respectively. MySQL database hosted by a web server is utilized as a database connector between the Android application and the Web application. This paper presents design and implementation details of the proposed system and offers a comparative study on existing systems in Sri Lanka to understand the significance of the new system.

**Keywords:** *emergencies, emergency medical services, ambulance, latency, realtime, cloud-based, platform*

## I. INTRODUCTION

### A. Background of the study

An emergency is a situation that poses an immediate threat to personal health, life, property, or the environment. The statistics of emergency cases are being rapidly increased, putting people's lives in danger. This can comprise single-person emergencies including heart attacks, strokes, cardiac arrest, and physical injuries, as well as large-scale occurrences like tornadoes, hurricanes, flooding, earthquakes, mudslides, and epidemics like coronavirus, cholera, Ebola, and malaria. Moreover, the number of road accidents have increased in the city day by day and it is even more crucial to prevent the loss of life due to such accidents. Therefore, in case of any of the above emergencies, immediate medical treatment is required to transport the patient from the place of incident to the hospital. The necessity of transporting a patient to the hospital can be judged from the fact that if an ambulance arrives late due to any reason, it can deteriorate the patients' medical condition and even lead to death. In such cases, Emergency Medical Services (EMSs) play a key role in saving the precious lives of innocent people. Indeed, improving efficiency in healthcare sector is one of the hardest and most challenging tasks. This involves several aspects like getting an ambulance in a brief period and giving the proper treatment to the patient, which increases the patient's chances of survival in a critical situation (Poonam, et al., 2016). The main objective of successful EMS (Emergency Medical Services) systems can be operationally defined by the effective and consistent provisions of immediate medical care to the patients in case of any medical emergency (Wei, et al., 2015).

In Sri Lanka, EMSs are a recent concept. Both local and international health organizations have been interested in establishing an emergency medical service in Sri Lanka since the catastrophic natural disaster faced on December 26, 2004 (Wimalaratne, et al., 2017). The EMSs are being developed using a public-private approach aimed at providing emergency ambulance services, as well as emergency care and transporting patients to hospitals. Initially, the 1-1-0 number has been recognized as the emergency access number for Emergency Medical Services in Sri Lanka by the Telecommunications Regulatory Commission, and it is currently operating in Colombo, Galle, Kandy, and Jaffna districts, with the intention of expanding it nationally. The process of this system was when an EMS called the hospital or Government sector for an emergency case, they would send an ambulance from the hospital to the patient's location and take him/her to the hospital as soon as possible. But this process takes some time and factors such as the distance between hospital and the patient's location and traffic congestion can affect the time spent by the ambulance. In fact, accessing patient's locations at the right time will increase the possibilities of saving their lives and enables providing the right medical treatment (Campbell & Ellington, 2016).

In addition, in 2016, the Government of Sri Lanka launched a Suwa Seriya Emergency Ambulance Service as a free emergency prehospital healthcare service along with the 1990 hotline. This service allows the patient or patient's caretaker to call the Suwa Seriya Emergency Ambulance Service by dialling the 1990 hotline in case of an emergency. At that time, that person must wait until the call is connected and then guide the ambulance dispatcher to the location of accident or emergency. The dispatcher then alerts an ambulance near the patient's location and directs it to the patient to go to the nearest hospital. However, there are some drawbacks in this system, such as hospitals cannot track the ambulance and this system does not inform the hospital of an emergency patient's arrival. As a result of that, the nearest hospital where the ambulance travels may not have the facilities to treat the patient. Also, there are a limited number of ambulances available for this service throughout Sri Lanka and unfortunately, if an ambulance is not available close to the patient's location, it may not be possible to save the

patient's life. Because in case of emergency, every minute is crucial for saving a life and one cannot afford to wait longer. Furthermore, both systems existing in Sri Lanka do not store and manage patient health records.

#### A. *Research Problem*

Although there are several systems in Sri Lanka to improve the efficiency of the healthcare sector, each of these systems has some limitations as defined above. Further, today thousands of unknown ambulance services are running to the public. Every hospital has its own contact for the ambulances and even private and government services have their own contact number for the ambulances. Therefore, it is difficult for a person to find out nearest ambulance in that area in case of an emergency.

As a solution to the problems defined above, a Cloud-based Realtime Emergency medical service Platform can be built using a Web application and an Android application that serve as the admin panel and user panel, respectively. Further, a MySQL database hosted by a web server is utilized as a database connector between the Android application and the Web application. This proposed platform will help to solve the above defined limitations in the existing systems in Sri Lanka. The main aim of this system is to provide a mechanism to reduce the latency of finding a suitable hospital for emergency patients.

#### B. *Research Objectives*

The objectives of this study are twofold; to provide a common platform for all ambulances and to facilitate communication between hospital and ambulance.

The rest of the paper is organized as follows; through the section 2 of the paper, an insight will be provided about existing technologies related to sending ambulances immediately to the patient's location so that the patient can reach the hospital in the quickest time possible, controlling traffic lights and constructing spread health care centres. Further section 3 of the paper will elaborate a solution system that will overcome the defined problems in existing systems in Sri Lanka. Section 4 elaborates on how the proposed system works along with user



response to proposed system. Finally, section 5 concludes the paper with a note on further improvements.

## II. RELATED WORKS

Several works were conducted to enable patients to request ambulances or check the availability of the ambulances in case of emergencies and for the hospitals to implement fast-tracking systems to reduce patient waiting time and overcrowding. Some of these works depend on GPS (Global Positioning System) and GIS (Geographic Information System) systems and others depend on tracking down the minimal path between the patient location and a hospital considering the street conditions. But unfortunately, a working system as this research paper proposed has not been developed progressively in the current world. As researches suggested, a system was developed that consists of two applications. One is the web administration panel for the hospitals and other is the mobile application, which was introduced for the ambulance staff who transport patients to the hospital. Further, this proposed application stores the Personal Health Records (PHRs) of patient on a Cloud Based Platform and creates a unified space for patient. This will enable doctors to take decisions in future and they can view those health records only through the hospital application. After considering some related existing works, there are some technology-based solutions for the issues related to delays in arrival patients to the hospital and some concepts for providing an effective emergency medical system to prevent death and disability as mentioned below. These will be reviewed to understand their unique functionalities and differences.

### A. One Click Smartphone Application

The work presented by Khaliq, et al., (2017) is an application named "One - Click Smartphone Automatic Sending System". It was created to provide access to patients for request ambulances effectively by a convenient interface. This smartphone-based application which comprises an "Automatic Ambulance Dispatch System" (AADS), simply requires the user (victim or the caretaker of the victim) to press a "help" button to notify the nearest ambulance driver directly of any emergency instead of calling the

emergency service numbers. After accessing this application, it looks for the nearest accessible vacant ambulance and sends a message to the system including patient information such as patient's location, personal information, and kind of infection. After receiving the message, the ambulance driver can see the real-time position of the patient on the map through system and then move towards him/her. This can be considered as a major advantage to reduce the time consumed in communication between the victim or victim's caretakers with ambulance.

### B. Ambulance emergency response application

The deployment of a control room, based on GPS and GIS system was developed by Sakriya & Samual (2016) to monitor streets congestion and control the traffic lights. The Authors of this work developed a mobile application for viewing vacant ambulances nearest to the patient's location and that was more efficient and reliable for emergency medical services. The application responds with just one tab on the button and sends the user's details and location via GPRS to the nearest ambulance control Center. This allows the user to get any ambulance at any time without calling hospitals to check for the ambulance availability. Furthermore, based on the data provided to the application, the control rooms can identify the route of the ambulance to reach the requested hospital, which allows the control room to regulate the traffic lights involved in the road to facilitate the patient's arrival at the hospital. This is immensely helpful because if an inexperienced ambulance driver has taken a wrong route, the driver will be late for the arrival on the emergency scene (Nordin, et al., 2012).

### C. GPS and GSM (Global System for Mobile) based intelligent ambulance monitoring system

Another system relates to the development of a device with an ARM 7 processor module, including biomedical sensors, GPS receiver, and GSM modem, presented by Dixit & Joshi (2014). The method will be useful for tracking the location of an ambulance using Google Maps. It includes a body temperature sensor and a heart rate sensor to obtain patient health information. The information gathered in this compact device is saved in the microcontroller's memory and

transferred to a dedicated server. After receiving SMS messages, the position of the ambulance can display the patient's heart rate and temperature and hospital staff can be prepared for the proper treatment of coming patient.

#### D. Blockchain technology in health-care for emergency patients

A blockchain technology health care system is being developed to improve the quality of the health care system in modified form for emergency patients to get the immediate treatment without any wait (Tahir & Nadeem, 2019). The main objective of this system is to manage the emergency patients and suggest the nearest hospitals with a minimum queue. In this system, patient's request sends through a certain server and in response to the request, the patient receives information about the shortest distance hospital. When some hospital responds to a patient, the hospital will also ask from the patient about the Smart Ambulance (SA) service for basic treatment. The request will then be sent to the SA if the patient gain this service and then SA goes to the location for basic treatment. Furthermore, the medical history of the patients can be saved in this system using blockchain architecture. The main limitation of this system is that the proposed system is private and the data set of the experiment is only a single node of the hospital. Therefore, the feasibility assessment of this system has not been confirmed.

### III. DESIGN & IMPLEMENTATION

The proposed solution is a Cloud-based Realtime Emergency medical service Platform, which is important for reducing the latency of finding a suitable hospital for emergency patients and providing a common platform for all ambulances. The figure 1 shows how the practical situation works from the time of patient is in an emergency to the time patient is taken to the hospital.

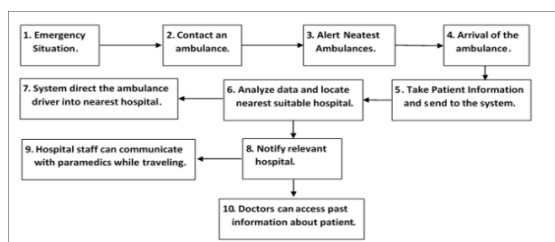


Figure 1. Practical Situation Diagram  
Source: Author(s) 2021

Furthermore, the proposed system facilitates communication between hospital and ambulance and stores the PHRs of patient which will be useful for doctors to take decisions in future. The basic architecture of the Cloud-based Realtime Emergency medical service Platform is depicted in figure 2.

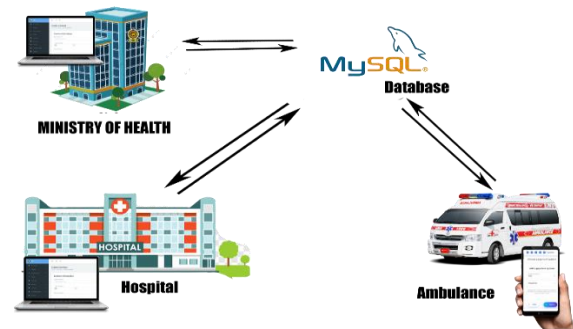


Figure 2. System Architecture  
Source: Author(s) 2021

Web application as admin panel, an Android application as user panel, and MySQL as database connector between the Android application and the Web application are the main components used in the construction of this system. Android Studio is used to create the mobile application, and HTML, PHP, and CSS (Cascading Style Sheets) are used to create the web application. This mobile application can be considered as the system's "user-interface" (Ref. figure 3), while the web application can be considered as the system's "admin-interface" (Ref. figure 4). The MySQL platform is used to capture changes in the information and keep the system synchronized with the mobile application.

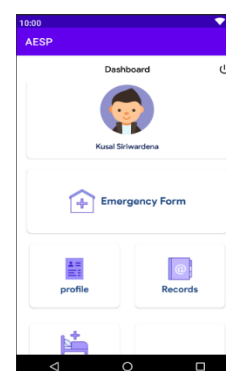


Figure 3. Mobile user interface of the system  
Source: Author(s) 2021

User interfaces of the system (Ref. figure 3, figure 4) are designed to be straightforward and user friendly. Using this, the user can manage the device. User type 1 which means drivers get patients locations as well as the nearest hospitals location.

User type 2 which means paramedic can fill out a quick survey using the application.

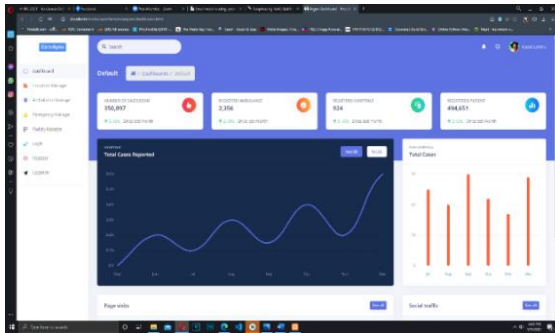


Figure 4. Web admin interface of the system  
Source: Author(s) 2021

#### A. Process of Registering Ambulance and hospitals

The administrator of the proposed system oversees registering ambulances and hospitals. Ambulances of any kind, whether government, private, or other, can register via this system. While registering, the ambulance's administrator should also update the driver's and paramedic's details. When registering a hospital, the name and location of the hospital are required so the hospital must be identified on the map after registration.

#### B. Process of updating hospital facilities

Hospital staff can log into the systems after registering the hospital. Staff members of hospitals are responsible for keeping their facilities up to date. There are two different methods of updating services.

1. Facility updates - A country has many health-care services. As a result, hospital employees should be aware of the types of services they can offer as well as their capacity.
2. Daily updates – Since service recipients change daily, the availability of a facility can fluctuate from day to day. Hospital staff should oversee keeping those regular changes up to date.

#### C. Process of finding an ambulance

Someone should call the hotline number and provide basic details such as the patient's or guardian's name, address, and ID number. The information will be sent to the administrator, and

the data will be updated in the database. After that, the system will send an alert to all registered ambulances within a radius of 5-kilometer from the specified area, and wait for a response. If no response is received, the radius will be increased, and ambulances will be alerted until one is found. When the ambulance arrives at the hospital, it can be tracked.

#### D. Process of finding the nearest suitable hospital

After the ambulance arrives at the patient's location, the paramedic can take care of the patient while completing the quick survey through the paramedic's application. After submitting the survey, the system analyses the data provided by the paramedic and sends a message to the driver's application recommending the most appropriate hospital for the patient's needs.

#### E. Process of creating a unified cloud space for patient

The data collection phase begins when a patient requests for an ambulance. As soon as the ambulance arrives at the patient's location, the paramedics fill out a quick survey and send it to the system. The system then creates a unified cloud space for that patient. If the patient is already accustomed to this service, the previous form relevant to him or her will be updated. This file stores all the record information such as date, actions etc. These reports may be useful in the future when doctors make decisions about a patient's health.

The platform can be used across the country to link all ambulances and hospitals. After that, the method becomes more accurate and efficient. Hospitals and administrators should connect to the system through Wi-Fi or Ethernet, while ambulance crews should use mobile data. To keep this proposed system running, the government should provide smartphones to every ambulance driver and computers to hospitals so that they can access this platform as a simple necessity.

The proposed system employs algorithms to locate nearby ambulances and hospitals, which are implemented in the administration application. These algorithms are linked to a database to extract data as input for the

operation Admin program sends alerts to drivers when the algorithm is being processed. For system implementation in the administration application, researcher is also use two Google APIs (application programming interfaces). That are connected to system database system (Ref. figure 5).

1. Maps JavaScript API
2. Places API

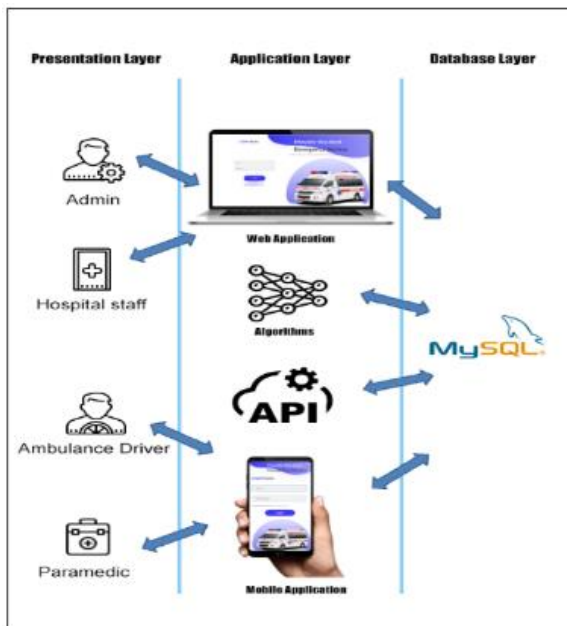


Figure 6. Overall System Architecture  
Source: Author(s) 2021

Maps JavaScript API allows us to customize maps with our own content and imagery for use on websites and mobile devices. The Maps JavaScript API includes four basic map types (roadmap, satellite, hybrid, and terrain), each of which can be customized with layers and styles, controls and events, and a variety of services and libraries (Google, 2021).

The Places API is an HTTP-based service that returns information about locations. Establishments, geographic areas, and famous points of interest are all examples of places in this API. Each service is accessed through an HTTP request, and the response is either JSON or XML. The https:// protocol must be used for all requests to a Places service. A place ID is used by the Places API to uniquely identify a location (Google, 2021).

Since implementation is not in production level, researchers will host web application and database on a private web server to manage resources. When it reaches the production stage, it will take more latency to process and update real-time data. As a result, researchers can migrate it to Amazon Web Services (AWS) such as Amazon EC2 as system server (Amazon, 2021) and Amazon Simple Storage Service (S3) as system storage (Amazon, 2021). It will assist in improving the system's efficiency.

#### IV. RESULT & DISCUSSION

The Cloud-based Realtime Emergency medical service Platform sends an alert message to all registered ambulances within a radius of 5 km from the patient's location and wait for a response. Once a response is received, the ambulance can arrive at the patient's location and the paramedic can take care of the patient while completing the quick survey through the paramedic's application. Then the system analyses the data provided by the paramedic and sends a message to the driver's application recommending the most appropriate hospital for the patient's needs. Additionally, paramedics can use the application to communicate with the hospital while on the road, and hospital staff can advise paramedics on pre-meditation techniques. Figure 6 shows the system interrelated diagram that explains how system modules and processes are linked.

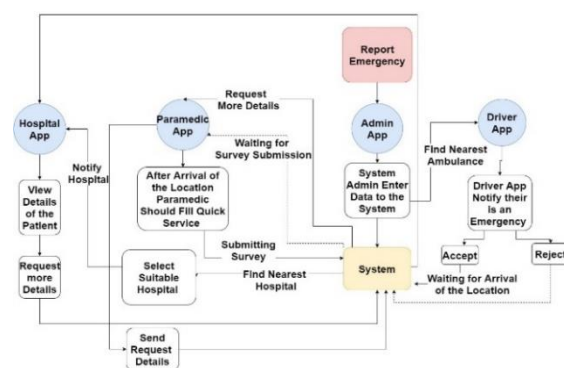


Figure 7. System Interrelated Diagram  
Source: Author(s) 2021

To understand the significance of the new system, the researchers compared the proposed system with current systems in Sri Lanka. Initially, the 1-1-0 number was identified as an emergency access number for emergency



medical services so that patients could get an ambulance in case of an emergency. However, this system has some limitations such as delay in contacting an ambulance, delay in identifying the exact location of the patient and the hospital not knowing about the facilities required by the patient. Therefore, the hospital is unable to make any preparations for the incoming patient, and the patient's case records do not last long in this system.

The Suwa Seriya ambulance service arrived shortly after, resolving some of the issues in the prior service, such as the time it takes to contact an ambulance and the time it takes to transport a patient. However, there are still some issues such as hospitals cannot track the ambulances and this system does not inform the hospital of an emergency patient's arrival. As a result of that, the nearest hospital where the ambulance travels may not have the facilities to treat the patient. Also, this system has a limited number of ambulances and does not store and manage patient health records.

The proposed system solves these problems by including features such as finding an ambulance closest to the patient's location, selecting an appropriate hospital for the patient's needs, setting up a patient arrival notification system, providing a common platform for all registered ambulances, facilitating communication between hospital and paramedic and store and manage patient health records in an assigned cloud space. Furthermore, with the spread of the covid19 epidemic, people are now accustomed to working with digital devices and therefore the technical literacy of people is now improving. Hence, people can now quickly grasp such a technical based system without a hesitation.

## V. CONCLUSION & FURTHER WORKS

In this paper, researches have presented a Cloud-based Realtime Emergency medical service Platform that can be used across the country, providing a proper mechanism for all people in need of immediate medical treatment to reach the hospital as soon as possible. This application is built using a Web application as admin panel, Android application as user panel and MySQL database which is host on web host as database connector between the Android application and the Web application. This proposed system

allows the patient to find a suitable hospital that can meet his/her needs in an abbreviated period. It provides a common platform for all ambulances and facilitate communication between hospital and ambulance. Further, this system stores PHRs of patient and it will enable doctors to take decisions in future.

For future works, researches plan to develop the paramedic application, including a function of taking a voice call to the hospitals over the internet and activating a mobile application into the IOS platform. Further, this system can be improved by using this application in both Sinhala and Tamil languages and USSD activation mode can be developed in this system as an additional functionality.

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# Sound Event Recognition and Classification Using Machine Learning Techniques

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**Abstract** – Sound event recognition and classification are exciting and vital applications in the era of the Internet of Things (IoT). These Sound events carry information that is useful for our daily lives. The perception of surrounding events by humans depends strongly on audio signals. Awareness of what happens in the surrounding environment depends heavily on the ability of an individual to perceive sounds and accurately recognize events related to them. The subject of audio signal recognition is now very popular and has numerous applications. This paper presents machine learning approaches to classify sound events extracted through sound sensors, where the sound signals acquired by sensors will be processed using machine learning algorithms to classify them. The results show that the accuracy of CNN, SVM, MLP classifiers are 82%, 81%, and 79.48%, respectively.

**Keywords:** *sound event recognition, Convolutional Neural Networks (CNN), Support Vector Machine (SVM), Multilayer Perception (MLP)*

## I. INTRODUCTION

The world is filled with sounds that are carrying information. Sounds are essential for the execution of regular activities, social interaction, and even personal protection. It provides information about character, place, and time. Sounds can inform and move us in ways that visuals alone cannot. The topic of audio signal recognition has received a lot of attention in recent years. Audio signals can be split into three categories: music, voice, and sound. Out of them, sound event signal detection has recently become more critical in the general daily environment. Sound event recognition has many applications. It can be used for elderly care, to

build devices for people with hearing loss, for defense and surveillance purposes, for identifying sounds in emergency and notifying authorized people, such as the house's fire alarm or someone crying for help, and many more. Machine learning approaches can be used to give a human-like performance on sound event recognition and classification. This paper presents our investigation on popular machine learning techniques for sound event recognition and classification.

Sound event recognition consists of three stages: sound acquisition, feature extraction, and classification. First, most audio signal identification systems nowadays use a microphone array or a camera to receive sound signals. A large number of high-sensitivity microphones are required for microphone arrays. Hence microphone arrays are expensive. Furthermore, it is time-consuming to analyze the signals received by the microphone array. A camera is also costly, and interference of objects can happen. Therefore, we have used only a single microphone to receive the sound signals and detect the sound events in this paper. Second, the features of signals were extracted using MFCC (Mel-frequency cepstrum). Finally, different Machine learning techniques were used for classification.

In this work, the ESC-50 dataset was used for model training [1]. It consists of 50 different sound events. Out of them, ten sound events were defined: dog barking, baby crying, siren, glass breaking, fire crackling, rain, washing machine, car horn, clock alarm, and birds chirping.

## II. RELATED WORK

Mete Yaganoglu and camal kose proposed a wearable device for hard-of-hearing people detecting sounds and notifying the user using vibration patterns. The use of different vibration

patterns made the system complicated and hard to understand. It uses a KNN algorithm for classification.[2]

Tariq, Z., Shah, S., and Lee, Y. e discussed speech emotion analysis and how emotion can be used in medicine, a psychological study on old adults in nursing homes. Further discussed is an IoT-based speech emotion detection system that can process real-time audio to predict the emotion of aging adults. A 2D CNN model was used together with RMS, Peak, and EBU normalization and data augmentation techniques [3].

Wang J, Lee, S., Fu, Z., and Shih, P. suggested a method for Robust Sound Recognition Applied to Awareness for Health/Children/Elderly Care. This research uses an ICA-transformed MFCCs feature frame-based multi-class SVM. An accuracy of 90.97 percent was achieved [4].

This paper presents our investigations on automatic daily sound recognition using ensemble methods. First individual classifiers are used with different acoustic features to measure their performance in recognizing everyday sounds. Ensemble methods are then employed to identify the daily sounds better [5].

Chang, C., and Chang performed research on recognizing abnormal indoor sounds; Y. SVM algorithms were used as the classifier. Four discriminative features (peak, valley, and contrast of Octave-based and MFCC) were chosen. An accuracy of 86 percent was achieved [6].

### III. DATASET

**The dataset was prepared using recordings of the ESC-50 dataset for model training. The ESC-50 dataset consists of 5 - second long 2000 environment recordings of 50 different sound events. Out of them, ten various sound**

**events were selected.** They are baby crying, siren, glass breaking, rain, washing machine, car horn, clock alarm, birds chirping, fire crackling, dog bark. The dataset consists of 5 second long 400 recordings. Each class has 40 recordings. The data set is divided into 80% training data and 20% testing data

When it comes to classification, features are crucial. They represent the sound in a simplified numerical format. To make the classification process more effective and accurate, we have to extract features from the audio clips. MFCC (Mel-frequency cepstrum) is a standard feature extraction method for sound recognition because of its high efficiency. The basic procedure to develop MFCCs is,

i) Convert from Hertz to Mel Scale

$$m = 1127 \times \log\left(1 + \frac{f}{700}\right) \quad (1)$$

ii) Take the logarithm of the Mel representation of the audio

$$\log E = \log(\text{sum}(x^2)) \quad (\text{Log of Time-domain}) \quad (2)$$

iii) Take the logarithmic magnitude and use Discrete Cosine Transformation

$$F(u) = \left(\frac{2}{N}\right)^{\frac{1}{2}} \sum_{i=0}^{N-1} A(i) \cos\left[\frac{\pi \cdot u}{2 \cdot N} (2i + 1)\right] f(i) \quad (3)$$

This creates a spectrum over Mel frequencies as opposed to time, thus creating MFCCs.

Here we use librosa's mfcc() function, which generates an MFCC from time series audio data to extract the MFCC for each audio file (Ogg) in the dataset. [7]

The sound files are read using the Soundfile library. Then MFCC is extracted from each sound

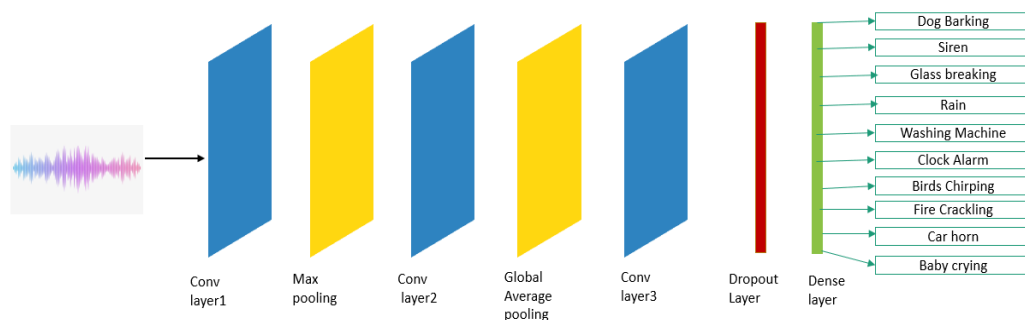


Figure 8: CNN Model

file. Finally, a data frame is created with the MFCC feature and corresponding class label. Once the feature extraction is done, it is converted into a NumPy array and taken as input to the classifiers.

#### IV. RECOGNITION OF SOUND

A study was done to find which ML algorithms are most suitable for sound event recognition and classification. It was found that mainly convolutional neural networks (CNN), Support vector machine (SVM), Multilayer perception (MLP) algorithms are used for Sound event recognition and classification. So, the data set was trained and tested on these classification models, and the accuracies were taken.

##### A. CONVOLUTIONAL NEURAL NETWORK

A convolutional neural network is gaining popularity in deep learning, and its use in the audio domain is increasing. CNN is a well-known model in the fields of image, text, and other computer vision applications. We have implemented a 1D CNN model using the Keras framework. A convolutional neural network has two main components: a feature extractor and a classifier. The feature extractor extracts the MFCC from the audio signal and sends them to a classifier for classification. The classifier is made up of various convolutional and pooling layers, which are then followed by activation. Following Activation, Functions are used in this project.

ReLU Activation Function –

$$f(x) = \max(0, x) \quad (4)$$

Softmax Activation Function –

$$\sigma(z)_i = \frac{e^{z_i}}{\sum_{j=1}^K e^{z_j}} \quad (5)$$

The 1D CNN architecture is composed of 8 layers. The first layer is made up of a 40x1 input image. Then it is convolved with 64 filters of size three kernel in the next layer. Then the second layer is a Max Pooling Operation. Then in the third layer, it is again convolved with 128 filters of size 3. All of the convolution layers are followed by ReLU as the activation function. Then the fourth layer is a Global Average Pooling Operation. Next, a dropout layer of rate 0.5 was used to stop overfitting. The last layer is a Softmax output layer with the ten classes in the dataset. The model is compiled using Adam optimizer. The

Total accuracy obtained after 100 epochs with a batch size of 32 is 84%.

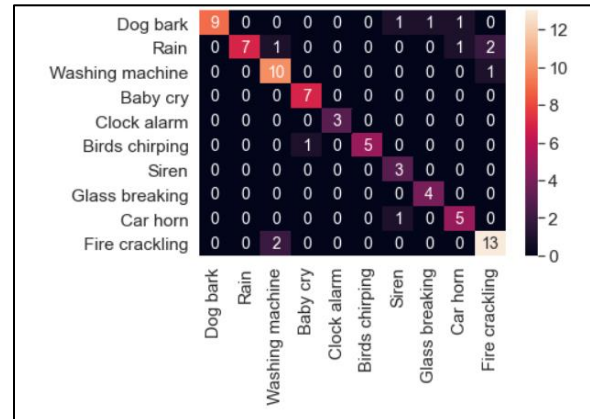


Figure 10 confusion matrix of CNN test data

##### B. SVM CLASSIFIER

A robust and popular classification machine nowadays is the support vector machine (SVM). Its idea is simple; the algorithm builds a dividing line to divide data into classes. SVM takes data as an input and produces a hyperplane which, if possible, separates these classes. SVM attempts to make a decision boundary so that there is a maximum distance between the two categories. In SVM models, several kernels can be used. These include polynomial, RBF, and Sigmoid function. In this project, the kernel type was taken as a second-degree polynomial. Thus, a higher-order polynomial sets out the decision boundary that separates classes.

Below is the polynomial function.

$$K(X_1, X_2) = (a + X_1^T X_2)^b \quad (6)$$

where b is the degree of the polynomial

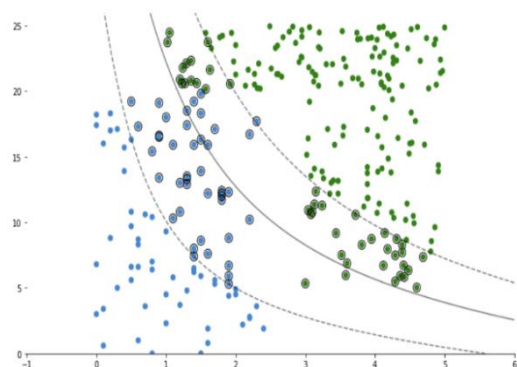


Figure 9: A conceptual diagram of a second-degree polynomial

A grid search algorithm is applied to find the best parameters of C to improve the classification accuracy of the SVM. The total accuracy of the SVM classifier is 81%.

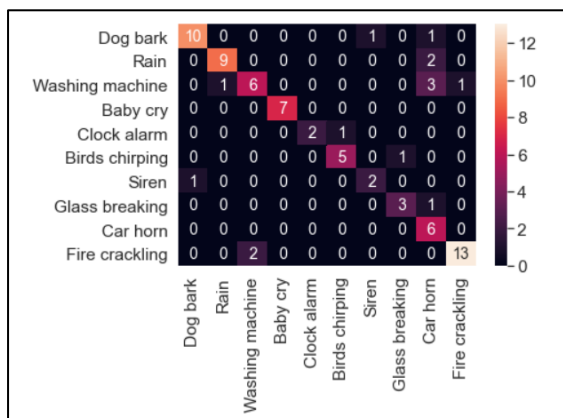


Figure 11 Confusion matrix of SVM test data

### C. MULTILAYER PERCEPTRON

Multilayer perception (MLP) is a class of feedforward artificial neural networks (ANN). An MLP has at least three nodes: one input layer, one covered layer, and one output layer. MLP uses a supervised learning method known as backpropagation for training. The below figure illustrates a simple, fully connected two-layer MLP network.

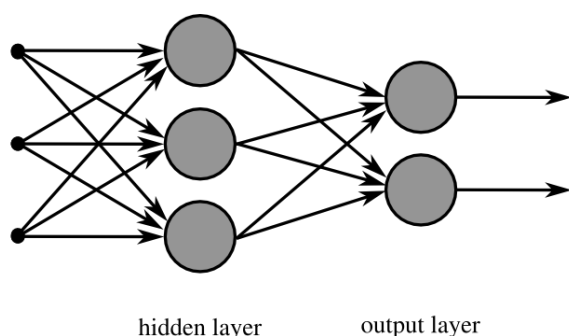


Figure 12 A conceptual diagram of an MLP

The mlp created for this project consists of 3 fully connected layers. The layers have 256, 256, and 10 neurons in them. Relu activation function is used in all layers except the last layer. The softmax activation function is used in the previous layer. In the first two layers, dropout layers have been used to reduce the overfitting of the training data. The model is compiled using Adam optimizer. Keras was used to build the MLP. The MLP was trained for 200 epochs with a

batch size of 32. The total accuracy of the MLP classifier is 79.48%

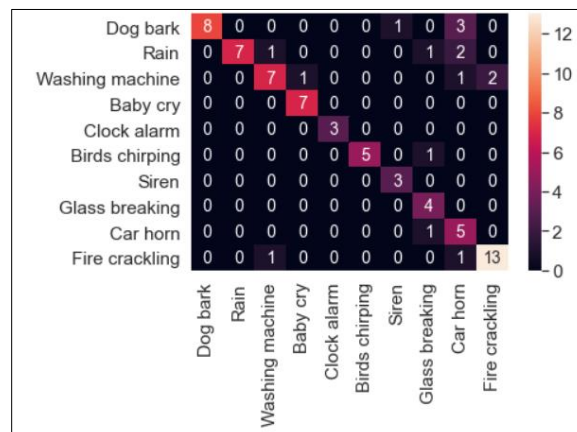


Figure 13:Confusion matrix of mlp test data

## V. RESULTS AND ANALYSIS

We trained and tested CNN, SVM, and MLP learning algorithms to identify the sound events accurately in this experiment. For the experiment, we used **ESC-50 data set, which consists of 50 sound events and among them 10 number events, namely "baby crying," "dog barking," "siren," "glass breaking," "fire crackling," "rain," "washing machine," "car horn," "clock alarm" and "birds chirping," were tested. During the testing phase, 80% were selected as the training set, and 20% were used as the test set. Data pre-processing were done using MFCC (Mel-frequency cepstrum), and features were extracted. The results show that the total accuracies of the CNN, SVM, MLP classifiers are 84%, 81%, and 79.48%, respectively. Out of the three models, the CNN model has the highest accuracy of 82%. So, the convolutional neural network has outperformed the other two models.**

## VI. CONCLUSIONS

In this paper, we discussed how popular machine learning techniques work for the classification of sound events. The **ESC-50 data set was used for the training and testing. The experiment was carried out identifying sound events "baby crying," "dog barking," "siren," "glass breaking," "fire crackling," "rain," "washing machine," "car horn," "clock alarm" and "birds chirping," with the approaches for sound event recognition and classification. MFCC (Mel-frequency cepstrum) features were extracted from the signals. Three machine learning algorithms were discussed in this paper. They**



are SVM, CNN, and MLP. The CNN architecture consists of 8 layers followed by ReLU and Softmax activation functions. It was trained for 100 epochs with a batch size of 32. The SVM uses a second-degree polynomial kernel. A grid search algorithm is applied to find the best parameters of C to improve the classification accuracy of the SVM. The MLP architecture consists of three fully connected layers. ReLU and Softmax activation functions also follow these layers. The MLP was trained for 200 epochs with a batch size of 32. Both the CNN and MLP models use the Adam optimizer for compilation. From the models, CNN, SVM, MLP, the following accuracies were obtained as 84%, 81%, and 79%, respectively. The CNN model has the highest accuracy compared to the other two models, so it outperformed in terms of accuracy.

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# Sinhala Chatbot with Recommendation System for Sri Lankan Traditional Dancers

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**Abstract**— Traditional dancing which originated in the 4th century B.C. is one of the most popular dancing styles in Sri Lanka. Though it has highly developed throughout the years, novel technologies are not much engaged with the development of traditional dancing. Therefore, Sri Lankans still use ordinary methods even for finding choreographers, dance track editors, props providers and costume providers. These have become the most common problems of Sri Lankan traditional dancers. With the objective of giving a computer-based solution for these problems, the paper proposes an information providing website that acts as a location and rating-based service provider recommendation system capable of solving the ‘cold start problem’. Since most of the terms related to traditional dance are in Sinhala, the web system was created in English as well as in Sinhala for ease of use. A Sinhala chatbot has also been introduced to the system, making it easier for any local user to use and a user-to-user private chat system is also proposed to directly communicate with service providers. The system is able to identify the five closest service providers with the highest ratings for users and generate more user recommendations based on location and ratings. Chatbot has achieved a good level of accuracy in directing users and answering user questions.

**Keywords:** *information providing platform for dancers, place recommendation system, nearest place finding system, Sinhala chatbot*

## I. INTRODUCTION

Sri Lankan has been called the “Wonder of Asia” due to its phenomenal natural beauty and multicultural background. Without any doubt

dance is one of the most popular performing art which act as a main element of this culture. The origin of dance in Sri Lanka goes back nearly to 3 B.C where it started as a method to expel natural disasters and sicknesses and as a result of various spiritual belief in gods (Rajapakse, 2004). Up to now, various dance styles have been introduced throughout its development journey and many western dance styles have also been studied by Sri Lankans. As of today, there are mainly three dance styles according to regional variety as, dances of the hill country (known as Udarata Natum), dances of the low country (known as Pahatharata Natum) and Sabaragamuwa dances (known as Sabaragamu Natum) (“Traditional Dances of Sri Lanka | Amaya Resorts & Spas Blog,” n.d.). Other than these main categories, there are some inherent dance styles such as devil dances, folk dances, dance dramas and some foreign dance styles such as kathak, ballet, hip hop, salsa, polka, tango etc. in Sri Lanka (“Dances of Sri Lanka: Culture, History and Where To Watch Them,” n.d.). All these dance practices vary in their styles of movements and steps, in costumes worn by performers, dance props used and, in the rhythms, sounds, songs and instruments used to the dance.

Although Sri Lankan dance is highly developed and popular all over the world now, it is one of the domains of Sri Lanka that is not much connected with modern technologies. While finding for a suitable way, to bridge these two fields, identified the several most common problems of Sri Lankan dancers can be solved using computer-based system. Nowadays, the most common problem of Sri Lankan dancers is the lack of a proper method to find details of dance service providers.

When focusing on current methods of finding dance service providers, the most used method is to ask someone familiar with the dance. The main disadvantage of this method is that they should rely on the scope of that person's knowledge and the recommendation made by one person may not be so reliable. In this kind of situation internet search engines also do not provide significant results as they only display information about few most popular dance service providers usually in the western province. But there is no use of details about a choreographer in Colombo, to a person who are searching for a dance choreographer from Eastern province. On the other hand, there is not even a written/ printed manual database in anywhere about dance service providers in Sri Lanka. Thus, this paper is proposing an intelligent website which provides details about service providers. The system aims to make it easy to find information to Sri Lankan dancers about required dance service providers, quickly and accurately throughout a standard database. In order to achieve the above aim the following key objectives has been identified.

- Computerizing information about Sri Lankan dance choreographers, track editors, costume providers and props providers.
- Allowing users to find the nearest service providers to their preferred location.
- Displaying information of service providers in the detailed vise, summarized vise, and category vise.
- To reduce the user effort on searching for different services many times, providing relatable suggestions about other service providers according to users' locations.
- Implementing Sinhala chatbot to increase the user interaction and user friendliness.

For comparison, there is still no local system in Sri Lanka to solve this research problem. But some websites have been implemented to find the nearest choreographer in foreign countries("The 10 Best Dance Choreographers Near Me 2021 // Lessons.com," n.d.) ("The 10 Best Dance Choreographers Near Me (with Free Estimates)," n.d.). But there is no website to find all the basic service providers on the same platform. This method is useful for users looking

for service providers as well as dancers looking for service providers. It is because some unpopular service providers may register as a service provider for the system, which may increase their popularity and sales. In the proposed system, users are recommended about service providers by first comparing location and secondly by considering user ratings. Thus, even a service provider who is new to the system will recommend to users if they do not have ratings.

## II. LITERATURE REVIEW

### A. Prevalent Methods

As mentioned earlier, this research is mainly conducted to give a solution to Sri Lankan traditional dancers to the problem of lack of method to find details about dance service providers. They are unable to find service providers in an accessible distance and find their contact details because of this issue. While searching about existing methods dancers use to find service providers, mainly identified methods are as followed,

- By asking someone who has knowledge of dance (ex: Ask from a dance teacher)
- By searching the internet

After identifying the present manual methods, the requirement of a proper database with details of Sri Lankan dance service providers was identified. Through this literature review, it was able to identify the earlier applied techniques and methodologies by other researchers to implement similar systems and advantages and drawbacks of them.

### B. Nearest Place Finding System

The nearest place and people finding systems are highly growing development to increase the efficiency of people all over the world. It is a much important feature to the proposed system also, as dancers may need to access a service provider at least once. For examples, before planning a dance, the choreographer should check the stage/area of the dance. Most of the time it happens by physically accessing the space as it is the best way to get an idea of the use of space. To get measurements, to correct costume errors, and to get rented costumes

back, the costume providers also need to be in physically accessible distance. Therefore, system should compare a user's input address with service providers' location address to calculate the minimum distance and select the nearest service provider. To investigate the technology behind this function, relevant research publications in various domain were reviewed.

The paper (Ahmed et al., 2017) has been proposed a system with services such as online hotel exploration, reservation and finding the best path to nearest hotel. The researchers have been used Dijkstra Algorithm written in PHP to implement the function of finding nearest hotel.

Another research study (Chamikara, 2013) which has been conducted by four Sri Lankan researchers have been proposed a system to identify the nearest police station to a user location using different methodology. It based on classification technology, and it has been implemented using integration of J48 algorithm with GIS (Geographic Information System) and a GPS (Geographic information system) technique. Users can select their location through the Google map and then the longitude and latitude information of that location has been used to classify that place into predefined police station group. Then the identified nearest police station has been indicated on the map.

### C. Recommender System

Recommender Systems are a subset of information filtering systems and are software tools and techniques providing suggestions to the user according to their need. It is a way of reducing the user effort on searching for many items. Thus, it helps to give more user-friendly environment for the websites, and it has become a popular feature of many E-commerce sites.

There are mainly two types of recommendations can be categorized into three main categories as content-based recommendations, collaborative recommendations and hybrid recommendations based on the way they are made (Shah et al., 2017). The idea behind collaborative filtering is people who agree with the evolution of same items in the past are likely to agree again in future. These types of

recommendations are easy to make. Collaborative Recommendations can be further divided into two categories as Neighborhood based, or model based. Content based recommendations are made based on a comparison between content of the item and a user profile data. These types of recommendations are difficult but good at generating recommendations to new users. other type of recommendations are hybrid recommendations which implements as a combination of earlier discussed filtering methods.

The proposed system takes user location as input from the users and provide recommendations based on that location and ratings of service providers to users. The paper (Han, 2012), has been proposed an exploitation model of personalized recommendation system based on Multi-Agent Collaboration system. This multi agent system has been proposed with multiple agents to perform different tasks. Basically, two algorithms have been used to in this system to generate recommendations. Collaborative filtering algorithms have been used as the recommendation algorithm to comparatively analyze user's past interests and behaviors with other target users. Thus, the system has been based on both client-client and project-project relationships. A similarity algorithm also has been used in the system to predict the similarities between users. But according to the paper (Ghanwat and Chacko, 2017) collaborative filtering methods are less effective in providing solutions to the cold start problem and data sparsity Problem. It is because this method generates recommendations by analyzing earlier user preferences or similar user behaviors, which reduces the chance of generating accurate recommendations of new user/item. Thus, they have been proposed an approach which combined review text and rating to generate recommendations. They have been used machine learning techniques to predict user ratings on unknown items according to the aspects that user is interested. The architecture behind that was, they have implemented a model to find the aspects and sentiments in the user reviews. After analyzing the sentiments in reviews that system has been created a profile for item and user by presenting

important characteristics of the item and user. Finally, they are calculated using decision tree algorithm to predict the ratings.2

#### D. Chatbot

Chatbot is one of the novel applications of Artificial Intelligence which act as virtual agents on software applications. It is a software application which can communicate with user in natural languages. The key technology behind this application is Natural Language processing. Chatbots interact with human users and simulates conversations through text messages or voice outputs. The most famous examples for chatbots are Alexa from Amozon, Siri from Apple, Cortana from Microsoft, Google Assistant etc (Smutny and Schreiberova, 2020). In the proposing localized system, users may need more interactive proper guidance to work with the system due to the novelty of this kind of application. Therefore, a chatbot application was implemented to answer user questions.

The paper (Jayalath et al., 2019) has been implemented to provide information about ayurvedic plants, their information and information about doctors and their locations. As it was a localized system, they have implemented a Sinhala chatbot as virtual assistant to answer user questions. The chatbot intent and patterns have been defined in plain JSON files. For the classification of user input and recognition of intent tensorflow and Python have been used. Though chatbot applications are very useful in increasing the interactivity of the system, the large number of questions receiving from users may leads to some misbehaviors. As a solution for this problem a system has been proposed (Calvaresi et al., 2019) a chatbot to answer questions efficiently and handle thousands of messages simultaneously which has been implemented using Multi-Agent Framework. That chatbot has been implemented in social network webpages for smoking cessation. The paper has been proposed a multi agent approach with common modules and structures for all the agents. Thus, instead of single chatbot, multiple chatbot applications worked on the same goal simultaneously to increase the efficiency.

### III. METHODOLOGY AND DESIGN

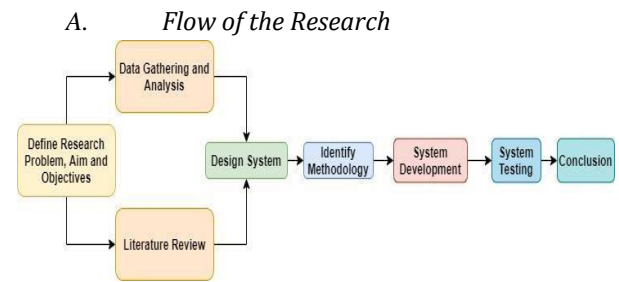


Figure 1. Flow of the Research, Source: Author

#### B. *Requirement Gathering and Analysis*

This Study was started by identifying what are the exact problems of Sri Lankan dancers that needed be addressed. For that purpose, a very simple survey was conducted using 91 dancers ("E-Guide Application for Dancers," n.d.). The survey kept as simple as possible to ensure that it was easy for each participant to respond. With the obtained results from this survey the research objectives were defined and then started to design the proposed system to fulfill each of them. Identified main problems of Dancers are as follows,

- Finding a Dance Choreographer
- Finding a Dance Track Editor
- Finding a Dance Costume Provider
- Finding a Dance Props Editor

After identifying the research problem, it was broken down into several sub questions to identify that what should be the exact objectives of the project to achieve the project aim. Following research questions were formulated with the aim of identifying areas that need to be studied in more depth to find a proper solution to the research problem. They pinpoint exactly what to find out and gives a clear focus on the research study. Also, these research questions highlight the key features of the proposed system to cover all user requirements.

- Question 1: What is the computer-based solution that can be given to solve the research problem?
- Question 2: What kind of information should the system provide?



- Question 3: What should be the most important functions of the proposing system?
- Question 4: How to use novel concepts and technologies to increase the efficiency and user friendliness?

### C. Proposed System Design

1) Overall System Architecture: The overall system architecture defines the how the components of the system are related. The architectural design is given in a layered architecture under the three layers of presentation layer, application layer and database layer.

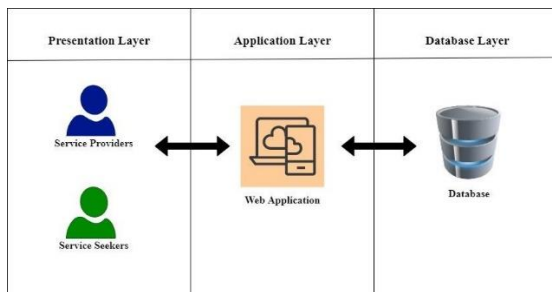


Figure 3. Overall System Architecture  
Source: Author

2) Modular Architecture:

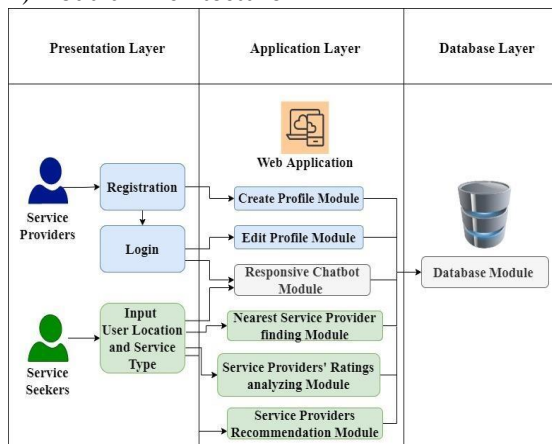


Figure 2. Modular Architecture  
Source: Author

### D. Data Gathering

Data gathering phase was an important and hard step which had to gone through while developing this computerized database of service providers' details. As mentioned earlier, there is no even a manual database to collect this

information. Therefore two google forms has been created in both English and Sinhala medium to gather details and distributed it among service providers ("Collecting Information about Sri Lankan Traditional Dance Service Providers,," n.d.) ("ශ්‍රී ලංකාවේ නර්තන ව ඵේවා පයන්තන් පිළිබඳ විකාරතුරු රැ ඵේ කිරීම,," n.d.). But very few of them came forward to fill it, though the google form did not request any sensitive data of them. Thus, had to contact each service provider personally to gather data. It was also a difficult process to make time to meet them physically due to their busy schedules. Finally had to collect them over the phone or emails to gather required information and it was a time-consuming process.

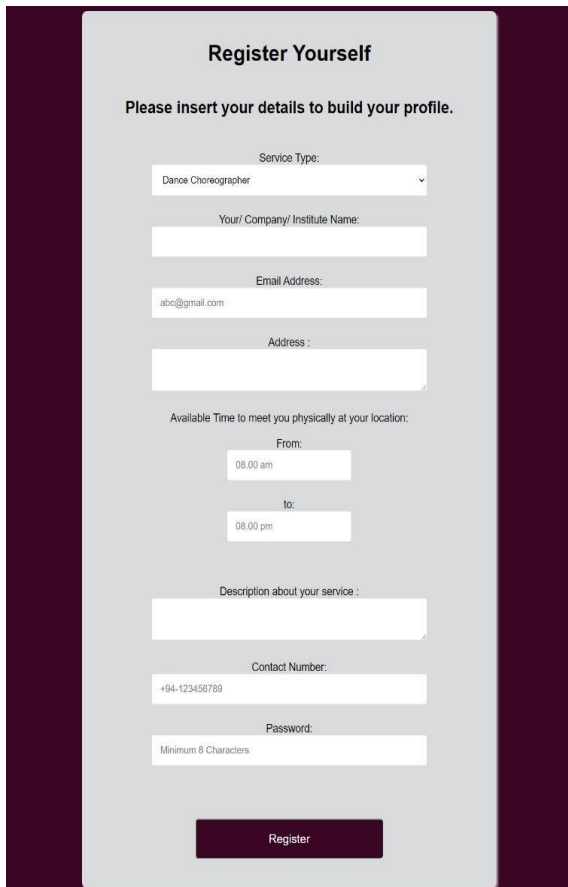
The collected database contained basic information about service providers, such as name, email, address, location, available time to meet them at their location, service description, and contact number. The details are divided into four categories according to the service category of the service providers. In addition, the current ratings and number of reviewers of service providers are extracted from Google Map and social media for testing purposes.

### Technology Adaptation

1) *Website Development:* The main requirement according to the identified research problem is a standard database with details of Sri Lankan dance service providers. There occurred the doubt of whether a website or an android application is more appropriate. For this, the early mentioned google survey was used to ask preference of selected 91 dancers. Majority of them were opted for a website over an android application. The website implemented using HTML, CSS, JavaScript and PHP.

2) *Database Architecture:* When computerizing dance service providers information, the next question was what specific information users should know about dance service providers. Thus, at the home page of the website, the system categorized users as service providers or service seekers. Service providers can register into the system by filling the registration form and there collected information such as name, email, contact

number, address, available time, and a simple description about them/their service to show service seekers.



**Register Yourself**

Please insert your details to build your profile.

Service Type:

Your/ Company/ Institute Name:

Email Address:

Address :

Available Time to meet you physically at your location:

From:

to:

Description about your service :

Contact Number:

Password:

Figure 4. Registration Form  
Source: Author

In the data gathering phase, the techniques that have been used are google forms and interviews conducted over the phone. The gathered data was stored in four tables (choreographer table, track editor table, costume provider table and props provider table) of MySQL Database according to the service types selected by service providers. Rather than gathered details the database contains a table which stores rating details of service providers. These rating details were got from google Map. In addition, service seekers' location details also stored in a different table.

3) *Google Map API*: When looking for a service provider, the primary consideration is whether his or her workplace is physically withing reach. Then consider the quality of service and reliability of the service provided. Therefore, this system should primarily offer the service seeker, the service providers closest to

his/her location. The system takes service seeker's location and service providers locations as an input to the system and then they are converted to longitude and latitude coordinates using google geocoding API. These coordinates also stored in particular tables of the database. The distances between these coordinates are calculated together using google Distance Matrix API. The coordinates of service seekers' addresses are determined as source and the coordinates of service providers are determined as the destination. Then service providers, the destinations are sorted into ascending order considering distance with the source. This process ensures providing accurate location-based recommendations to users.

4) *Rating based recommendations*: The system allows service providers to display pictures of their previous works as evidence to give users an idea about the quality of their services. But, because this is not sufficient, "rating", another world-renowned method is selected to provide recommendation about service providers to users. Because factors that measure the quality of service vary from person to person, the use of this method can give an idea of the general opinion of more people. But the problem is the rating value of a service provider should be always checked with the number of rated users. It is because the service provider who has 4.0 rating value obtained from 25 users, will be more suitable than a service provider with 5.0 rating value obtained from 5 users. To solve this problem, some approaches have been used the method of taking simple mean of the ratings. But if there exist small number of ratings, cannot keep much faith in the rating. Thus, instead, of simple mean, the damped mean is calculated by damping the overall mean ("Introduction to Recommender Systems," n.d.). There assume that every service provider is average, and that each additional rating is a proof of whether the service provider is at higher or lower level to the average. Therefore, rating value is analyzed with number of rated users by using following formula.

$$R = \frac{\sum_u r_{ui} + k\mu}{n + k}$$

In this formula  $\sum_u r_{ui}$  stands for the sum over users of users' rating for particular service provider, and  $n$  refers to the number of ratings. The  $k$  value refers to an assumed value that represents additional number of ratings which are added to each service provider at the global mean  $\mu$ . When there are small number of ratings, this  $k$  factor damps some extreme positive ratings, and as the number of ratings grows, this effect will reduce, and the real mean will begin to appear ("Non Personalised Recommender System in Python | by Ankur

Tomar | Medium," n.d.). This  $\mu$  is calculated by taking the average rating value of all the service providers of particular service type. The formula for calculate  $\mu$  is as follows,

$$\mu = \frac{\sum_p r_{pi}}{N}$$

In this formula by  $\sum_p r_{pi}$  stands for the sum of all the same kind of service provider's ratings and  $N$  stands for number of service providers. By using these two formulas, the cold start problem of new service providers is also solved. After the service providers are listed according to the distance, five service providers among them who have the highest rating values calculated from above mentioned formula, are displayed to the user on the integrated map.

5) *User- user Private chat system:* By clicking on particular user on the map they are directed to profile of that service provider. There service seekers can see images of earlier services, description about services and other basic information such as contact details. In addition, service seekers can send private messages to that service provider using private chat system. This private chat system is designed using PHP language.

6) *Sinhala Chatbot:* This is a localized system and since the traditional dance of Sri Lanka deals with the Sinhala language, it was decided to activate a Sinhala chatbot to increase

the user friendliness and interaction of the website. The Chatbot was developed using Dialogflow. This chatbot is able to direct users to appropriate place in the system.

#### IV. DISCUSSION

Sri Lankan dancing is not much used novel technologies to solve the problems in dancing. As a result of this most of the processes related to dancing is still done in manual inappropriate ways. The selected problem in this study is inconsistency of a proper database/ method to find details about dance service providers. Therefore, an information providing platform is proposed as a computerized database with easy access to users.

The system basically focused on providing recommendations about service providers to the service seekers. A hybrid approach which combined location-based recommendations and rating-based recommendations is used to provide more appropriate. Google API s are used for generating locationbased recommendations and, calculated damped means of ratings are used to generate rating-based recommendations by avoiding cold start problem.

The following figure displays the initial ratings and number of reviewers of service providers. There exist service providers with no ratings and reviews which leads to cold start problem.

	name	ratings	number-of-reviews
0	ImzyS Dance Loft	5.0	5.0
1	Rhythm World Dance Studio	5.0	4.0
2	Deanna School of Dancing	4.4	55.0
3	Cool Steps Dance Studio Colombo	4.3	45.0
4	Dance With Hiruni	0.0	0.0
5	Antonio's Dance Circle	5.0	1.0
6	INVINCIBLE DANCE STUDIO	4.9	46.0
7	Budawatta Dance Troupe	0.0	0.0
8	Sparrows Dance Studio	4.4	23.0
9	Dance with Anidha	5.0	4.0
10	Danceworld School	5.0	1.0
11	Ruhunu Kala Ayathanaya	4.5	4.0
12	Uma Dancing Academy	4.1	8.0
13	Footwork Dance Studio	0.0	0.0
14	Sway Dancers	5.0	43.0
15	Salvo Dance Group	4.0	9.0
16	Chitrasena School of Dance	3.8	6.0
17	Chandana Wickramasinghe Dancer's Guild	4.0	17.0
18	Royal Dancing Academy	5.0	6.0
19	Meranga Fine Arts Ensemble - Traditional dance...	5.0	4.0
20	Hansani Dancing Academy	0.0	0.0
21	DanceInspire - Dance Studio & Academy	4.8	25.0
22	Nayani Dance School	0.0	0.0
23	TRITHAL DANCE STUDIO	5.0	1.0
24	ranga gamage dance studio	0.0	0.0
25	Ranara Academy	5.0	6.0
26	Saranga Dance & Drum academy	0.0	0.0

Figure 5. Initial Ratings and Reviews of Choreographers

Source: Author

The figure below shows the median ratings calculated by considering both their initial rating and the number of reviewers. Choreographers who do not have initial ratings or reviews have been also given a rating value in this system and thus, the cold start problem has been solved.

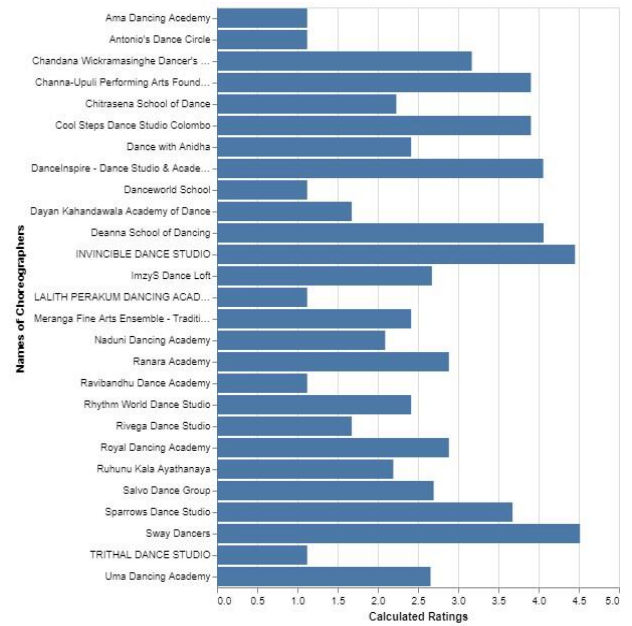


Figure 6. Generated rating values using damped mean.

Source: Author

To increase the interactivity of the system Sinhala Chatbot is designed. System also provide ability to have a private conversation with service providers to service seekers. The system evaluation process has basically done under the following categories: Recommendation evaluation, Verification of system functionality, Verification of the accuracy of chatbot responses and evaluate the performance of the user-user chat system.

## V. CONCLUSION AND FUTURE WORKS

There are many ways to use novel technologies for solving problems of Sri Lankan dancers. This research study selected the problem of inconsistency of standard database with details of Sri Lankan dance service providers. The Paper is proposed a web system to avoid the difficulty of finding information about Sri Lankan dance service providers due to the lack of an appropriate database. The web system is capable of providing reliable recommendations about service providers to users and allows them to communicate with them through a private chat system. A Sinhala chatbot system was also suggested to make the system easier for every local user to use. The limitations of this system are it is only focused on Dance Service Providers around Colombo to limit the scope of the project. This system can be

further improved by adding details about service providers all over the country into the system. Also, researchers can add more features to the system such as ability to see the costumes of costume providers in 3D view using Virtual Reality technologies.

### ACKNOWLEDGEMENT

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# An E-Learning Platform for Hearing Impaired Children

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**Abstract** – E-learning, also known as electronic learning, is a method of disseminating knowledge with the separation of teachers and students. Hearing loss and hearing impairment are common examples of disabilities that affect people. E-learning is found to be an effective method for hearing impaired children for their education as it gives them the ability to do their education at home without having to go anywhere else. Although the concept of e-learning gives a full idea of the opportunities it can offer, it has some shortcomings that need to be considered. For children who are learning letters and numbers, this online learning method would not be as effective as it would be for the older generation. Therefore, children under the age of five should have a proper solution to learn letters and numbers, even in times of crisis. The main objective of this research is to discuss the need for a proposed solution for hearing impaired children. The proposed e-learning platform will support both Sinhala and English languages. Therefore, children can get an education in the language of their choice. This platform will teach the children step-by-step how to write letters, in both Sinhala and English as well as numbers. The system uses machine learning with Support Vector Clustering (SVC) to identify the letters and numbers they provide. This algorithm is constructed by SVM (Support Vector Machine). In addition, the system will provide simple questionnaires and activities for them to complete, while doing their studies through the platform. The aim of this paper is to make e-learning more effective and efficient for hearing impaired children.

**Keywords:** *hearing impaired children, e-learning, distance education, crisis situation, education, deaf children*

## I. INTRODUCTION

Every citizen on this earth has the right to education. Every child has the right to learn and attend school no matter where they live or how

wealthy or poor their families are. The same condition applies to hearing impaired children. However, children with hearing impairment face significantly different barriers and challenges to learning. Some of the main barriers to learning for hearing impaired children are societal attitudes, lack of access to basic services and crisis situations such as public health issues, political issues, and environmental crises. As a result of these barriers, hearing impaired children are confined to their homes and their education gets disrupted. Therefore, people have started using the latest technologies to prevent these kinds of barriers.

The rise of technology has been a great opportunity for education and as a new implementation, distance education also known as e-learning was introduced. E-learning is considered as an important factor as the younger generation feeds upon technology during their difficult times. E-learning entails physical separation of students and teachers. At the same time, the students and the teachers have the capability to interact with each other online as well as offline. Video conferencing has become one of the most popular types of distance education. Video conferencing is the most common way for students to interact directly with their teachers during live lessons (Daniel, 2020). This technology has become a great support to students with disabilities as they are capable of doing their studies at home without going anywhere. Some of the students with disabilities are reluctant to attend traditional classrooms to do their studies due to their sociological differences. Hence, distance education or e-learning can be supportive for students like them (Tomaino et al., 2020).

According to the world health organization, there are 466 million individuals with disabling

hearing loss and from that 34 million are known to be children (“Deafness and hearing loss,” n.d.). The ability of hearing-impaired children to receive education and access to it has become one of the most establishing and challenging discussions in the history of deaf people (Hashim et al., 2018). For many years, sign language was primarily used to distribute education to hearing impaired children. Sign language is also used by deaf people to communicate with others. It is considered as one of the most emerging research fields in the research history. Figure 1 and figure 2 show samples of sign language using both hands and only one hand (Vinoth and Nirmala, 2017).

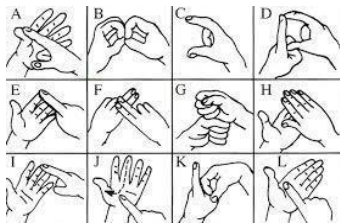


Figure 1. Two hand sign language Source: Deaf Students Higher Education System Using E- Learning

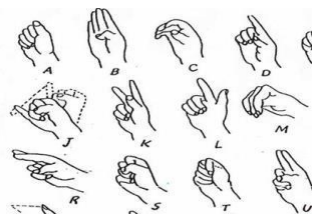


Figure 2. Single hand

Source: Deaf Students Higher Education System Using E- Learning

E-learning is known as a modern method that can be used for education. It does not require physical representation of children in a classroom. It can be considered as a great opportunity to do education remotely anywhere in the world.

E-learning is known as a method of education that is based on student-student interaction (SSI), student-content interaction (SCI) and finally the most common relationship, student-instructor interaction (SII) (Gunsekera et al., 2019). However, this method requires several electronic devices such as laptops or

smartphones or tablets and Wi-Fi. Those who are unable to afford to find such devices will have to face some difficulties to find a solution (Sokolova, 2018). Many people nowadays benefit from e-learning, including differently abled people. This method can only adversely affect anyone’s life if they are not familiar with the newest technologies (Vinoth and Nirmala, 2017). Hence, it is important to keep people informed about the latest technologies and upcoming trends.

Differently abled children require more attention than other children. A typical online classroom for them would not be as effective as it would be for hearing children when it comes to learning letters and numbers. A structured environment is highly required for hearing impaired children to succeed in their education. Some of the researchers who are in the field of e-learning have found several methods and techniques that can be used to overcome the above-mentioned barriers. The issues they faced when developing those systems and the advantages of the techniques and the methods they used will be discussed in this study.

The main purpose of this study is to introduce a method for hearing impaired children to do their education even in times of crisis. A method to learn numbers and letters in both English and Sinhala languages will be introduced in this research.

The significance of this research is that this study is based on e-learning platforms for hearing impaired children. The idea of e-learning platforms for children with disabilities is an emerging trend in the field of e-learning. Therefore, this study deliberates existing e-learning platforms for hearing impaired children and the technologies and trends used by other researchers to solve existing problems. Also, this study presents the developed model that can be used to solve the existing problems. The structure of this paper is as follows. Second section of the paper describes the background of the study and section 3 includes the methodology of the study. The section 4 and section 5 include the evaluation and the conclusion of the paper.

## II. LITERATURE REVIEW

Researchers have observed various techniques and methods that can be helpful for hearing impaired children in their education. The effectiveness of e-learning for them has been observed in different perspectives by the researchers who are working in the field of e-learning. This section of the study is devoted to identifying the proposed perspectives of researchers which can later be used to analyze the technologies and the newest trends they have used. According to Saunders, Lewis and Thornhill, the literature will support the research question and objectives providing a complete justification for the research aim and objectives, gaining insights as per the outline of the research and providing important information and ideas for other research (Saunders et al., 2019). Therefore, this section is structured in accordance with the research objectives.

#### A. Existing Systems

There are many e-learning platforms currently available for hearing impaired children and the content of most of platforms is based on Math, general education, and communication. Some of the studies that were done by researchers are as follows,

Table 1. Existing studies on e-learning for Hearing Impaired Children

Name of the Study	Participants	Areas Based On
"A Gamified E-learning Framework for teaching Mathematics"	Deaf students	Mathematics
"Adaptive Learning System and an Academic Advisor Agent"	Deaf students	General Education
"Design an Application for the Hearing Impaired People"	Hearing Impaired People	Communicate with others
"Deaf Students Higher Education using E-Learning"	Deaf Students	Higher Education
"E-learning course based on AdAPI"	Deaf and hard of hearing participants	Computer literacy

Table 1 covers a wide range of subjects taught to hearing impaired children and adults. The system implemented by Samaa M. Shoheib is a gamified e-learning framework that can be used to teach mathematics to hearing impaired students.

According to the author, Gamified is an approach to accelerate the experience curve of teaching, learning, and thinking in education. Simply, gamification is an application of game planning elements and game principles in non-game contexts. The general contents of the implemented system were, content, Arabic sign language avatar, quality standards, learner support as well as characteristics, and gamification components. The content of this study contains the course syllabus, structure, quantity, depth, and activities. The learner support includes grading, feedback, and guidance. Grading and feedback are given in using score and instant feedback. These are included in the gamification components. Special guidance is provided using the Arabic sign language avatar.

Gamification components that were used in this study were, points and performance graphs, challenges, badges and achievements, leader modes, levels, time-based activities, stories, and characters as well as freedom to fail (Shohieib, 2019).

The main objective of the adaptive learning system proposed by (Hammami et al., 2017) was to monitor the student's achievement in the learning program and instruct them to do better. They proposed this system to overcome the difficulties hearing impaired learners face. According to the researchers, some of the challenges hearing impaired people face are, difficulties in writing and reading online and being compared with other normal students, grammatical errors they make when writing, and not having tutors who are willing to educate them without any hesitations as most of the tutors find it difficult to teach hearing-impaired students. For the above-mentioned problems, the authors proposed a solution based on a set of defined skills that would help hearing-impaired children to enhance their knowledge in writing and reading. These skills were specified as DSLO's ("Deaf

Students Learning Outcomes”) (Hammami et al., 2017).

Matjaz Debevc and others have created an e-learning environment that is adapted for people with hearing disabilities. In this study, the utility and educational effectiveness of the e-learning curriculum was evaluated using an inventory and adapted education index system that measures software usage. The researchers have used sign language videos to teach hearing-impaired students to make the system more effective for them (Debevc et al., 2014).

A design and implementation of an application for hearing impaired people have been studied by ChoulWoo Kim and the others. They have designed this application for the smooth communication and easy life of hearing-impaired people. For this, sign language, voice to text translation features were included. In addition, a vibration alarm was added for the safety of the people. In this application, eight functions were implemented including, sign in, sign up, sign language search, voice translation, vibration alarm, SOS, substitute order, and welfare facility guide. This application was designed to ask for the minimum personal information from the users (Kim et al., 2017).

### B. Approached Techniques

This section contains the technologies and the approaches used by the above-mentioned authors to implement the systems they proposed.

Table 2. Technologies used in Proposed Systems

“Adaptive Learning System and an Academic Advisor Agent”	N-tiers, Multi-Layer architecture, Multi agent system, Model View Controller pattern maintenance
“Design an Application for the Hearing Impaired People”	Sign Language, Voice to text translation
“Deaf Students Higher Education using E- Learning”	Cloud Computing, Big Data, Video Streaming, Text

“E-learning course based on AdAPI”	Video Streaming (sign language and subtitles), Animations
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According to Samaa M. Shoheib, Gamified is an approach to accelerate the experience curve of teaching, learning, and thinking in education. Simply, gamification is an application of game-planning elements and game principles in non-game contexts (Shohieb, 2019). This is known as a game-based method. Hence the goals of the system are presented to users as games. According to the researchers, a study was conducted to determine the effectiveness of this method by applying a gamification plugin to a learning management system. The results show that the gamification method has better effects than the traditional education system. Hence, the researchers used an avatar that supports Arabic sign language to support hearing-impaired children with their education.

Adaptive learning system which was proposed by (Hammami et al., 2017) and others used N-tier, multi-layer architecture, model view controller pattern maintenance, and the multi-agent system as techniques to implement the system (Hammami et al., 2017).

### C. Effectiveness of E-learning for hearing impaired children during Crisis Situations

With the development of the world, distance education also known as e-learning has started growing rapidly all around the world. It has also become the major solution to provide education to the younger generation in difficult times. The effectiveness of e-learning cannot be analyzed just by comparing it with the traditional education system as both the systems have many advantages as well as disadvantages. Especially in times of crisis.

According to the authors, the distance education system is the most effective and efficient way to handle education in crisis situations. During crisis situations people are stuck at home unable to go anywhere. There are times when people are not able to get the essential products for themselves. In such situations, advanced technology is needed in order to sustain the situation. As a result, distance education was developed to address all barriers that affect the education sector in a country.



According to Oliveira, in a crisis, schools and institutions are closed to prevent external damages. Hence there won't be a place for students to do their studies. In the distance education system, no specific space is required for students (Oliveira et al., 2018). Students can do their education at home. In the traditional education system, the teacher may have to teach the same subject to different classes at different times but with the distance education system the teacher or the tutor can conduct only one session (video) and can ask students to join that at the same time. It is much easier than teaching the same lesson at different times.

According to "The rise of online learning during the COVID- 19 pandemic", distance learning requires 40-60% less time to learn than in the traditional learning system ("The rise of online learning during the COVID-19 pandemic | World Economic Forum," n.d.). The main reason for that is that students have enough time to self-study and clarify the queries on their own. According to the authors, the effectiveness of distance education varies among age groups. Since young children require more attention, they require physical activities as well as in depth guidelines.

### III. METHODOLOGY

#### A. Data Gathering

To gather the required data for the development of the system were done using data collection protocols such as interviews, questionnaires, and documentary reviews. The main purpose of this system is to deliver an effective learning method for hearing impaired children that can be used to do their education even in their difficult times.

#### B. Data Analysis

Data required for the implementation of the system were analyzed using charts and diagrams. In the analysis process, problems and difficulties faced by hearing-impaired children were identified. This helped the authors to discover the need for a new learning method for hearing impaired children in times of crisis.

#### C. Approach

Main users of this system are hearing impaired children and lecturers or teachers of hearing-impaired children. There are two types of inputs for the system. They are basic information such as the name, the date of birth etc. of both users and uploaded course materials by the teachers.

#### D. Technology Adapted

To gather user inputs through sign-in and registration modules, the system has been implemented using HTML, CSS, JavaScript, and firebase. These technologies were used by considering the functional and non-functional requirements of the system. It is important to develop a system that satisfies the requirements of the users.

The proposed e-learning platform for hearing impaired children is a web-based system. Non-functional requirements such as availability, security, learnability, and usability were mainly considered when developing the system. To develop the frontend of the system, Html, CSS, and JavaScript were used with visual studio code. To develop the backend of the system, machine learning, python, Jupyter notebook, and firebase were used. Since the main goal of this system is to teach hearing-impaired children how to write letters and numbers, machine learning was used to recognize the handwritten text and digits.

#### E. Proposed Design

The architecture of the system was broken down into four main components and they are, software architecture, database, modular architectures as well the interfaces of the system.

##### 1. Overall System Architecture

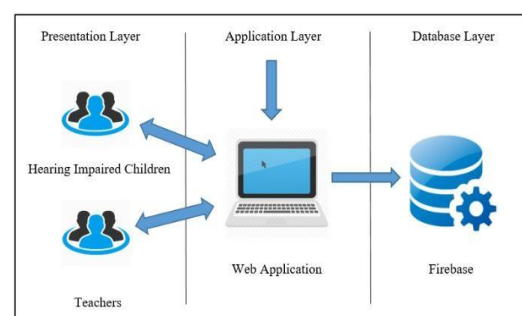


Figure 3. Overall System Architecture

**Presentation Layer** - This shows information about the system and the web application. It is a user-friendly layer and is the front part of the system. In this layer, user interfaces of the system are largely considered. User interfaces of this system are eye-catching and graphical.

**Application Layer** - The application layer consists of the web application. The application layer presents the functional logic that shows the basic functionalities of a web-based system. It is an abstracted layer that connects to the other two layers as it acts as the central part of the entire system. This presentation layer performs a detailed configuration of the system.

**Database Layer** - The database layer consists of databases, tables, records, etc. It has database servers that can be used to store all the required information. This layer is independent of the application layer and the presentation layer. This storage will be used to ensure the efficiency of all operations related to the database of the e-learning platform.

## 2. Modular Architecture

The overall modular architecture of the e-learning platform is shown using figures. The modules of the system are mentioned below with related interfaces.

**Language Selection Module** - The system is designed for both English and Sinhala Languages. Users can go further by selecting the language they prefer.

**Login/Signup** - There are two categories of users in the system. They are hearing impaired children and teachers. Both the categories of users can log in or create a new account in the system.

**User Profile** - Every user will have their own user profile. The details which were entered by the user will be displayed in their user profiles. Details such as name, age, and courses they follow on the platform.

**Course Selection** - There will be several course materials for hearing impaired students access. They can choose to follow any of the included courses on the system.

**Letters and Numbers Identification** - This module includes an algorithm to identify the handwritten texts and digits entered by the users. This module includes the SVC (Support

Vector Clustering) algorithm. This is constructed by SVM (Support Vector Machine). SVM can be used for classification, regression, and for other tasks (Zhou et al., 2018). The recognition of handwritten digits is done as the flow chart mentioned below (Zhou et al., 2018).

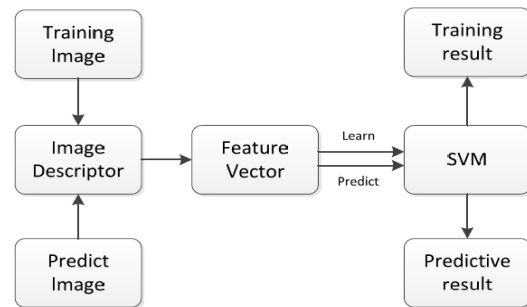


Figure 4. Flow Chart of Digit Recognition  
Source: Study on Handwritten Digit Recognition using Support vector machine.

SVC uses a kernel function to map data points from data space to high dimensional feature space. Using the support vector domain description algorithm, the kernel's feature space algorithm finds the smallest range that covers the image of the results. When this range is remapped into data space, it creates a series of contours that surround the data points. The SVC then interprets such contours as cluster borders and links the points covered by each contour to the same cluster (Ben-Hur, 2008).

**Home Page** - The home page contains the available courses for hearing impaired children. For teachers, the home page will include the option where the platform lets teachers add their own courses to the system.

**Feedback** - Users can send their feedback on the course material they follow or regarding the system. They will be given a section to add their comments on the platform. For this, a feedback form will be provided.

The developed e-learning platform for hearing impaired children is based on colorful themes and colors because children require eye-catching interfaces. Figure 5 shows the home page of the platform and figure 6 shows the course selection interface of the system. Figure 7 is the signup interface for children.



Figure 5. Home Page of the System



Figure 6. Course Selection Interface

Figure 7. Sign Up Interface

#### IV. RESULTS AND DISCUSSION

Hearing-impaired children need an effective solution to continue their education in times of crisis. A typical online classroom where teachers talk, and students listen would not be effective for them at all. Therefore, an e-learning platform was proposed to be used as an alternative that hearing-impaired children can use to learn letters and numbers with proper guidelines. This allows children to draw letters and numbers on their own.

To recognize the digits and letters written by children, machine learning is used. For this, a dataset consisting of 100 images per digit was used. This data set was split into two sets. 20% were used for the training process of the dataset and 80% were used for testing. The following figure shows the accuracy of the digit recognition algorithm.

```
In [32]: #calculate accuracy
         from sklearn import metrics

In [33]: prediction = classifier.predict(test_x)
         print("Accuracy = ",metrics.accuracy_score(prediction, test_y))

Accuracy = 0.98
```

Figure 8. Accuracy of Digit Recognition

For the digit recognition 1000 images were used. In this system, the SVC (Support Vector Clustering) algorithm was used to fit the model and to calculate the accuracy. The purpose of this method is to divide the data into groups according to specific criteria and to organize data in a more meaningful way. The following figure shows one of the results taken from the system.

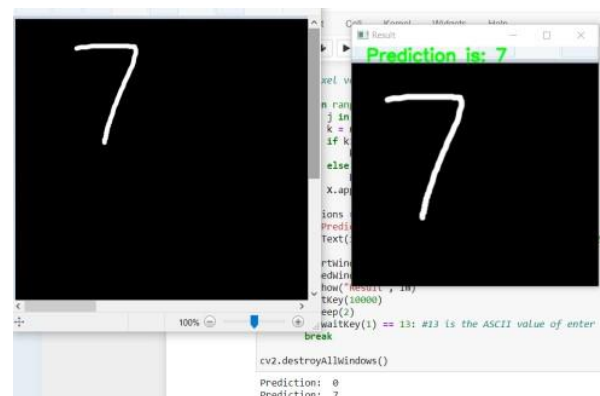


Figure 9. Prediction of Handwritten Digits

#### V. CONCLUSION AND FUTURE WORK

The main purpose of this research is to suggest a better solution for hearing impaired children to do their education in crises such as public health issues, political issues, and environmental crises. Learning letters and numbers has been a difficult task for children in times of crisis. Some of the existing e-learning platforms are not cost-effective and not as efficient as traditional education. To overcome those difficulties, we were able to develop an e-learning platform that teaches hearing-impaired children to learn and write letters and numbers step by step.

This article suggests a web-based e-learning platform that includes several course materials

that teach students how to write letters and numbers. This system will be further developed for other differently-abled children and will include more course material for other age groups.

In addition, this method of learning can be presented to a group of hearing-impaired children and obtain feedback. Based on the feedback obtained, the system can be further developed to make it more effective for children.

This platform can be very useful for children who struggle with learning letters and numbers in times of crisis. Some parents find it difficult to persuade their kids to sit in one place and study, especially when they're at home. Children seek entertaining activities. Hence, this platform will help not only children but also parents regarding the education of their children.

From the research and surveys which were carried out, we can conclude that using proper technologies during appropriate situations can enhance the education system of a country even in times of crisis.

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## An Approach to Design a Smart Helmet Using Kansei Engineering

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**Abstract**— Motorbikes have been a great medium of transportation among many people for decades. Nowadays, road accidents are much prominent on roads, and the tendency for motor bike users to get affected by those accidents is high. Owing to the reason that motorbike users are exposed to the outside world, their death rate is at a higher rate. Moreover, there is an increased rate of injury other than the deaths that occur as a result of road accidents. Though there are various helmet designs, they only ensure the safety of the motorbike riders to some extent. Therefore, there is the need to design a smart helmet that secures the lives of motorbike riders. Nevertheless, various smart helmets have been designed for the safety of motor bike riders integrating much more functionalities. This study mainly focuses on designing a smart helmet using the Kansei Engineering principles. This paper presents the design of a smart helmet that involves identifying the motorbike riders' emotions and integrating those results in designing the smart helmet.

**Keywords:** *Kansei engineering, smart helmet, human emotions, safety, designing*

### I. INTRODUCTION

At present, road accidents have reached a state that has caused fatal injuries and deaths to many people. Therefore, this crucial issue requires greater attention and this must be addressed with design approaches to the helmets that are a major component that secures the lives of motorbike users. Moreover, safety and security are crucial in every aspect of human lives and when the roads are considered (Divyasudha, et al., 2019).

Among the road accidents, motorbike accidents are increasing rapidly and have caused many deaths to road users. Helmets can reduce the

probability of the negative aspects of road accidents (Jesudoss, et al., 2019). Also, it has been compulsory for motorbike riders to wear helmets when they ride on roads and it is essential to force drivers to wear them. On the other hand, the conventional helmets are uncomfortable and inconvenient to use and thus, this results in avoiding the motorbike riders to wear them (Divyasudha, et al., 2019).

The major driving causes for society to move into the use of motorbikes is that bike riding is considered as a fun activity, cheaper to afford, flexible in traffics, and easier to park. This higher usage has also caused the tendency of insecurity the lives of motorbike users. Influence of alcohol consumption and violating traffic rules has been identified as a reason for the fatal accidents that cause on roads (Nataraja, et al., 2018) (Pathak, 2020). Nevertheless, the root cause of the accidents that occur may not be the fault of the motorbike rider but a fault of some other vehicle driver (Gour, et al., 2020).

With the development in every aspect of the fast moving world, the work associated with people increase rapidly and this results in the mental and physical nature of humans result in forgetting the wearing of the helmets (Gudavalli, et al., 2017).

The development of the smart helmet we propose is done basically using Kansei Engineering principles. Kansei Engineering was founded at Hiroshima University 35 years ago and is a strategy that converts the customer psychological feelings into design elements (Kalansooriya, 2016). Also, it can be defined as a branch of Ergonomics that focuses on developing new products based on the demands of the consumer and, therefore, as a consumer-oriented technology (Nagamachi, 1996).

The figure 1 depicts the flow of Kansei Engineering that involves the conversion of human emotions into design specifications.

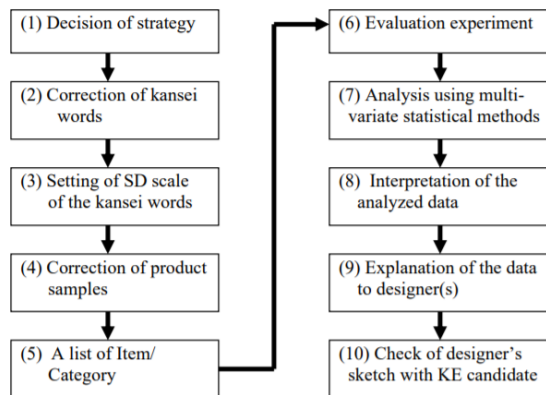


Figure 1. A diagram for the flow of Kansei Engineering

Source: (Nagamachi, et al., 2019)

Section 2 of this paper deals with the related works on smart helmet designing that identify the Kansei words for the proposed system. Section 3 presents the methodology of the proposed smart helmet that involves the Kansei Engineering principles in its approach. Section 4 presents the results of the conducted study and section 5 provides the discussion and conclusion section of this paper.

## II. RELATED WORKS

Research done by (Muthiah, et al., 2015) have designed a smart helmet for automatic control with the functionality of security system for the bike rider with the usage of exemplary helmet and maintain the control of headlamps using smart techniques such as intelligent headlamps that are capable of reacting by understanding the movement of rider's face and lead to the rotation of headlights using electric motors with the use of sensors and accelerometer. Improving the rider's vision and ensuring the safety of the rider are the main objectives that have been focused by this paper with the intention of making a prototype model. It has further concluded that with the project's progress, consciousness would rise for road security for riders.

A smart helmet has been designed by (Nataraja, et al., 2018) where they have focused on two-wheelers instead of four-wheelers as motorcyclists face fatal accidents due to

drunkenness, disobeying traffic rules; the main reason, according to them, is not wearing helmets. The suggested system is an intelligent helmet that can detect whether the rider wears the helmet or not. It has also been proposed to add a module to the bike and to the helmet to sync with each other to check whether the rider puts the helmet on. If the helmet is lost, it has provided an android application that can be used for igniting the bike using a password. Also, they have suggested reducing the size of the system by embedded components on the controller and making the system friendly, enduring and economical.

In another research, the researchers (Pathak, 2020) have designed a smart helmet with a motorbike unit for accident and rash driving detection. The helmet unit and motorbike unit are the two units discussed under the project. The helmet unit can detect the pulse rate of the motorcyclist using a pulse rate sensor to recognize whether the motorcyclist has put on the helmet or not, alcohol in exhaling is detected by sensors and further detects the positioning of legs and hands of the motorcyclist. There are GPS and GSM modules in the motorbike unit to direct a message with the location where the motorcyclist faces an accident. There is an accelerometer in both units to distinguish accidents. Rash driving, proceed vehicles towards and from behind are detected by using LIDAR sensor, place in motorbike unit which starts alarming to inform the rider and by the way a text is displayed on the OLED screen.

Researchers (Kanetkar, et al., 2020) have proposed a smart helmet wiper that detects the presence of water droplets over the eye shield through sensors and the wiper starts consequently. Adjusting the speed of the wiper is done automatically by the wiper itself and it integrates a switch at the ear shield that can be used at some instance to stop the functionality of the wiper. The main objectives of this project are to give a clear vision for the motorcyclist in the rain when he is wearing the helmet and thereby reducing road accidents that occur due to lack of clear vision.

Another system proposed by (Sasikala, et al., 2015) has aimed to safeguard motorcyclists through helmet recognition. RF communication

is used to detect whether the rider has worn the helmet and then ignites the engine to start the motorcycle. To avoid unauthorized access, a passkey is provided by the motorcyclist to start the bike.

The smart helmet Raphael designed by (Lokeshwaran, et al., 2020) has added the feature that can automatically dial to the ambulance service at the instance of an accident. Current technologies like smartphones and IoT are used in the system to maximize the system's functionality and lower the overall cost of the system.

The researchers (Rahman, et al., 2019) have designed a smart helmet indicator warning refined oil in a motorcycle with fuzzy logic and sound navigation. Though there is a fuel meter in the motorcycle, motorcyclists need an immediate warning if gasoline runs out due to some breakdown. Therefore the proposed system has the capability of indicating the level of fuel in the tank using the readings taken from buoys in the tank and then sends a voice warning to the motorcyclists through a microcontroller fixed in the tank to the microcontroller fixed on the helmet and then to the speaker attached to the helmet.

The proposed system by (Rahman, et al., 2020) consists of IR for detecting whether the motorcyclist wears the helmet or not, alcohol sensor to detect alcohol level in a breath of the motorcyclists. The system has been designed to prevent accidents and decrease the fatality of accidents by making sense in wearing helmets to ensure the safety of the motorcycle riders.

The objective of the system designed by (Chandran, et al., 2016) is to detect and report accidents to emergency contacts using a cloud-based service. Changeable variations that are taken from using accelerometer values, are sent to the processor and then to the cloud base service. Though the technology used in developing and operating the system does not give many expenses and ensures the protection of the motorists, and the safety of using this technology is not yet compromised. It has been proposed to include the feature of detecting alcohol quantity in the rider's breath in future implementation.

Another research done by (Ahuja & Bhavsar, 2018) has designed a microcontroller-based

smart helmet using GSM and GPRS. They have mainly focused on the deaths that occur due to the late arrival of an ambulance or late medical services in case of motorcycles accidents. Therefore, it has included GSM and GPRS with the microcontroller to this proposed system to receive immediate services. The sensors included in the helmet can detect when an accident is met with the rider, then the location is tracked by GPRS and using GSM, an immediate voice message and a text message are sent to the responsible individuals. They have concluded that implementing this project is better for people in rural areas with fewer facilities to obtain police, ambulance, and crowd services.

### III. METHODOLOGY

The methodology of designing the smart helmet proposed through this paper is done using the statistical procedure of the Kansei Engineering principles. The following are the basic steps that involve in the process.

1. Gather the Kansei words from the reviewed literature on smart helmets
2. The collected Kansei words are arranged in 5-point Semantic Differential(SD) scale
3. Evaluation experiment using the target group of people
4. Statistical Analysis of the Kansei words obtained from step 3
5. The highest-rated Kansei words are addressed using a questionnaire
6. Analyse the questionnaire results
7. Interpret the results to collaborate with the designers

#### A. Collection of Kansei words

Table 1. Kansei word collection

Inspiring	Attractive	Durable	Light	Safety
Relaxing	Non-distractive	Creative	Cheap	Trendy
Friendly	Comfortable	Luxurious	Heavy	Sporty
Pleasure	Satisfying	Complex	Unique	Smart
Expensive	Functional	Convenient	Stylish	Modern

Table 1 depicts the 25 Kansei words that are gathered from the reviewed literature based on smart helmet designing that can also be defined as a new database for a smart helmet. These Kansei words mirror the requirements of the

target users of the smart helmet and help propose new designs.

*B. Importance weighting using the SD Scale*

Table 2. Total Grades and weighting of Kansei words

Kansei Word	Total Grade	Importance weighting
Smart	155	0.775
Safety	164	0.82
Non-distractive	154	0.77
Comfortable	172	0.86
Friendly	120	0.6
Modern	107	0.535
Expensive	81	0.405
Attractive	172	0.86
Functional	179	0.895
Durable	137	0.685
Unique	95	0.475
Stylish	89	0.445
Cheap	96	0.48
Convenient	104	0.52
Light	131	0.655
Complex	83	0.415
Creative	93	0.465
Relaxing	108	0.54
Trendy	89	0.445
Heavy	75	0.375
Luxurious	90	0.45
Sporty	78	0.39
Inspiring	108	0.54
Pleasure	128	0.64
Satisfying	117	0.585

The 5-point SD scale is used to obtain the evaluations on the collected Kansei words. For easy evaluation, the 5-point SD scale is more suitable (Nagamachi, et al., 2008). Therefore, this SD scale is used in this research for receiving the respondent's preference. In order to determine the importance of each Kansei word shown in Table 1, those words are weighted and the most weighted Kansei words would be addressed in the questionnaire. The weight of each Kansei word is calculated as shown below.

$$\text{Word weight} = (\text{Word's total grades}) / (5 * \text{no. of participants})$$

The Kansei words along with the 5-point SD scale were distributed among 40 motorbike users. Table 2 depicts the grades and importance weightings of each Kansei word in Table 1 that

have been analysed through the results obtained from the responses from the 40 participants.

*C. Kansei words addressed in the questionnaire*

According to the word weights obtained from the importance weighting, the highest scored Kansei words are functional, attractive, comfortable, safe, smart and non-distractive.

*D. Questionnaire Formation*

The questionnaire prepared consists of four sections where section 1 involves the participants' demographic details, and sections 2, 3 and 4 deal with the functional and non-functional features of the smart helmet. Moreover, the questionnaire focuses on the six Kansei words that scored highest from the importance weighting questionnaire that was distributed in the early stages of the research. The questionnaire was distributed among the same 40 participants who were involved in rating the Kansei words.

**IV. RESULTS**

*A. Smart Helmet Appearance Analysis*

The smart helmet appearance was divided into three main sections, namely, Shape, Type and Colour.

1) *Smart Helmet Shape Analysis:* Among the shapes that are more prominent and identified as the head shapes of the individuals, Round Oval, Intermediate Oval and Long Oval were questioned by the participants for their preference. The preference was to be chosen from a five liked scale and according to the importance weighting of the results, the highest preferred shape was identified as the Intermediate Oval.

Table 3. Total Grades and weighting of Helmet Shapes

Helmet Shape	Total Grade	Importance weighting
Round Oval	138	0.69
Intermediate Oval	190	0.95
Long Oval	94	0.47

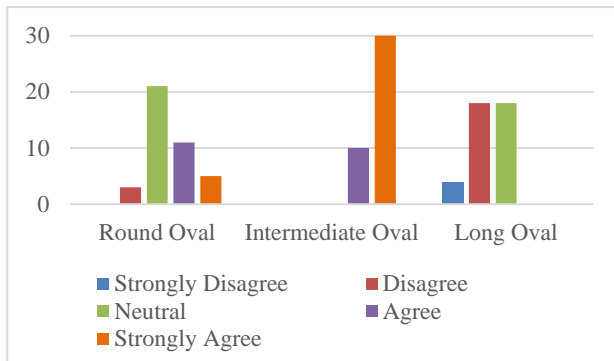


Figure 2. Smart Helmet Shape Preference

2) *Smart Helmet Type Analysis:* The participants were asked to choose between the Full face and Flip up helmets. According to the participant responses, 67.5% of the participants prefer Flip-up Helmet and 32.5% prefer Full-face helmets. With the flip-up helmet, the rider may use the smart helmet as a normal helmet.

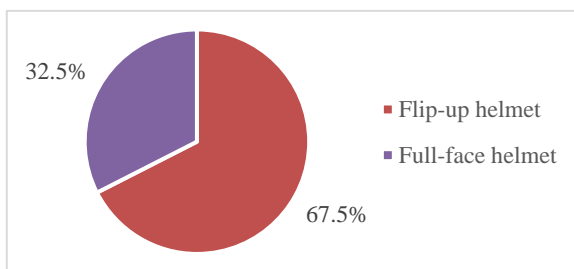


Figure 3. Smart Helmet Type Preference

3) *Smart Helmet Colour Analysis:* A range of colours was put into a liked scale for the respondents to mark their preference for using the highest preferred colour for designing the smart helmet. The colours questioned were black, ash, dark blue, yellow and white. The highest importance weighting is for the colour black and the value is 0.96. Ash, Dark blue, Yellow and White colours obtained 0.74, 0.765, 0.38, and 0.41 importance weightings respectively. Accordingly, Black colour was chosen for the smart helmet to be designed.

#### B. Smart Helmet Material Analysis

The material analysis was done for the three main components of the smart helmet, namely, Shell, Visor and Liner/Padding.

1) *Smart Helmet Shell Material Analysis:* The participants were questioned about the Composite material, Carbon fiber, Fiberglass, Kevlar, and Acrylonitrile Butadiene

Styrene(ABS) for the shell material of the smart helmet. 55% of the respondents prefer Carbon fiber as the shell material. Carbon fiber has higher durability, scratch and crack resistivity, and its strength is much higher than steel. Also, with carbon fiber, helmets can be made lighter so that much easy to be worn.

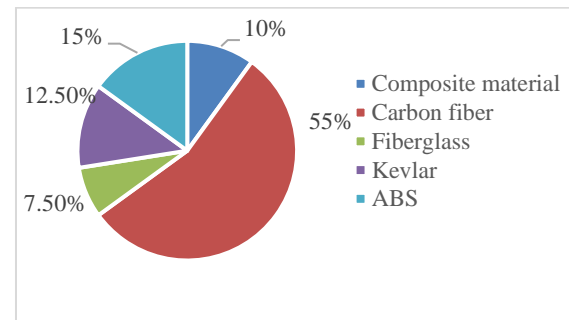


Figure 4. Smart helmet Shell Material Preference

2) *Smart Helmet Visor Material Analysis:* The participants were asked to choose between the Glass and Polycarbonates as the visor material. 67.5% of the participants prefer Polycarbonates as the visor material. Polycarbonates are with an impact of resistance a much hundreds higher than glass and with higher strength with easy installation.

#### 3) Smart Helmet Liner/Padding Material Analysis:

As the Liner/Padding material of the smart helmet, Expanded Polypropylene(EPP) foam, Expanded Polyurethane(EPU) foam, and Expanded Polystyrene(EPS) foam were questioned from the participants and 60% of the participants prefer EPP and EPS and EPU are preferred 20% each. EPP foam is highly durable, multiple impact-resistant with outstanding energy absorption, rigid and lighter.

#### C. Smart Helmet Functional Analysis

In this study, functionalities of the Smart Helmet have been divided into two sections, mainly as the smart helmet features and optional features. This division has been done based on the Kansei Keywords that have been selected at the early stages of the research process.

The optional features include the smart helmet features that are considered optional since Non-distractive is a concern in this study. Therefore, it



is optional for the respondents to select those features for the smart helmet designing.

1) *Smart Helmet Feature Analysis:* Table 4 includes the features and the respondents' preference as a percentage value for the smart helmet features questioned in the questionnaire. According to the results obtained, the features F1, F2, F6, F7, F8, F9, F10, F11 have been selected to be included in the smart helmet to be designed.

2) *Smart Helmet Optional Feature Analysis:* Table 5 depicts the results obtained for the optional features included in the questionnaire. From the results obtained, optional feature O2 has been selected for designing the smart helmet. All the other optional features are with less preference as shown in Table 5.

Table 4. Smart Helmet Features and Percentage Preference

Feature	Preference
F1. A/C Integrated	95%
F2. Camera mounted	70%
F3. Airbag integrated	35%
F4. The vehicle ignites only with wearing the helmet	20%
F5. Detecting obstacles in front	42.5%
F6. Alcohol detection and prevent starting the vehicle	92.5%
F7. Smoke detection and alerting	80%
F8. Accident detection and alerting the emergency contact with the location	82.5%
F9. Alerting on over speed	77.5%
F10. Driver drowsiness detection	55%
F11. Battery backup	67.5%

Table 5. Smart Helmet Optional Features and Percentage Preference

Optional Feature	Preference
O1. Bluetooth connectivity with the phone	47.5%
O2. Play and listen to music	87.5%
O3. Make calls	45%
O4. Voice commands	45%

#### D. Smart Helmet General Opinion Analysis

In the final section of the questionnaire, the participants were asked to provide their opinion on the concept of Smart Helmet, whether Strongly Agree, Agree, Neutral, Disagree, or Strongly Disagree. According to the results obtained, it is observed that many participants

have a positive idea of the Smart Helmet concept. 22.5% of the participants Strongly Agree and 55% of the participants agree on the concept of Smart Helmet, while 22.5% of the participants stay Neutral.

#### E. Smart Helmet Design

Figure 5 depicts the smart helmet that has been designed following the Kansei Engineering principles as discussed above. As shown in figure 5, the designed smart helmet is a flip-up helmet.

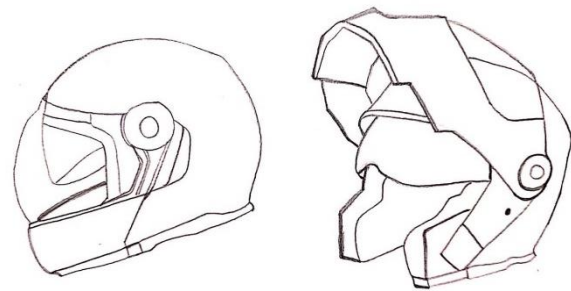


Figure 5. The Designed Smart Helmet

Although the proposed smart helmet is with a feature of A/C integration that requires a full face helmet, since the respondents prefer to have a flip-up helmet, the designed smart helmet is with the option for the user to use it as a flip-up helmet as well. Furthermore, the designed smart helmet will include all the features and functionalities that have been identified in the Results section of this paper.

## V. DISCUSSION AND CONCLUSION

The smart helmet concept is being used widely worldwide, and many such brands have taken a position in the helmet designs. Nevertheless, some countries like Sri Lanka still have not given the authority for the motorbike riders to use the smart helmet for their day-to-day ridings and on the other hand, full face helmets have also been banned by the Sri Lankan government for the general use of the bike riders. Despite this fact, when the above study is concerned, it is clear that people have a positive attitude to incorporate smart helmets for their ridings. This study has aimed to incorporate Kansei Engineering principles to the smart helmet design proposed here, which involves human emotions in the design phase.

In fact, the smart helmet concept has greatly assured the safety and comfortability of individuals with the multiple integrated features to provide the functional aspect of the smart helmets. Nowadays, accident prevention is of great concern because many valuable lives are at a higher risk of drunkenness and drowsiness. Therefore, the proposed smart helmet assures the above-discussed issues with driving. Furthermore, as discussed in the Methodology section, many more features have been proposed to be integrated into designing the smart helmet.

However, before incorporating smart helmets for general use, a much authentic evaluation must be carried out to guarantee the safety and efficiency of the motorbike users and other road users. Moreover, individuals must be made well aware of the use of the new technology. In addition, since this paper presents a Kansei engineering approach that identifies the design considerations along with the appearance and the functionalities to be integrated while developing a smart helmet, there is a significant and essential need concerning the health aspects while designing the smart helmet that is proposed here. Therefore, the authors suggest obtaining the ideas of the relevant medical authorities and researchers while developing the smart helmet that is proposed, ensuring the safety of the bike riders who are to wear this smart helmet.

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# Image Captioning in Tamil Language with Merge Architecture

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**Abstract**—Image Captioning is the process of describing the content of an image using a natural language. This task that involves computer vision and natural language processing has been attempted on the English language with enormous success, owing to the presence of massive image-caption paired corpora as Flickr and Microsoft Common Objects in Context (MS-COCO). However, such developments in this arena have been a novelty for non-English languages with the exception of a few such as Chinese, Turkish, German and Arabic. In the case of Tamil language, this premise has been barely touched upon, due to the lack of a large, paired corpus. In this work, a paired corpus inspired from Flickr30K dataset has been created in Tamil language for the image captioning purpose. Along with it, this paper includes the experiments with an image captioning model, using a combination of Convolutional Neural Network (CNN) and Long Short-Term Memory (LSTM) architecture; specifically the Merge model for Tamil language caption generation. This methodology incorporates the image vectors in a layer following the LSTM layer. The results of the research have proven satisfactory in the evaluation with a Bilingual Evaluation Understudy (BLEU) score of 0.37, and this indicates further development with the presence of a more refined and improved dataset.

**Keywords:** *Tamil caption generation, convolutional neural network, long short-term memory, natural language processing*

## I. INTRODUCTION

Image Captioning refers to describing an image on what is portrayed in it including the entities present and the actions performed by identifying the objects, their attributes, and their relationships in the image. This task involves two of the major fields in Artificial Intelligence:

Computer Vision and Natural Language Processing. For an input of an image, an output of syntactically and semantically correct and meaningful sentence is expected as a caption in a typical image captioning task. Image captioning has several applications in the natural language processing domain such as recommendations in editing applications, in virtual assistants, usage in social media and more. This is incredibly useful in aiding the visually impaired to provide them with an understanding of their surroundings. Image Captioning is a promising premise with various applications in its wake involving Natural Language Processing. Several remarkable developments have been made in the past in Image Captioning in the English language, except for a very few non-English languages as Chinese (Zhang C et al. 2018), Turkish (Yilmaz BD et al., 2019) and Arabic (Al-Muzaini HA, Tasniem N and Benhidour H, 2018) using deep-learning in handling the complexities for semantically complex languages.

As the number of large datasets increase, many deep learning-based techniques have come to hold great promise in their performance and accuracy in image captioning tasks. Many of these technologies addressed for English language (Chen X and Zitnick CL, 2015; Karpathy A and Fei-Fei L, 2015; Vinyals O et al., 2015; Xu K et al., 2015), along with the non-English ones, have made use of the Long Short-Term Memory (LSTM) networks, a special type of Recurrent Neural Networks (RNN). The technique utilized in this study involves a combination of Convolutional Neural Network (CNN) and LSTM architecture. Most of these previous works has used CNN as an image encoder by first pre-training it for image classification and using the last hidden layer as an input to the LSTM decoder that generates captions.

Since the Flickr30K (Plummer B et al., 2015) and Microsoft Common Objects in Context (MS-COCO) (Lin T et al., 2014) corpora are addressed for English with English caption dataset, several non-English languages have attempted image captioning by translating the dataset to the corresponding languages. Among such works, the ones on Arabic, Turkish and Chinese stand remarkable for their technique used in creating the image captioning dataset in their respective languages. Al-muzaini HA, Tasniem N and Benhidour H (2018) have created an Arabic version of a combination of Flickr and MS-COCO datasets and have used a deep LSTM-CNN model on the dataset with 'Merge' architecture with promising results. In this work, the authors have surmised that the results could be improved with much larger dataset, with the implication that Arabic is a morphologically complex language compared to English. Considering the similarity in the complexity of the language and the promising performance of Merge architecture in Arabic, this is chosen to be carried out for Tamil as well.

As for Image Captioning in Turkish language done by Yilmaz BD et al. (2019), their methodology has involved an encoder-decoder model inspired from the work of Vinyals O et al. (2015) consisting respectively CNN and RNN. They have defined the CNN portion of the model to extract the features of the image dataset and the RNN part to generate the Turkish captions. To build the Turkish dataset, the authors have utilized machine translation on MS-COCO dataset. This approach is fairly like the work on Arabic except for the difference on the architecture. Zhang C et al. (2018) have described a Recurrent Attention LSTM (RAL) model for the image Chinese Caption generation. This model has utilized Inception-v4, a CNN model, to extract image features and the RAL model mechanism determines feature weights. In these works, the models used are based on the CNN-LSTM architecture to extract features and generate captions with a few variations. This often-used CNN-LSTM architecture, also referred to as Encoder-Decoder, was first proposed by Vinyals O et al. (2015), based on a CNN acting as an encoder, which is followed by an RNN which generates the caption for English, thus becoming the Decoder. The non-English works stated above utilize machine translation and human effort to build and

refine their dataset and then proceed to apply the deep learning model to the dataset. Due to its consistent performance with non-English languages, this architecture which is referred to as 'Neural Image Caption' (NIC) generation is used in the research study for a comparative analysis against the Merge architecture in its performance with Tamil dataset.

A few other non-English works have compensated for the lack of large datasets in their languages by utilizing techniques as Unpaired Image Captioning by Language Pivoting and Image Captioning using Multilingual Data, which enables them to make use of English datasets to suit their requirements. However, these techniques often involve parallel corpora in large scale which are unaffordable resources for this project at this stage. Gu J et al. (2018) have attempted a method of capturing the characteristics of an image captioning component from the source language and align it to the target language using another source-target parallel corpus. The proposed framework is composed of an encoder-decoder model that can describe images in the pivot language and another encoder-decoder model (Neural Machine Translation model) to translate sentence from pivot language to target language. In this work, the authors have assumed of Chinese as a resource-rich language and English to be the resource-scarce, target language, wherein Chinese is used as the Pivot language and the results have outperformed the baseline methods on MS-COCO and Flickr30K databases. This involves the use of two different datasets to train both the image caption generation model and the machine translation model along with a Pivot-Target parallel corpus. Due to the heavy requirement of large datasets for the two models involved, this method is unsuitable for the scope this research aims for.

Beyond the use of pivot language technique, Jaffe A (2017) has proposed the use of a training corpus composed of both German and English captions to generate image captions in German, while ignoring the English output during evaluation. In this work, the German caption dataset has been created not necessarily as the direct translation of its English counterpart. Mostly, the German captions have been manually created to suit the image rather than to be a translation of the



English dataset. In the case of Tamil, this implies the necessity of manually curated set of datasets.

## II. METHODOLOGY

As aforementioned on the existing methodologies for image captioning for English and non-English languages, the method analysed by H. A. Al-muzaini, N. Tasniem and H. Benhidour (2018) in the creation of an Arabic version of a combination of Flickr and MS COCO corpus and the usage of a deep Long Short-Term Memory Network and Convolutional Neural Network (LSTM-CNN) model on the dataset with 'Merge' architecture has been chosen as the high-level methodology for this study as well.

### Dataset Pre-processing



Figure 1. Flickr30K Sample Image

Flickr30K dataset contains 31,783 images and each comes with five English sentences, forming around 150,000 sentences which have been translated to Tamil, the target language. Figure 1 is a sample image from the Flickr30K image dataset. Its paired text corpus in English have been translated to Tamil respectively without losing the core meaning to be used in the training.

- i. A man in a blue baseball cap and green waders' fumbles with a fishing net in a blue boat docked beside a pier: ஒரு நீல பேஸ்பால் தொப்பியில் ஒரு மனிதன் ஒரு நீலப் படகில் ஒரு மீன்பிடி வலையுடன் தடுமாறினார்.
- ii. A bright blue fishing boat and fisher at dock preparing nets: பிரகாசமான நீல மீன்பிடி படகு மற்றும் கப்பல்துறையில் மீனவர் வலைகள் தயாரித்தல்.
- iii. A man in a small boat readies his net for the day ahead: ஒரு சிறிய படகில் உள்ள ஒரு

மனிதன் தனது வலையை அடுத்த நாளுக்குத் தயார் செய்கிறான்.

- iv. A lone fisher is on his boat checking his net: ஒரு தனி மீனவர் தனது படகில் தனது வலையை சரிபார்க்கிறார்.
- v. Man in blue boat holding a net: நீலப் படகில் வலையை வைத்திருக்கும் மனிதன்.

Machine translation using Google Translator was used to translate the text corpus to Tamil and owing to the inaccuracy in the translations, they were reviewed and cleaned as required. The translated sentences were reviewed by native Tamil speakers to rectify the issues and discrepancies in the text by removing redundant words, untranslated English words, meaningless characters and rephrasing the text to make it more meaningful by clearly explaining the entities and their actions. Majority of the efforts were invested in translating the words which were unable to be translated by the Google Translator during the bulk translation process. The translated sentences were stored in a text file with UTF-8 encoding and the pre-processing process was conducted. The dataset was split into two for training and validation purposes in the 75:25 ratio, respectively. This resulted in 23837 images in the Training dataset and 7946 images in the validation set.

### Model

The difference in Neural Image Captioning (NIC) discussed in Vinyals O (2015) in Figure 2 and the Merge model analysed by Tanti M, Gatt A and Cammilleri KP (2017; 2018) as in Figure 3 is based on the variations in performance when the feeding of image dataset to the neural network, either by directly incorporating it in RNN or in a layer following RNN (Merge). Although Merge and NIC architecture differ with regards to where the image is inserted, Merge architecture has been stated to make better use of the RNN memory and they require less regularization than the others.

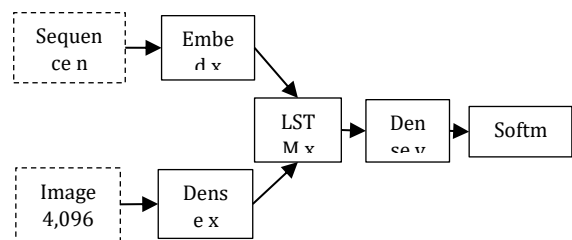


Figure 2. Flow of Neural Image Captioning Architecture (Vanilla CNN-LSTM).

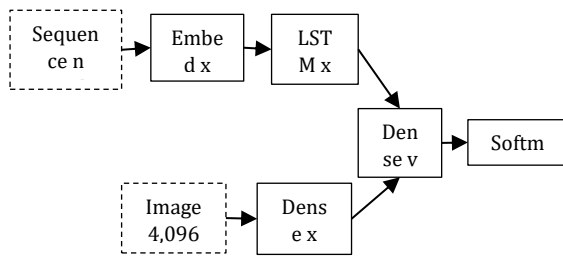


Figure 3. Flow of Merge Architecture used in Arabic and Turkish Image Captioning.

Rather than combining image features together with linguistic features from within the RNN, merge architectures delay their combination until after the caption prefix has been vectorized. This keeps the image out of the LSTM and would be capable of training the part of the neural network that handles images and the part that handles language separately. To be succinct, the RNN is not exposed to the image vector directly at all. Instead, it opts to introduce the image vector into the language model after the prefix has been encoded by the RNN to the entirety. To develop the Deep learning model in Merge architecture, the datasets (image and text) were loaded, and the vectorization of text was done with Keras Tokenizer class. Then the pretrained model and the sequence processor (a word embedding layer handling the text input with LSTM followed by it), result in a fixed length vector which are merged and processed by a Dense Layer. Then the model is fit to the dataset and is evaluated. The architecture of the of the “Merge” approach in the model is shown in Figure 2. An experiment was conducted with the existing architecture with and without the inclusion of mapping of input layer to the 300-d embedding vectors for Tamil from fastText (Bojanowski P et al., 2016). As displayed in figure 3, after the FastText 300-d Tamil embedding, the dropout layer follows which is then fed into the LSTM for processing the sequence. The attempt with the model created with the inclusion of FastText embedding vectors resulted in more comprehensive text sequences than the one without the Embedding vector.

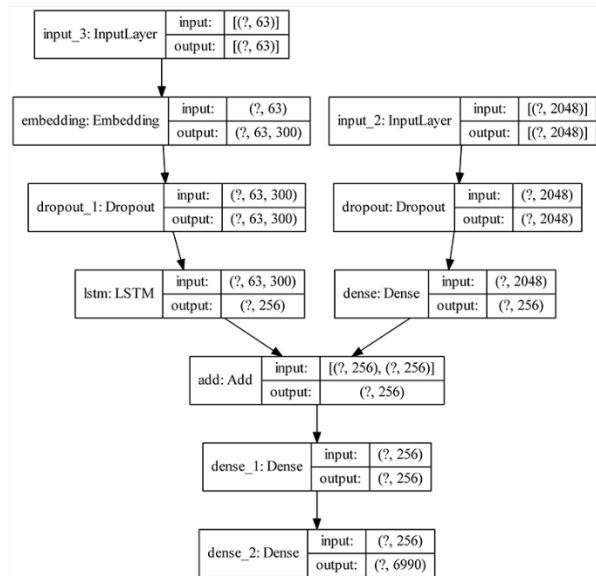


Figure 4. Merge Model Summary with 300-d FastText word vector

The Figure 4 refers to the Merge methodology where the image is left out in the LSTM network such that the LSTM manages only the caption prefix. As the prefix is encoded, the image vector is merged with the prefix vector in a separate layer. The merged vector is handled in a feedforward layer. With the development of the Deep learning models with 20 individual models which were received as an outcome of 20 epochs, the model with less Cross-entropy loss while ensuring that the model does not overfit was chosen to proceed with. The pretrained word vectors of 300-d from fastText for Tamil was chosen to be included in the research. The image captioning process can be grouped into three modules as Image Feature Extractor, Sequence Processor and Decoder. The following subparagraphs give a general introduction of the components of our model.

*1. Image Feature Extractor:* VGG16 and Inception-V3 were finalized among the five pretrained models available on Keras. Among them, VGG-16 was used to test the proof-of-concept with 8092 images dataset derived from the Flickr30K dataset. The results were satisfactory considering the performance of VGG-16 for other non-English complex languages. However, Inception-V3 being a more advanced CNN model, has better performance on ImageNet dataset in comparison with VGG-16. Hence, Inception-V3 pretrained on ImageNet dataset was chosen as the finalized CNN model for the research. The images were pre-

processed with the Inception-V3 model without the output dense layer since the research does not involve any image classification functionalities. The extracted features predicted by this model will be used as the input for the SoftMax layer.

**2. Sequence Processor:** The Sequence Processor is a word embedding layer for handling the text input, followed by a LSTM Recurrent Neural Network layer as stated previously. Word embeddings, that is, the vectors that represent known words prior to being fed to the RNN, consist of vectors that have been randomly initialized. The purpose of the LSTM, a type of RNN, is primarily to take a prefix of embedded words and produce a single vector that represents the sequence. The LSTM neural-language model begins with 'startseq' token, an artificial word placed at the beginning of each generated caption as a prefix when predicting the first word. The same way, there will be an 'endseq' token denoting the end of the caption sentence.

**3. Decoder:** The Decoder merges the vector output from the extractor and Sequence Processor, wherein the merged output is processed by an output 'SoftMax' layer to make a final prediction

iii. BLEU-3: 0.188267  
iv. BLEU-4: 0.086652

over the entire output vocabulary for the next word in caption until the 'endseq' token is reached.

#### *Experiment with a subset of Flickr30K dataset*

During the early stage of the research, the Proof-of-Concept was tested with an 8092-image dataset curated from the Flickr30K dataset along with its Tamil paired corpus. The dataset was split into 6092 images for training and 2000 images for testing. The model that was trained on the training dataset in the Merge architecture for 20 epochs with 6092 steps had a loss of 3.04 and had satisfactory outputs. This involved the use of VGG-16 CNN model and the fastText word vectors for Tamil were not used. The loss function that was used is categorical cross-entropy. The aim of this is to minimize the loss to minimize the difference between the distribution of the predicted sentences and the actual captions of the image given in the training data.

The 8K model was evaluated on the test dataset on the Bilingual Evaluation Understudy (BLEU) (Papineni K et al., 2002) score. To this project we calculate BLEU scores for unigrams to 4-grams (BLEU-1 to BLEU-4 respectively) to evaluate the chosen model. As for this experiment, the BLEU scores are as follows:

- i. BLEU-1: 0.468239
- ii. BLEU-2: 0.288166

As per the BLEU metric definitions, the 0.46 score refers to high quality captions. In the trial run with the

8K set, a greedy search was used for the caption prediction. This means the model generates the caption word-by-word, as in, it uses the previously generated words to generate the next word.

Using the results from the 8K dataset experiment, a few changes were made to the training of the 30K dataset by swapping VGG-16 with Inception-V3 and including a word representation vector from fastText for Tamil. The latter is a pre-trained word vector for Tamil language, trained on Common Crawl and Wikipedia using fastText. Besides, the Greedy search was switched with Beam search for predictions. In contrast, Beam Search expands the scope of Greedy search and takes the best 'N' words out of the predictions. The hyperparameter 'N' is known as the Beam width and we used 3, 5, 7 and 9 as the Beam width for generation. But, the evaluation with 30K dataset was conducted with beam width 5.

### III. RESULTS & DISCUSSION

Although the results from the 8K dataset experiment had a good BLEU score, it had its limitations due to the use of Greedy search for the caption generation. The generated caption for the Figure 5 is as follows:

*ஒரு மனிதன் ஒரு பெரிய கட்டிடத்தின் முன் ஒரு பெரிய கட்டிடத்தின் முன் நிற்கிறான்.* (A man stands in front of a big building).



Figure 5. A sample image used for testing.

However, there is a noticeable issue in the generated caption regarding the repetition of the underlined phrase in the sequence. Although it does not affect the meaning of the caption, it is an obvious inconvenience which could destroy the meaning of caption in any other circumstances.

Nevertheless, with the observations made from the 8K model, the 30K model training with the inclusion of Inception-V3, Tamil word vector representation from fastText and Beam search algorithm was conducted. The Loss vs Epochs graph in Figure 6 for the 30K model for its first 10 epochs proved that the model has a good learning rate, and it could be improved with a much higher value of epoch. Hence, the model was trained until 20 epochs, resulting in a model with 3.59 loss in the 20th epoch model.

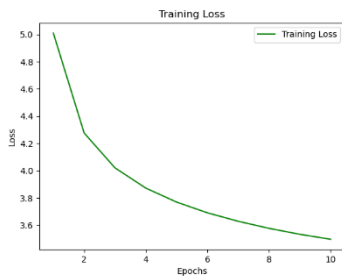


Figure 6. Training Loss vs Epoch graph for 30K model for 10 epochs.



Figure 7

A few examples of captions generated by the model can be observed in the Figure 7. The BLEU scores for 30 K using the test dataset are:

- i. BLEU-1: 0.370611
- ii. BLEU-2: 0.217844
- iii. BLEU-3: 0.160439
- iv. BLEU-4: 0.077670

The scores are comparatively lower than that of the 8K model, but their performance in the caption generation has been more than satisfactory. Regardless of the performance, this model consists of limitations when faced with images with entities which were not included in the training dataset. An example is the Figure 8 and its generated caption which Figure 7. Best



Tamil Captions Generated by the model. The English translations are provided for the reader's comprehension.

misidentifies the laptop as a book is shown below:  
ஒரு பெண் ஒரு மேஜையில் உட்கார்ந்து ஒரு புத்தகத்தைப் படிக்கிறாள். (A girl sitting at a desk is reading a book.)



Figure 8. A sample image used for testing.

#### IV. CONCLUSION

This paper is a preliminary study on the potential of generating captions for images in Tamil language. This research has utilized the "Merge" model architecture proposed by Tanti M, Gatt A and Cammilleri KP (2017) and the methodology carried out for Turkish language in by Yilmaz BD et al. (2019, pp. 1-5). This Merge model is a variant of the CNN-LSTM model proposed by Vinyals O et al. (2015). This study began with the creation of a paired 30K dataset in Tamil inspired from the Flickr30K dataset using machine translation and manual review process. There are a few limitations in the caption generation as to the inaccurate identification of the model in certain unique entities which were not present in the training dataset. The results obtained through this research certainly proves that the performance of the model can be improved further with a more refined corpus.

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# Finding the Best Feature Selection Method for Dengue Diagnosis Predictions

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**Abstract**— Dengue is a mosquito-borne viral disease that has dramatically increased around the world in recent years. The spread of Dengue depends on the tropics, rainfall, temperature, relative humidity and unplanned urbanization. Severe Dengue can lead to circulatory system failure, shock and even death. The development of an effective Dengue fever prediction model is therefore essential for better Dengue case management. Feature selection is the predominant phase in developing the Dengue diagnosis prediction model. It is required to identify the most crucial attributes, as not all attributes have notable effects on the results. Therefore, this study focuses on the feature selection methods such as Principal Component Analysis (PCA) and Wrapper feature selections method with Naïve Bayes, K-Nearest Neighbor (KNN), and J48 algorithms. Simple Artificial Neural Networks (ANN) were developed to validate the performance based on the accuracy of each feature selection method, since it can work well with the partial dataset. Myalgia and Retro-Ocular Pain are the most expressive features chosen by all wrapper feature selection methods. In addition, with PCA, the initial 22-dimensional system was reduced to an 8-dimensional system with a cumulative variance of 59%. ANN with PCA resulted in the higher accuracy of 72.47% and ANN with Wrapper feature selection (KNN) showed the lowest accuracy of 54.47%. In conclusion, PCA is identified as the best feature selection method for the given dataset in this study based on the accuracy of ANN. In future, multiple Dengue diagnosis prediction models can be developed with higher accuracy and efficiency using the most vital attributes.

**Keywords:** *feature selection, artificial neural networks, dengue diagnosis prediction models*

## I. INTRODUCTION

Dengue is a mosquito-borne viral disease that has dramatically increased around the world in recent years (World Health Organization, 2016). According to the World Health Organization (WHO), the spread of Dengue is influenced by the tropics, rainfall, temperature, relative humidity, and unplanned rapid urbanization (World Health Organization, 2016). In part Dengue spread fast in urban areas when the mosquito population increase during the rainy season (Cetiner, Sari and Aburas, 2009). Dengue viruses are infected on humans through the bites of an infective mosquito, which acquires the virus while feeding on the blood of an infected person. The person infected with the Dengue virus serves as a source of the virus for uninfected mosquitoes and becomes the main carrier and multiplier of the virus, and transmits it via Aedes mosquitoes (World Health Organization, 2016). The basic symptoms of Dengue are sudden high fever, pain in the eyes, muscle & joint pain, bone pain, severe headache, and a skin rash with red spots. Severe Dengue may cause complications related to internal bleeding, organ impairment, and plasma leakage (World Health Organization, 2016). Severe Dengue situations could show abdominal pain, vomiting, diarrhea, convulsions, bruising, and uncontrolled bleeding. Dengue fever can last up to 7 days, however, this can lead to complications like circulatory system failure and shock. If the severe Dengue has not been treated appropriately, it may lead to death (Pham *et al.*, 2018).

## II. LITERATURE REVIEW

Early diagnosing of Dengue is a cyclic need in the health system. It helps in improving the diagnostic time, cost, and reduces the pain (Mello-Román *et al.*, 2019). Dengue is genediagnosed checking blood pressure, heart rate, and body temperature. Comprehensive laboratory analysis must be done on the full blood count, which includes haematocrit, platelet, and white blood cell counts (Dasgupta *et al.*, 2019). Laboratory analysis depends on human work. Human involvement, however, contributes to the misidentification of Dengue and non-Dengue patients, which leads to negative medical results. Therefore, early diagnosis of an affected person without human errors is critical (World Health Organization, 2016; Mello-Román *et al.*, 2019). The development of an effective Dengue fever prediction model is therefore essential for better Dengue diagnosis (Binti Mohd Zainee and Chellappan, 2016). Feature selection is an important phase in developing the Dengue diagnosis prediction model using classification. It is a process; which selects the attributes most relevant for the prediction problem in the dataset. Clinical features of Dengue fever vary according to the age of the patient and not all attributes have significant effects on the result (Davi *et al.*, 2019). Therefore, it is required to identify the most significant attributes and avoid the least significant attributes when developing a Dengue diagnosis prediction model. The use of feature selection models has an enormous impact on developing prediction models, and it will improve the accuracy and efficiency (Dasgupta *et al.*, 2019). The purpose of this study is therefore to evaluate the performance of feature selection methods that can be used to develop a Dengue diagnosis prediction model. This study focuses on the Principal Component Analysis (PCA) and Wrapper feature selection methods with Naïve Bayes, K-Nearest Neighbour (KNN), and J48.

### A. Attributes used in Dengue diagnosis prediction models

In general, Dengue-related data can be collected and categorized under four areas: environmental, epidemiological, personal information, and socio-economic data (Dharmawardana *et al.*, 2018; Pham *et al.*, 2018). Environmental features include factors such as rainfall, humidity,

temperature, and wind speed (Cetiner, Sari and Aburas, 2009; Dharmawardana *et al.*, 2018; Chovatiya *et al.*, 2019). Socio-economic features consist of aspects such as population, year, poverty, and administrative boundaries. Personal features, such as age, sex, travel, and camping near to water source also contributed to Dengue prediction. Importantly, the epidemiological features play a crucial role in predicting Dengue. Although all four categories can be used for the Dengue diagnosis prediction models, epidemiological factors are important attributes in prediction models. Epidemiological factors are the attributes that were unused-time medical situations, and it directly affects the medical diagnosis of Dengue such as Body Temperature, Retro-ocular pain, Platelet count, White blood cell count, and Hematocrit. Environmental, socio-economic, and personal information factors play a significant role in Dengue diagnosis; however, they do not directly affect it.

### B. Feature selection methods used in Dengue diagnosis prediction models

Data pre-processing is a crucial step in developing prediction models as it directly affects the quality of the model and the ability of the learning process of the prediction model (Dhairya Kumar, 2018). The raw data might consist of many variations in the values of each feature, which might lead to incorrect results (Manivannan and Devi, 2018). Therefore, it is crucial to pre-process the data before it can be used (Dhairya Kumar, 2018). Researchers have been using various pre-processing steps to handle missing values, normalize the values, feature selection, and splitting data into the training set and validation set. Out of them, the feature selection is crucial to identify features that have no significant effects on the results and to remove them (Muhilthini *et al.*, 2018). Mello Roman, and others have selected the features which were only used to confirm laboratory diagnosis based on their knowledge of the domain to develop the Dengue diagnosis model (Mello-Román *et al.*, 2019). Adbiel has used the neural pathway strength feature selection method (NPSFS) to identify the most relevant inputs, by creating an ensemble of ANN's and comparing the similarities of the weighted results of the pathway. Attributes with the most similarity of pathway strengths across the whole ensemble of ANNs were selected as the most

relevant (Laureano-Rosario *et al.*, 2018). Chovatiya, has used Pearson's Correlation formula to calculate the correlation coefficient between the total numbers of cases with all the other attributes. Pearson's Correlation formula is used to calculate the correlation coefficient between attributes and target along with the ranker search method. The attributes with a maximum correlation coefficient have been selected for further processing in their study (Chovatiya *et al.*, 2019). Similarly, Nishanthini and others used a correlation analysis between each weather variable with the Dengue cases reported was carried out using the weather variables with time lags. The attributes holding the highest correlation to Dengue cases were chosen as input parameters (H.M.NishanthiHerath, Perera and Wijekoon, 2014). However, the statistical feature selection is mostly applied when the number of features is higher, and it was intended to reduce the number of attributes otherwise the domain knowledge is wildly used in feature selection. An appropriate feature selection method should be applied based on the situation uniquely for each dataset.

*C. Dengue diagnosis prediction models developed*  
Multiple Dengue diagnosis prediction models have been developed based on selected features. Jorde and others have used ANN and Support Vector Machine (SVM) to develop a Dengue diagnosis prediction model based on epidemiological data of 4332 registered Dengue cases from the public health system of Paraguay. The missing values of data were excluded, and principal factors were replaced with the mean of adjacent data. ANN with multi-layer perceptron resulted in 96% accuracy and ANN with radial basis function resulted in 55% accuracy. SVM with

linear function given the accuracy of 64%, SVM with Gaussian function given the accuracy of 86%, and SVM with polynomial function given the accuracy of 92%. ANN with multi-layer perceptron and SVM with the polynomial function showed the highest performance in their kinds. (Mello-Román *et al.*, 2019). In another study, Norhayati and Kalaivani utilized epidemiological features collected from 60 patients and used algorithms such as Decision tree, Discriminant analysis, SVM, KNN, and Ensemble Classifiers. Out of all these methods, the Discriminant Analysis has the highest accuracy (83.3%) and SVM has the lowest accuracy (63.3%) (Binti Mohd Zainee and Chellappan, 2016). Furthermore, Anusha used 60 instances of epidemiological data that consisted of 11 attributes with algorithms, such as Rule-based classifier, KNN, ID3, Naïve Bayes, and Decision tree. Out of these algorithms, Naïve Bayes has given the highest accuracy of 72.2% and KNN showed the lowest accuracy of 50% (Anusha, 2019). In another study, conducted by Harshada and Pramod have used real-time data of Heart Rate, Body Temperature, Blood Pressure, and other epidemiological factors to diagnose Dengue. They specifically used Naïve Bayes algorithms for the probability calculations (Somwanshi and Harshada, 2018). Similarly, Manivannan and Isakki used 1910 instances that consisted of 171 attributes with K means clustering to identify the serotypes of Dengue (Manivannan and Devi, 2018). Furthermore, Sanjudevi and Savitha have used epidemiological data with 108 instances that consisted of 18 attributes to develop a Decision tree and SVM with Sequential Minimal Optimization. Here, the accuracy of the Decision tree was 87.5% and SVM with Sequential Minimal Optimization was 99% (Sanjudevi and Savitha, 2019).

### III. METHODOLOGY AND EXPERIMENTAL

#### DESIGN

The dataset used in this study consist of epidemiological features of previous Dengue patients. Feature selection methods are applied to the given data set to determine the most relevant attributes and evaluate the impact of the feature selection process on the Dengue diagnosis prediction model. Figure 1 shows the proposed methodology of this study. First, the

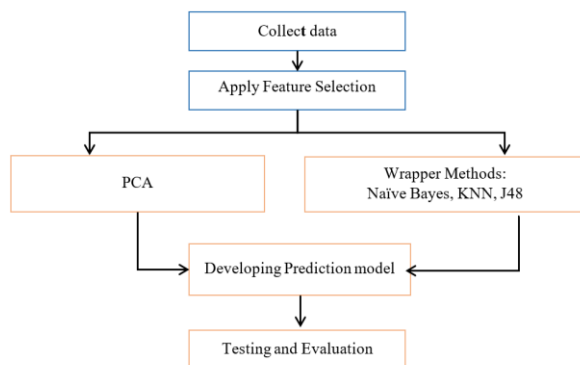


Figure 14. Proposed Methodology

dataset is collected from the scholars of a study conducted at Paraguay (Mello-Román *et al.*, 2019). Then the dataset is used for feature selection and train prediction models. PCA, Wrapper feature selection with Naïve Bayes, KNN, and J48 were applied to select the most sign noteworthy features on selected features ANN models were built for the task of Dengue diagnosis prediction problem and its accuracy was used to evaluate the performance of the feature selection method.

PCA is a statistical and unsupervised dimensionality reduction technique, which has been widely used in data mining problems. It projects the high dimensional space to a low dimensional space while improving the efficiency and accuracy of the data mining task. It is based on the eigenvectors analysis to identify critical original features for the principal component. PCA determining key variables in a high-dimensional data set and simplifies the analysis and visualization of high-dimensional data set, with less loss of information. In simple terms, PCA generates a new set of variables, called principal components. Each principal component linearly combines the original variables and works based on eigenvectors analysis to identify critical original features for the principal component. Secondly, Wrapper feature selection methods were used. As classifiers to the Wrapper feature selection method, Naïve Bayes, KNN and J48 were used along with the best-first search in the forward direction. Naïve Bayes is a probabilistic machine learning algorithm based on the Bayes theorem. It works as the probabilistic classifier of all attributes contained in the data sample individually and then classifies the data problem, KNN is an algorithm that stores all available training data and to predict, the algorithm chooses the closest data points in the training dataset, and J48 is an algorithm to generate a decision tree.

ANNs were developed to validate the performance of the feature selection methods. it can easily expand and can work with large numbers of features and datasets. More importantly, it can work well with partial data due to its structure. Therefore, in this study, ANN was chosen to evaluate the performance of feature selection algorithms. The selected features from each feature selection method were used to

develop the ANN, which evaluated the selected features based on their accuracy. ANN had input neurons and output neurons, and connections between neurons. The connections between neurons are defined by a weight associated with each connection (Khemani, 2013). This model has three layers. The first layer is the input layer and it uses the 'relu' activation function. The second layer is the dropout layer, which is used to randomly remove the interconnection between nodes with a frequency of 0.5. It helps to prevent the overfitting of the model, by not letting the model memorize the pattern, each time the modal has mustrn new patterns. The final layer is the output layer, it is used to produce the output of the model. It uses 'sigmoid' as the activation function. For every input, it keeps the output between 0 – 1. Apart from these, Adam Optimizer was used, which is computationally efficient and works well with a noisy and large amount of data. Along with that, batch sizes of 32, learning rates of 0.1, and 50 epochs were used.

#### D. Dataset

The medical dataset of previous Dengue patients (2012 – 2016) was obtained from a study conducted in Paraguay, Mexico titled “Predictive Models for the Medical Diagnosis of Dengue: A Case Study in Paraguay” (Mello-Román *et al.*, 2019). This dataset consists of 668 instances with 23 Dengue fever vital sign attributes. Table 1 shows the attributes and their descriptions. Only cases confirmed or discarded with the laboratory criteria were included in the dataset (Mello-Román *et al.*, 2019). Further, this data set is already preprocessed; importantly, all the missing data were imputed. Therefore, the dataset is directly applied to feature selection methods.

## IV. RESULT & DISCUSSION

PCA, where it generates a new set of variables, called principal components. Each principal component linearly combines the original variables and works based on eigenvectors analysis to identify critical original features for the principal component. Table 2 shows the eigenvalues of principal components and their variance. An eigenvalue is a number that shows the spread out of the data.



Table 1. Attributes and their descriptions (Mello-Román *et al.*, 2019)

I. Attribute	II. Description
Age	Age
Sex	Sex
Headache	Symptom of headache
Myalgia	Symptom of muscle pain
Arthralgia	Symptom of joint pain
Retro-Ocular Pain	Symptom of pain around the eye
Pruritus	Symptom of unpleasant sensation in the skin
Cough	Symptom of cough
Dyspnea	Symptom of breath shortness
Epistaxis	Symptom of nose bleeding
Gingivorrhagia	Symptom of bleeding from gums
Melena	Symptom of black stool with bleeding
Black Vomiting	Symptom of black vomiting
Exantema	Symptom of rash or eruption on the skin
Conjunctive Injection	Symptom of enlargement in conjunctival vessels
Tachycardia	Symptom of high heart rate
Hepatomegaly	Symptom of enlarged liver
Splenomegaly	Symptom of enlargement of the spleen
Sensory Alteration	Symptom of changes in the sensory stimuli
Stiff Neck	Symptom of stiff neck
Petechia	Symptom of red dots in the skin
Jaundice	Symptom of Jaundice
Final Class	Laboratory confirmation of Dengue

An eigenvalue less than 1 means that the principal component explains less strength than a single original variable explained. Therefore, principal components which have an eigenvalue greater than or equal to one taken into consideration. As showed in Table 2, the first eight principal components can be taken into consideration since those principal components have eigenvalues greater than one. Thus, it can be concluded that the initial 22-dimensional system can be reduced to an 8-dimensional system with a cumulative variance of 59%. Figure 2 interprets the distribution of eigenvectors between the first and second principal components. The first principal component has a variance of 12%. Moreover, it has a large positive association with Hepatomegaly, Jaundice, Splenomegaly, and Sensory alteration. These can be categories into

severe Dengue symptoms. Large negative association with Myalgia, Arthralgia, Headache, and Retro ocular pain. Where it can be considered as the basic Dengue symptoms. However, the second principal component shows a significant difference. It has no positive associations with any features. It has a large negative association with Hepatomegaly, Splenomegaly, and Dyspnea. Similarly, Tachycardia, Dyspnea, and Cough are the large positive association of the third component, and Black vomiting, Melena, and Gingivorrhagia are the large negative association of the third component. The ANN Model developed using PCA gives an accuracy of 72.47%. Further, in the Wrapper feature selection, with the Naïve Bayes algorithm; Myalgia, Retro-Ocular Pain, Dyspnea, and Petechia were selected; ANN model developed with these features has an accuracy of 55.97%, similarly in the K nearest neighbour; Myalgia, Retro-Ocular Pain, and Exanthema were selected; ANN model developed with these features has an accuracy of 54.47%. In J48; Myalgia, Retro-Ocular Pain, Tachycardia, and Petechia were selected. ANN model developed with these features has an accuracy of 55.97%. These results can be greedy since the wrapper methods only aim to find the best possible combinations of features that result in the best performant model. Moreover, wrapper methods find the optimal feature combination by developing machine learning models. Consequently, it results in better predictive accuracy. Apart from that, Myalgia and Retro-Ocular Pain are the most significant features that have been chosen by all wrapper feature selection methods.

Table 3 shows the summary of the selected attributes and accuracy of the ANN model developed using that feature. ANN developed without feature selection has an accuracy of 54.51%. Feature selection methods other than the Wrapper feature selection with KNN have greater accuracy than the ANN without feature selection. KNN shows the lowest accuracy of 54.47% and PCA results in higher accuracy of 72.47%. Further, the Naïve Bayes and J48 have an equal accuracy of 55.97%. As the key finding of this study, for the dataset that used in this study, PCA is the most suitable feature selection method.

Table 2. Correlation of each attribute to Final Class

Component	Total	Variance	Cumulative Variance
1	2.71116	12%	12%
2	2.14864	10%	22%
3	1.76419	8%	30%
4	1.55196	7%	37%
5	1.31615	6%	43%
6	1.24483	6%	49%
7	1.07744	5%	54%
8	1.0569	5%	59%
9	0.97304	4%	63%
10	0.94682	4%	67%
11	0.87966	4%	71%
12	0.78049	4%	75%
13	0.73764	3%	78%
14	0.70948	3%	81%
15	0.66657	3%	84%
16	0.64344	3%	87%
17	0.56404	3%	90%
18	0.55597	3%	92%
19	0.50935	2%	95%
20	0.49397	2%	97%
21	0.37051	2%	99%

## V. CONCLUSION

In this study two approaches were used for the feature selection, PCA and Wrapper feature selection methods with Naïve Bayes, KNN, and J48. Separate ANN models have been developed for each feature selection method. Out of the four feature selection methods PCA results in higher accuracy in developed ANN. In a conclusion, PCA performs better for the given dataset. Myalgia and Retro-Ocular Pain are the most expressive features that have been chosen by all wrapper feature selection methods. Further, with PCA the initial 22-dimensional system was reduced to the 8-dimensional system with a cumulative variance of 59%.

As the limitation of the study, the ANN model that has been developed here is not optimal, a basic model with the same hyperparameters is developed only to compare the results of each feature selection model; however, each of these ANN can be further optimized by fine-tuning the hyperparameters. Moreover, the result of feature selection methods only applicable for the dataset that is used in the study, for other datasets, these feature selection methods should be applied

again, which may output a different result than this. Furthermore, this study only used few feature selection methods, however, trying the other feature selection methods is highly welcomed and it may change the current result on the selected significant attributes that can be used to develop the Dengue diagnosis prediction model more efficiently. In the future, based on the result of the feature selection methods, Dengue diagnosis prediction models can be developed with higher accuracy and efficiency using the most significant attributes.

Table 3. Selected Features and Accuracy of ANN

Feature Selection Method	Selected features	Accuracy of ANN
No Feature Selection	All	54.51%
PCA	8 Principal Components	72.47%
Wrapper Feature Selection (Naïve Bayes)	Myalgia, Retro-Ocular Pain, Dyspnea, Petechia	55.97%
Wrapper Feature Selection (KNN)	Myalgia, Retro-Ocular Pain, Exantema	54.47%
Wrapper Feature Selection (J48)	Myalgia, Retro-Ocular Pain, Tachycardia, Petechia	55.97%

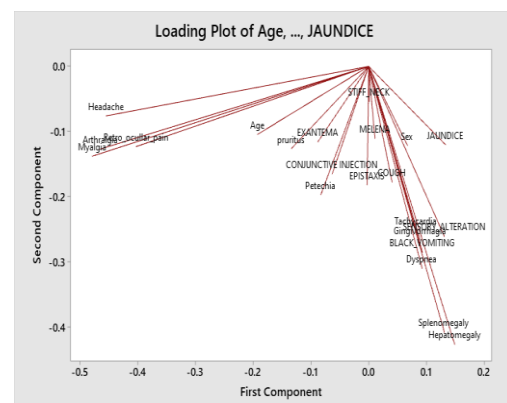


Figure 2. Loading plot of first and second principal component

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# Binary and Multi-Class Classification Using Supervised Machine Learning Algorithms and Ensemble Model

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**Abstract**— Classification is a vital aspect in data mining, where vast quantities of data are segregated into discrete classes. Models based on different statistical and machine learning approaches are used for this task. However, the classification performance depends on multiple factors like selected algorithm, domain and features of the dataset. The objective of this study is to evaluate the classification performance of widely used supervised machine learning algorithms; Decision Tree (DT), Naïve Bayes (NB) algorithm, Support Vector Classifier (SVC), K-Nearest Neighbour (KNN) algorithm and the Ensemble Model (EM) based on soft voting technique. These algorithms are tested on 6 datasets in different domains, and the datasets contain both multi-class and binary class data as well as balanced and imbalanced data. Accuracy, Precision and Recall are used as evaluation metrics to evaluate the classification performance in balanced datasets, where F1-measure is used in imbalanced dataset for the same task. The evaluation results indicate that EM outperformed single algorithms at most instances. When comparing single algorithms, KNN performed best with multi class classification, where SVC performed best in binary classification in balanced datasets. Also, KNN showed the best classification performance when it comes to imbalanced dataset. All the algorithms performed well when the data set is balanced. However, the classification performance in all models including EM is below expectation, when the data distribution is highly imbalanced.

**Keywords:** *classification, machine learning, supervised algorithms, ensemble model, soft voting classifier*

## I. INTRODUCTION

Classification is the process of categorizing a given structured, unstructured or semi-structured data into classes. It is an important aspect in data mining and analysis and widely used in different domains like business, health, education, medicine, telecommunication, security etc.

Supervised classification is one of the most frequent tasks done by Intelligent Systems. In classification, data instances are assigned to an appropriate class and there are machine learning and statistical models used as classifiers for this task. (Kotsiantis, Zaharakis and Pintelas, 2006) Supervised machine learning approaches are primarily used for this due to their ability to grasp complex patterns in datasets. Current research studies also investigate the ability of ensemble models for classification. Ensemble models combine several machine learning techniques into one predictive model thus improving the accuracy of the classification compared to individual supervised algorithms. Also classification mechanism differs with the complexity of the dataset. There are datasets with balanced or imbalanced class distributions. Also there are datasets with multiple class labels and binary labels. Balanced datasets have equal to nearly equal data points for each class where the data points in imbalanced datasets are biased towards one label. However, imbalanced data classification can be challenging since the class distribution is severely skewed and there are unequal misclassification costs. (Brownlee, 2017)

In this paper, I focus on analysing the classification performance of supervised machine learning algorithms and the ensemble models built upon them. For the evaluation I used four famously used supervised machine learning



algorithms namely Decision Tree, Naïve bayes algorithm, Support Vector Classifier and K-Nearest Neighbour algorithm. Ensemble model is built by combining these supervised algorithms using soft voting technique. I analyse and evaluate how these single algorithms and the ensemble model perform in the classification task in multi-class and binary class datasets as well as balanced and imbalanced data distribution datasets. Also the limitations of the study and the future direction of the research are discussed at the end of the paper.

## II. RELATED WORK

Machine learning algorithms have shown their effectiveness in data classification. Supervised machine learning algorithms hold prominence in this. These algorithms use a labelled training dataset first to train the underlying algorithm and this trained algorithm is then fed on the unlabelled test dataset to categorise them into classes. (Uddin, Khan, Hossain and Moni, 2019) There are famously used supervised algorithms for classification.

### 1) Decision tree

Decision tree is one of the earliest and prominent supervised machine learning algorithms used for classification. It is a tree based algorithm where the data is continuously split according to a certain parameter. Each node in the tree shows a feature and each branch shows a decision or rule. Also each leaf in a decision tree shows a class label. (Patel and Prajapati, 2018)

### 2) Naïve bayes

Naïve bayes classification technique is based on the Bayes' theorem. This theorem considers probability of an event based on the prior knowledge of conditions related to that event. The classifier assumes that features are independent given class. Even though this assumption is considered to be weak and even if calculated probability estimates are inaccurate, Naïve bayes classifier is proven to perform well in classification tasks. (Rish, 2001) Most of current machine learning libraries provide optimizations for this algorithm therefore improving the classification performance.

### 3) Support vector classifier

The objective of the support vector classification algorithm is to find a hyperplane in a  $N$ -dimensional space to distinctly classify the data points into classes. Support vectors are data points that are closer to the hyperplane and these vectors influence the position and orientation of the hyperplane. These support vectors maximize the margin of the classifier. (Gandhi, 2018) This classifier converts the machine learning problem to an optimization problem and uses mathematical programming to solve the problem. Support vector machines and classifiers are found to be beneficial in a wide range of classification tasks like text categorization, face detection, verification, recognition, speech recognition and bioinformatics. (Tian, Shi and Liu, 2012)

### 4) K-nearest neighbour

K-nearest neighbour is a non-parametric classification technique. This is very simple yet very powerful algorithm based on proximity or similarity. The algorithm assumes the similarity between the new data points and puts the new data points into the class that is most similar to the available data classes. The classifier is known to work best with numerical data. However, one needs to carefully select the features fed into the algorithms since this classifier is very sensitive to irrelevant or redundant features. However, this can be avoided using proper feature selection and feature weighting. (Cunningham and Delany, 2007)

However, there are certain pros and cons in each algorithm. Ensemble models are used to yield the benefits and reduce the limitations of each single algorithm. These models combine the results from single algorithms based on multiple metrics like weight and probability. This enhances the classification performance of the model. Ensemble approaches like soft voting classifier are proved to provide superior results compared to single algorithms in different domains. (Kumari, Kumar and Mittal, 2021)

## III. METHODOLOGY

### E. Datasets

For the evaluation in balanced data class distribution, I used labelled multi class and binary class benchmark datasets. They are Ecoli

(Horton and Nakai, 1996), Glass identification (Evelt and Spiehler, 1987), Iris (Hart and Duda, 1973), Stroke prediction (Zaki, Mohamed and Habuza, 2021) and Prima Indians diabetes (Choubey et al., 2016) datasets. These datasets are retrieved from well-known UCL machine learning repository and Kaggle.

Table 1. Balanced data distribution datasets

Dataset	Source	Data instances	Feature count	Data classes
Ecoli (D1)	UCL	336	7	8
Glass identification (D2)	UCL	214	9	7
Iris (D3)	UCL	150	5	3
Stroke prediction (D4)	Kaggle	5110	11	2
Pima Indians diabetes (D5)	Kaggle	768	8	2

For the evaluation in imbalanced data distribution, I used the Yahoo! S5 Anomaly benchmark dataset (Laptev and Amizadeh, 2015). It contains real data collected from Yahoo services and synthetically generated data separated in 4 data classes. A1 contains real data in 67 metrics where other data classes contain synthetic data in 100 metrics.

Table 2. Imbalanced data distribution dataset

Data class	Number of instances	Number of features	Contamination
A1	94,866	2	0.0176
A2	142,100	8	0.0033
A3	168,000	8	0.0056
A4	168,000	8	0.0062

#### F. Experimental design

Experimental design consists of two stages. First stage consist of data preprocessing and data split for training and test sets. Second stage consist of model training and testing.

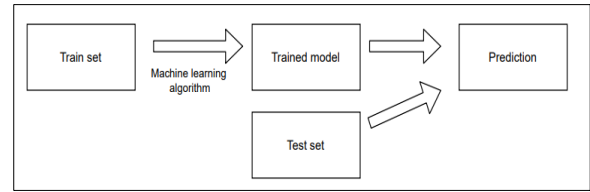


Figure 2. Data preprocessing and split stage

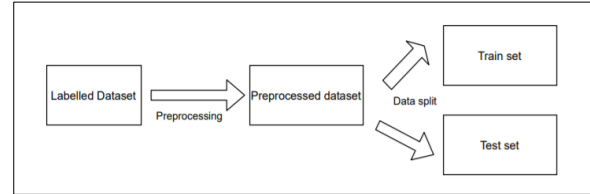


Figure 2. Model training and testing stage

At first, each machine learning algorithm was tested on each dataset. Finally, ensemble model testing was performed on each dataset. For the implementation, I used Python Scikit-learn library. (Pedregosa et al., 2011)

#### 1) Data preprocessing and Data splitting

The data sets were preprocessed before feed into machine learning algorithm. All categorical data were converted into numeric data using label encoder. Then all the numerical data were normalized using a min-max scale. In case of missing values, those data were imputed by the mean value of the data column. Preprocessed data was split into two subsets randomly, one with 70% for the training and 30% for test set.

#### 2) Model training and testing

Training set was used to train the classification model and the test set was used for model validation.

Models were built using famously used supervised machine learning algorithms. Hyperparameter tuning for each machine learning algorithm was done using previous literature and trial and error approach. Ensemble model was built by combining all of these supervised algorithms using soft voting technique. Soft voting is based on membership probabilities where the ensemble model sums the predicted probabilities from single algorithms for class labels and predicts the class label with the largest sum probability.

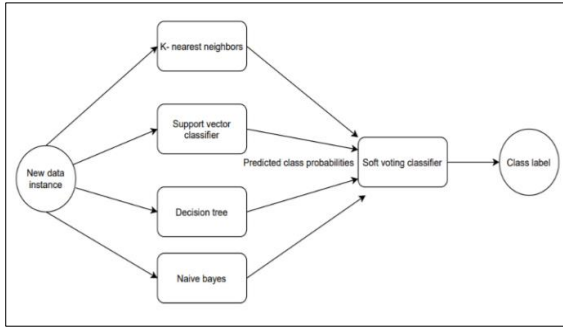


Figure 3. Ensemble soft voting classification

Hyperparameters used for each machine learning algorithms are depicted in Table 3.

Table 3. Hyperparameter values

Algorithm	Hyperparameter	Value
DT	Minimum sample split	2
	Minimum sample leaf	1
NB	Distribution	Guassian
SVC	Kernel	RBF
	Regularization	1.0
	Gamma	Scale
	Probability estimation	True
KNN	Number of neighbours	5
EM	Voting	Soft

Other hyperparameter values are set into default values in Scikit-ILearn library.

### G. Evaluation metrics

This study evaluates the classification performance of ensemble machine learning model in both balanced and imbalanced datasets. For the balanced datasets, Accuracy (A), Precision (P) and recall (R) were used as evaluation metrics. (Hossin and Sulaiman, 2015) Generalized confusion matrix was used to calculate these metrics. (Manliguez, 2016)

Table 4. Confusion matrix

		Predicted			
		Class 1	Class 2	...	Class n
Actual	Class 1	$x_{11}$	$x_{12}$	...	$x_{1n}$
	Class 2	$x_{21}$	$x_{22}$	...	$x_{2n}$
	...	...	...	...	...
	Class n	$x_{n1}$	$x_{n2}$	...	$x_{nn}$

The total numbers of false negative (TFN), false positive (TFP), and true negative (TTN) for each class  $i$  will be calculated using the 1,2 and 3 generalized equations respectively. The total true positive (TTP) in the system will be calculated using equation 4.

$$TFN_i = \sum_{\substack{j=1 \\ j \neq i}}^n x_{ij} \quad (1)$$

$$TFP_i = \sum_{\substack{j=1 \\ j \neq i}}^n x_{ji} \quad (2)$$

$$TTN_i = \sum_{\substack{j=1 \\ j \neq i}}^n \sum_{\substack{k=1 \\ k \neq i}}^n x_{jk} \quad (3)$$

$$TTP_{all} = \sum_{j=1}^n x_{jj} \quad (4)$$

Precision and recall for each class  $I$  were computed using the 5 and 6 generalized equations. For the overall precision and recall, macro average values are used. Overall accuracy is then derived using equation 7.

$$P_i = \frac{TTP_{all}}{TTP_{all} + TFP_i} \quad (5)$$

$$R_i = \frac{TTP_{all}}{TTP_{all} + TFN_i} \quad (6)$$

$$ACCURACY = \frac{TTP_{all}}{\text{Total Number of Testing Entries}} \quad (7)$$

For imbalanced dataset, accuracy will not be a suitable metric. So  $F_1$  - measure is used as evaluation metric for those datasets.  $F_1$ -measure of 0 means a useless classifier where  $F_1$ -measure of 1 means a perfect classifier.  $F_1$  - score is calculated based on overall Precision and recall using equation 8. (Jeni, Cohn and De La Torre, 2013)

$$F_1 = 2 \cdot \frac{P \cdot R}{P + R} \quad (8)$$

#### IV. RESULTS AND DISCUSSION

The results obtained for multi class classification and binary classification in balanced datasets are summarized in Table 5.

Table 5. Evaluation metrics for multi-class and binary classification in balanced datasets.

Accuracy (%)					
Dataset	DT	NB	SVC	KNN	EM
D1	75.24	69.3	76.23	78.21	89.1
D2	67.18	54.68	68.75	70.31	75
D3	95.55	93.33	95.55	97.77	100
D4	90.99	87.01	94.58	91.71	94.32
D5	71.86	75.75	77.92	71.86	77.92
Precision (%)					
Dataset	DT	NB	SVC	KNN	EM
D1	60.76	29.03	60.39	71.85	84.46
D2	66.87	55.58	64.45	70.31	70.98
D3	95.58	93.27	95.58	98.24	100
D4	55.61	57.82	47.29	52.75	66.93
D5	68.04	71.96	74.94	66.91	74.69
Recall (%)					
Dataset	DT	NB	SVC	KNN	EM
D1	53.45	31.76	64.94	63.54	80.22
D2	73.55	61.17	66.27	67.09	72.64
D3	93.58	93.73	95.58	97.43	100
D4	55.48	66.44	50	51.89	53.83
D5	69.11	69.75	71.7	62.48	72.43

D1, D2 and D3 are multi class data sets where D4 and D5 are binary datasets. Accuracy metric can be used to decide the high performing models since the datasets are balanced. From all the tested approaches, ensemble approach performed the best. Ensemble machine learning model provided the highest accuracy for all datasets. Also it provided the highest precision and the recall for the majority of datasets. From individual machine learning algorithms, KNN performed best with multi class classification where SVC performed best with binary classification. NB is the worst performing algorithm since it recorded low accuracy, precision and recall for majority of

the tested datasets. DT algorithm performed better compared to NB but it had less classification performance compared to SVC, KNN and ensemble approaches.

The results obtained for classification in Yahoo! S5 anomaly benchmark dataset are summarized in Table 6.

Table 6. Evaluation metrics for imbalanced data classes

Accuracy (%)					
Data class	DT	NB	SVC	KNN	EM
A1	99.17	99	99.35	99.14	99.2
A2	99.92	99.76	99.82	99.92	99.94
A3	99.18	99.41	99.55	99.63	99.6
A4	99.24	98.73	99.5	99.64	99.6
Precision (%)					
Data class	DT	NB	SVC	KNN	EM
A1	60.57	54.07	55.63	63.92	67.23
A2	91.26	57.57	63.63	90.88	93.83
A3	25.71	11.57	29.47	60	46.31
A4	18.79	15.49	15.55	55.18	42.22
Recall (%)					
Data class	DT	NB	SVC	KNN	EM
A1	58.75	63.62	47.77	64.84	64.99
A2	98.48	50.5	59.59	98.48	98.48
A3	20.84	3.52	21.07	34.87	26.43
A4	12.57	8.51	8.2	32.44	22.48
F1-measure (%)					
Data class	DT	NB	SVC	KNN	EM
A1	58.74	55.6	50.05	63.6	64.5
A2	93.5	52.42	60.75	93.54	95.47
A3	21.79	5.29	23.75	42.24	32.29
A4	14.24	8.49	10.16	38.54	27.85

When the classification classes are imbalanced in dataset, the accuracy of machine learning models are biased towards the majority class. The classification algorithm tends to predict the majority class often. Hence accuracy is not a good performance metric to evaluate imbalanced datasets. It is evident from these results as I got very high accuracy values but low precision and recall values. I used F1-measure to evaluate the models. From F1-measures, it is evident that KNN and ensemble classifier had better performance in biased label classification. Classification algorithm performance degrade with the increase of data instance count and biasness of data labels. That is the reason for the poor classification performance of all algorithms in A3

and A4 classes. Adding an ensemble learning model did not help much for the classification in these data classes.

In order to improve the classification in imbalanced datasets, one can introduce oversampling or undersampling. Oversampling replicates minority class data points where understamping removes majority class data points. This can reduce the class imbalance in the dataset thus improving classification performance in machine learning algorithms.

## V. CONCLUSION

In this research, I have investigated the classification performance of famously used supervised machine learning algorithms and ensemble model. Decision tree, Support vector classification, Naïve bayes classification and K-nearest neighbour classification algorithms were trained to perform classification in both balanced and imbalanced datasets. The balanced datasets consist of both multi class and binary datasets where imbalanced dataset is a binary dataset with anomaly data. This research study also evaluated the ensemble machine learning model classification performance on these datasets. The ensemble model was developed using voting technique with aforementioned supervised learning algorithms. The experimental results show that the ensemble model performs better compared to single algorithms in classification. From individual algorithms, K-nearest neighbour algorithms performed best in multi class classification where Support vector classification algorithm performed best in binary classification for balanced datasets. Naïve bayes algorithm had the worst performance. However all algorithm models including ensemble model performed average to poor in imbalanced dataset classification.

For future work, one can investigate the effectiveness of oversampling and undersampling techniques to solve the class imbalance problems. Also it is worth investigate on optimizing hyperparameters in these machine learning algorithms to improve the classification performance.

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# A Mobile Application for Blood Transfusion in Sri Lanka for Emergency Cases Based on Government Hospitals

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**Abstract** - Blood is known as one of the most precious gifts that humankind can give to one another, and the need for blood is most felt when one begs for life from anaemia. In an emergency, the increase in the number of victims is uncontrollable and a victim may need more than 100 pints of blood. In today's challenging environment, a Mobile Application for the transfusion of blood is a great blessing, and the goal here is to find blood donors in the shortest amount of time. This paper is primarily concerned with the transfusion of blood in the shortest possible time in an emergency. The proposed Mobile Application allows blood donors to enter details, including blood type, the location used by Google Maps and contact information. This Mobile application enables hospital staff members to request blood from the donors in an emergency through voice input. Hospital staff can track where the donors are according to their predicted minimum time, and could contact them for blood needs. The hospital should be able to provide transport facilities to solicit accepted donors. This blood transfusion system is crucial in emergency blood distribution, because it allows for central and immediate access to donor data and location from any location. The primary goal of this paper is to maintain a well-informed group of blood receptors that can be used at any given time.

**Keywords:** *mobile blood transfusion system, emergency, blood shortage*

## I. INTRODUCTION

Donated blood can be lifesaving for persons who have lost substantial amounts of blood because of serious accidents, new medical and surgical procedures, civil conflicts, and military wars as well as for patients who have become severely anemic because of serious hematological

diseases or treatments such as cancer therapy. Therefore, the availability of blood is an important concern to society. Blood Donation is a selfless act that will help to save one's life. Even though a vast number of blood transfusion mobile applications have been developed, most of them do not incorporate voice recognition as an input or are not designed for a large crowd in an emergency case. Therefore, it is mostly focused on building a blood transfusion mobile app to address these issues. According to the World Health Organization (WHO), 108 million blood transfusions are performed annually from all types of blood donors. (Voluntary free, family/replacement, and paid), with 65 percent of blood transfusions provided to children under the age of five in low-income countries. It is worth noting that about half of all blood donations are raised in high-income countries, which account for 15% of the global population. The WHO has set 2020 as the target year for all countries to receive 100% of their blood supplies from unpaid volunteers. (Sofia Ouhbi,2015) Supply chains of blood donation have been more complicated in recent years than in the past. Most of the deaths may have been caused due to a lack of blood donation or a delay in receiving blood. However, these inefficiencies in the blood donation chain caused due to the complexities can be minimized with the aid of technology. Technology-based blood transfusion aiding applications can save lives by:

- assisting blood donors to easily locate donation centers & keeping track of their blood donation activities.
- assisting blood requesters to easily find blood donors on time to save their loved one's life.

Considering the blood transfusion service of Sri Lanka, this is a manual procedure. Finding the nearest blood bank in Sri Lanka is performed through a manual cluster system. In case of an emergency, hospitals inquire about the victims' families and friends to see if a blood group that matches a victim can be found. If they are unable to locate them, they check into blood banks located in the area the hospital is located. Recently implemented in finding blood donors through social media sites such as Facebook. (National Blood Transfusion Service, 2016). However, during an emergency where blood is required in mass amounts for many patients (e.g., due to a mass bombing, large-scale accidents, etc.), the above procedure is inefficient to locate blood donors on time. If they fail to locate blood using the methods described above, the patient faces certain death. A recent example is at the time of the Easter attack in April 2019, six blasts that rocked Colombo and Batticaloa on Easter Sunday have left at least 160 dead and over 300 injured. The high casualties have caused an overflow of patients requiring treatment in hospitals. Sri Lankans requested people to donate blood through social media (news18, 2020). To minimize such inefficiencies in situations where a large crowd needs blood, we develop this mobile application. This mobile application is not only useful in emergencies but it can also be used for other small-scale blood transfusion services as well specifically developed to our country Sri Lanka based on government hospitals.

## II. LITERATURE REVIEW

(M. Fathima, A. Valarmathi, 2017) had developed a mobile application. The features included timely updating the information regarding the donors where the administrator accesses the whole information. The donor will be prompted to enter an individual's details, like name, phone number, and blood group. However, the drawback is that This app is designed for a single user, but it should be able to handle a large crowd in an emergency.

(K M Akkas Ali<sup>1</sup>, Israt Jahan, Md. Ariful Islam, Md. Shafa-at Parvez, 2015) had developed a Blood Donation Management System with a

smartphone app to go along with it. Donors must build profiles by entering basic details such as their name, blood type, email address, password, and precise location. From the home page, visitors can search for blood donors by blood group and location where blood is required. However, the drawback is that This device is also intended for a single person, but it should be able to manage a large crowd in an emergency and does not have voice recognition as an input.

(Moh. Nabil a, R. Ihab b, H. El Masr c, S. Said d, S. Youssef e, 2019) had developed a Cloud medical monitoring and Web-Based Blood Donation System will allow blood donors and patients to offer/request blood donation from blood banks. Medical experts remotely monitor the health status of patients and give prompt medical advice However, the drawback is that This system is also designed for a single user, but it should be able to handle a large crowd in an emergency.

(T. Hilda Jenipha R. Backiyalakshmi, 2014) had developed a Blood Donor App that offers a list of potential donors in your area. Only those who have enrolled and are willing to donate blood will be eligible to use the program. Users would be able to locate matching blood group donors in their area using a location-based app. However, the drawback is that Voice recognition is not included as an input here it should be included since no one can type in an emergency.

(Prof. Snigdha<sup>1</sup>, Varsha Anabhavane, Pratiksha Lokhande<sup>3</sup>, Siddhi Kasar<sup>4</sup>, Pranita, 2016) had developed a mobile application that includes a directory of local blood banks. A donor will be asked to enter personal information such as a person's name, phone number, and blood type. The app makes use of GPS (Global Positioning System) technology to track the route to the blood bank. However, the drawback Voice recognition is not included as an input.

(Sofia Ouhbi · Jos´e Luis Fern´andez-Alem´an · Ambrosio Toval · Ali Idri · Jos´e Rivera Pozo, 2015) From the 188 apps found, a search of Google Play, Apple App Store, Blackberry App World, and Windows Mobile App Store yielded 169 free BD apps. Most of the apps chosen were created for the Android operating system,

according to the findings presented in this paper. However, the drawback is that The App should be able to operate any phone brand and be available in any app store. (Samy S. Abu Naser, Dr. Ihab Zaqout, Rreham K. Abumughessib, 2016 that connect users with the Blood Centre to facilitate the blood collection from donors. However, the drawback Voice recognition is not included as an input.

### III. SYSTEM DESIGN

This mobile application has two types of users: donors and hospitals (authorized personnel from the blood bank division at the hospital) This mobile application supports the following technologies:

**1. Voice recognition for input-** It can capture speech much faster than you can type, which is useful

in an emergency, and it has drawbacks as well, especially in emergencies where voice commands are lost in the background due to ambient noise. However, the voice input embedded in this mobile application has the capability of filtering background noises and identifying the specific voice of requests.

**2. Geo-Location & Geo Tagging** - During an emergency, it is helpful to find donors using a variety of location-specific information and to identify the geographic location of the donors, specifically near the hospital that needs blood.

**3. OTP/Fingerprint for User Verification-**It is advantageous when it comes to donors accepting emergency blood requests because fingerprint identification is unique, highly accurate, and simple to use.

This app provides awareness about the basic requirements that a donor must meet for a blood transfusion when things need to be done urgently.

To assess the feasibility of a mobile application, we had to conduct a survey. According to the survey, 100% of the 40 respondents are willing to donate blood but only 2.50 percent have used a blood donation mobile app previously.

The most common blood type is B+, and 12.82 percent are unaware of their blood type. It would be beneficial if we create an awareness program for them to assist them in determining their blood type.

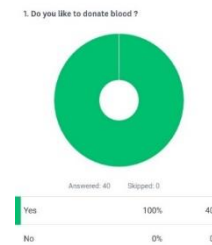


Figure 1-Willingness to donate blood.

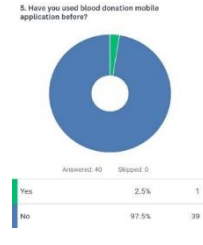


Figure 2-Before usage of Blood Donation app

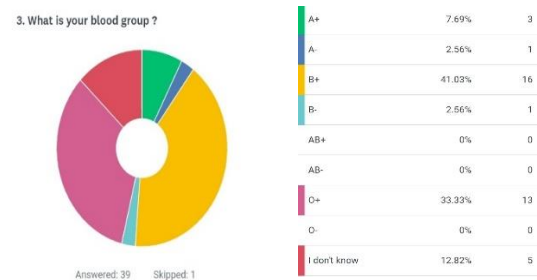


Figure 3-Blood group Classification

100% believe it is effective to design a mobile app that aids in blood donation.

6. Do you think it's effective to develop a mobile application that helps for blood donation?

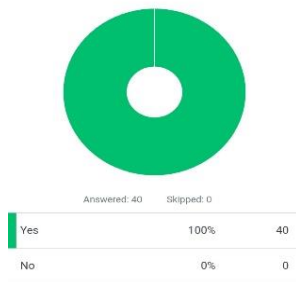


Figure 4-Effectiveness of developing a mobile app.

Also, according to the responders' suggestions, Sri Lanka's daily blood needs, current blood storage status, and blood group information should be available in a mobile application and available on both Android and iOS.

### Proposed System

The interfaces in our proposed application are designed and set up in such a way that both the donor and the requesting hospital can communicate with one another. The Mobile Application will track where the donors are according to their estimated time of arrival to the hospital and will contact them through calls in case of an emergency for blood needs.

During an emergency, we use Geo-Location & Geo Tagging to find donors using a variety of location-specific information and to identify the geographic location of the donors, specifically the year the hospital requires blood and OTP/Fingerprint for user Verification It is advantageous for donors who accept emergency blood requests. It provides an elevated level of security as well as multiple levels of authentication. It provides central and immediate access to donor data and location from anywhere.

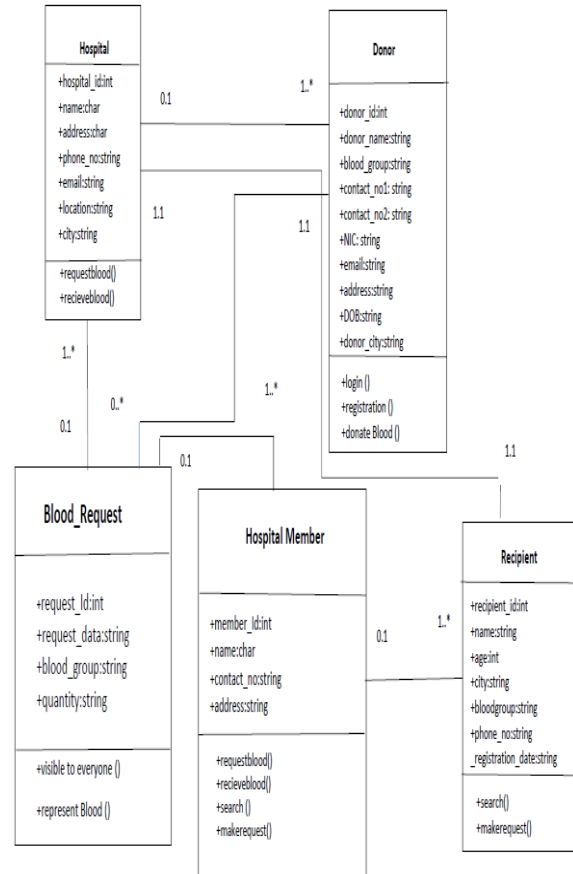


Figure 5-Class diagram for the proposed system

When a user first opens the Blood Donation Mobile Application, the main page appears as shown in Fig. 6 And we named our mobile application as “ප්‍රාණ”.



Figure 6-Main page 1



Figure 7-Main page 2

## 1. DONOR REGISTRATION ELIGIBILITY VERIFICATION



Only users who weigh more than 50kg and are over the age of 18 can register for this app also If donors have previously donated blood, they must wait at least four months before donating again.

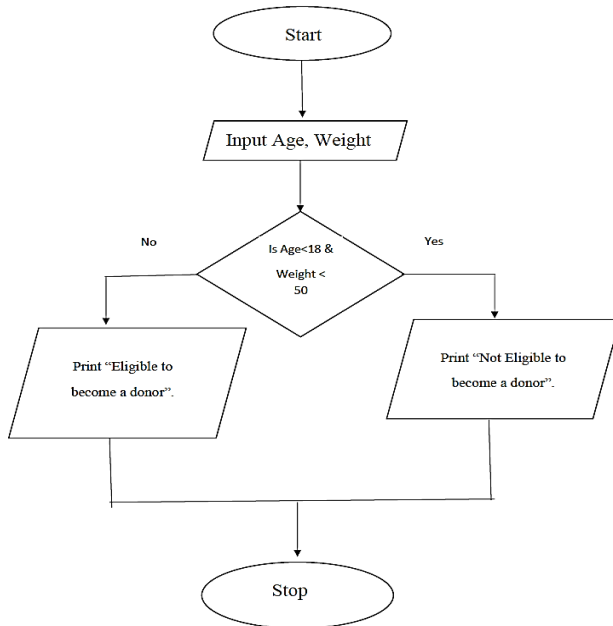


Figure 8-Flowchart to calculate the time to wait for the next donation.

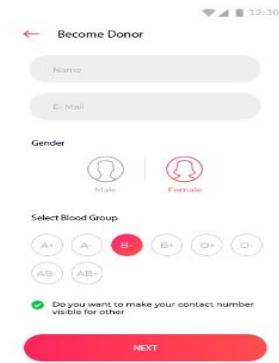


Figure 11-Eligibility Check

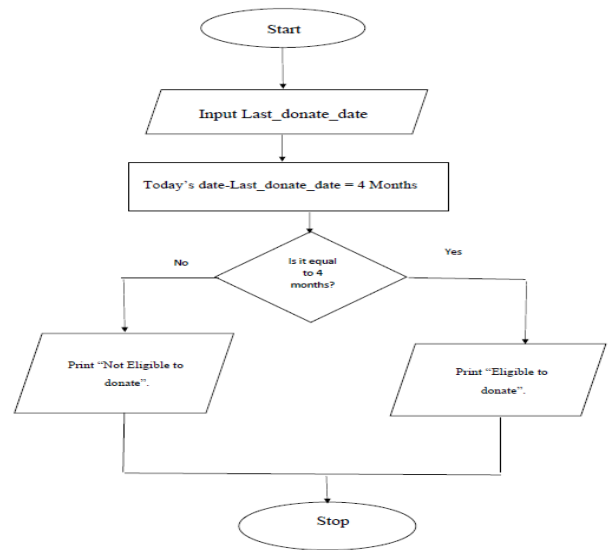


Figure 12-Flowchart to calculate Eligibility.

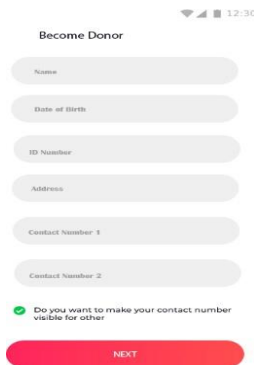


Figure 9-Registration

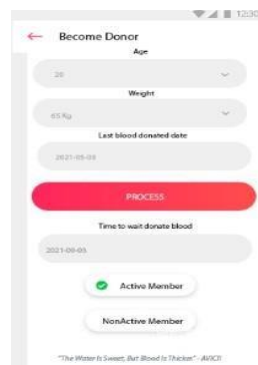


Figure 9-Registration

## 2. DONAR INTERFACES



Figure 13-Login



Figure 14  
Emergency

It saves time since the user can log in to the system using a fingerprint.

A donor profile displays the donor's name, profile, and how many donations the donor has made thus far.

This Emergency interface is displayed on the donor's interface during an emergency.

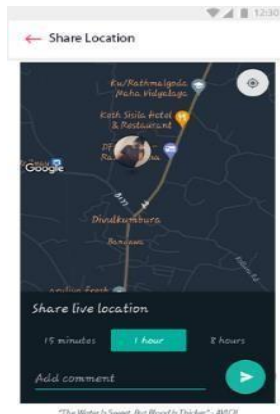


Figure 15-Share Location

After clicking confirm button application displays the share location option.

### 3. HOSPITAL INTERFACES



Figure 16-hospital portal

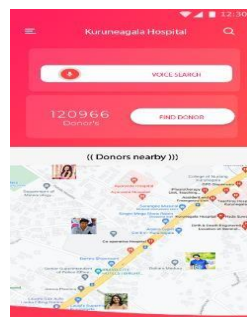


Figure 17-Search portal

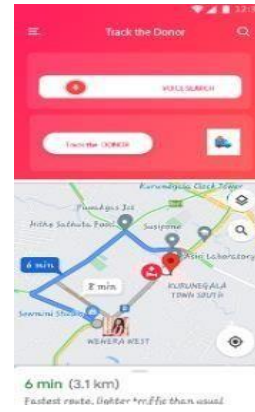


Figure 18- Search Donor for an estimated distance

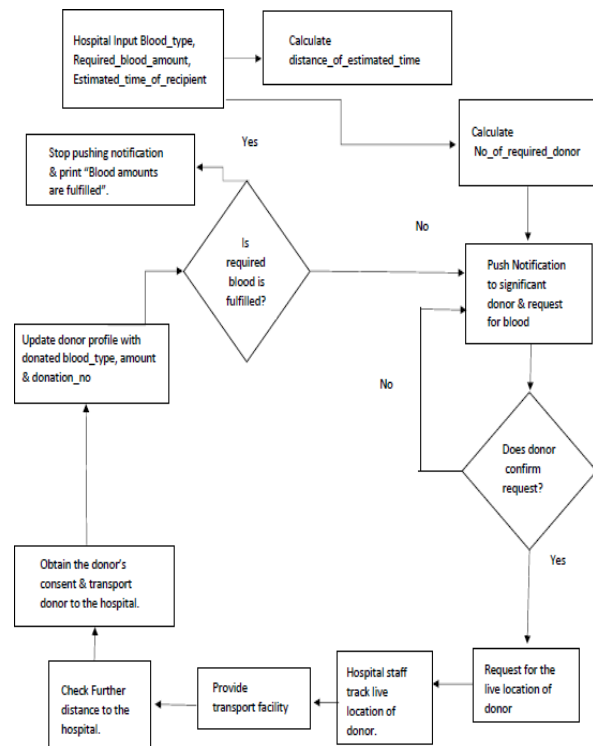


Figure 19-Workflow diagram for an emergency

### IV. CONCLUSION

The main objective of this article is to reduce the Inefficiency caused during transfusion when large amount of blood is required. The proposed solution is in which both the donor and requester are transparent. The app helps to locate the nearest hospital and blood bank. Can be used in rural areas where hospitals and blood banks are far away.

### V. FUTURE WORK

After donating blood in one of the blood donation programs in collaboration with a government hospital, those who wish to donate blood again will be registered with this mobile application. Creating an association with awareness programs through mobile applications targeting the youth generation. Implementing programs to check the basic requirements for blood donation in collaboration with the nearest hospital. Giving users a higher priority in case of emergency blood needs by issuing a card categorized as gold and silver based on donation blood recommending it to donors.

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# Classification of Software Frameworks Utilised in Water Resource Management Modelling

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**Abstract** - The framework of a particular unit or a system is the structure on which it is built or founded. There appears a conflict in the understanding of frameworks by water resource decision-making professionals and software development professionals. This contradiction affects the quality of the software systems developed for water resource management decision-making. Hence, the objective of the present work is to classify the available understanding of frameworks to contribute to a clear understanding to achieve better and sustainable framework classification to water resource management software system. The present work carried out a systematic review and conceptualised the principle of the framework through an evaluation of interdependencies between presently available understandings. The reviewed environmental modelling frameworks revealed the availability of four different categories such as, Software language foundation, Software on platforms, Techno-business platforms, and Building blocks frameworks. This classification allows the environmental system modellers to understand which framework they will develop and decide in which depth they need to explore technology and business domains.

**Keywords:** *software, system, framework, water resource management, environmental modelling, empirical literature review*

## I. INTRODUCTION

### A. *Monolithic to microservice*

Monolithic software development refers to the construction of traditional single-tier systems and codes are carrying out the interconnections between user interfaces, business logic and the data that existed in a single platform. Even the

modification to the system carries a cost; monolithic had been established as the primary architectural approach to many business systems due to development and implementation simplicity. However, due to the dynamicity in the requirements and advancement of technology, present day trends move towards microservices where user interfaces, business logic, and data are provided and maintained separately as services (Gos and Zabierowski, 2020).

Conceptually the microservices are utilised in automating the complex water resource management process (Wybrands et al., 2021). But such systems need to be evolved from scratch due to absent of fully pledged environmental microservices, dynamics in management process and stakeholder requirements. Hence, the construction is still with the characteristics of monolithic development. This influence the developers to carry out trial and error attempts to accumulate necessary constructional instruments such as user interface guideline, development methodology, security mechanisms while the development (Pradeep and Wijesekera, 2017, 2015b; a). The common acceptance is, such approaches are challenging to achieve the required software qualities as the resources are utilised to discover/invent the basic concepts and artefacts repeatedly (Schmidt, Gokhale and Natarajan, 2004). Nevertheless, due to no proper exemplary works in water resource decision making, it has to follow the monolithic approach (Pradeep and Wijesekera, 2020).

### B. *Software Framework solves Software Entropy*

The monolithic architecture requires adding different components to the developed system. It

results in uncontrollable software architecture - software entropy, the internal levels of disorders in complex or closed systems that get messy over time, same as the second law of thermodynamics (Canfora et al., 2014; Roth, 2017). Roth (2017) highlighted two reasons for software entropy which are common situations for the water resource management systems as: the complexity of the systems and communication requirements across the complex distribution of the system in multidiscipline.

However, as the software frameworks are being developed to depict the subclasses and components for the required scenario, those facilitate better selection of appropriate techniques and methods (Taligent, 1996 as cited in Aksit et al., 1999). Then, software framework could handle the foresaid complexity and communication difficulties. Therefore, it can consider that the most practical solution to manage the software entropy in monolithic development is the utilisation of software framework which is more appropriate to the scenario. Therefore, it required to select a suitable framework for water resource management problem and solution domains.

### C. Problem Statement

Even though software frameworks are important, when searching them, contradictory information results from the existing literature. For example, some frameworks describe the technical implementation of the software codes in libraries, while others describe the business artefacts' architectural positioning in software frameworks. Then the situation is getting more complex when searching the suitable water resource modelling software frameworks. As most of such literatures' attention is being paid to the core area of water resource management. Those are simultaneously describing both the technical and business structures under the heading of framework.

Hence selecting the suited is devious and ambiguous as there is no proper classification in the water resource modelling software frameworks. As well as when considering the terminology, it could observe an absence of standardising classification. Therefore, it is vital to demarcate the conceptual boundaries of different

software frameworks; then, researchers will select or express the practising frameworks more clearly.

### D. Objective

The present work aims to classify the water resource management modelling software frameworks.

## II. METHODOLOGY AND EXPERIMENTAL DESIGN

### H. Methodology

As the present work based on the knowledge of the previous work, it systematically selected the literature for the study. First, it googles the term software framework and collects the primary keywords of "design pattern, reusable components, modularisation" from different blogs and technical discussion forums. Then through google scholar keyword search, it found the most appropriate research articles. Going through such papers' abstracts, it isolates the essential papers for the study. Then using the connectedpapers.com, an AI website, it develops a connected-paper graph, as shown in Figure 1.0. By studying the literature in the graph links, select the most appropriate literature works for software frameworks.

As the water resource management/environmental modelling frameworks are not included in the previous search, it searches the related papers through Scopus data base using *Publish or Perish 7@* app for the key words "water resource management software, environmental modelling frameworks". From the 200 papers output, it selected only the research articles which satisfied all the following conditions: (1) describe a software tool or software utilisation for a practical implementation of environment/water resource management decision-making process, (2) published in a journal with impact factor more than 2.5, (3) having more than 20 citations and (4) published within the last 20 years. Further, it selected only ten literatures as it can justify the ten are substantial to demonstrate more than 85% accurate view of the population according to the study of Pradeep & Wijesekera, (2012) on the water resource management tool evaluation sample size research.



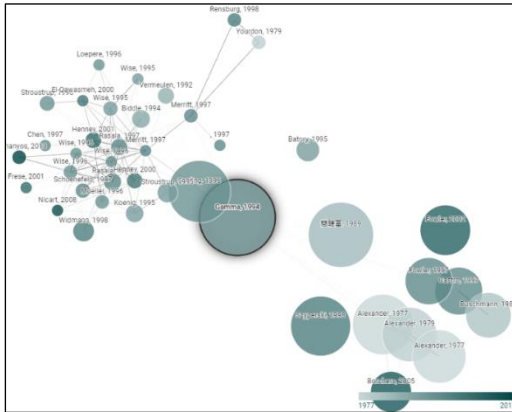


Figure 1.0 Connected Paper graph for Gamma et al., (1994, 1993)

Source: Created through <https://www.connectedpapers.com/>

## I. Literature Review

1) *Framework Definition:* According to the general dictionary meaning, the framework is a supporting structure that can construct something physically, such as a house or bridge. When such construction becomes the conceptual structure of decision, plan, organisation or workflow, the framework consists of interrelated individual or combinations of ideas, information, beliefs, rules, and principles (Cambridge University Press, n.d.). However, the three terms: (1) standard, (2) guideline, and (3) framework, which carrying similar meaning and using concomitantly. Nevertheless, the standards are more mandatory activities or commitments than the recommended activities and commitments described in the guidelines. Then frameworks provide a more conceptual understating of what activities and commitments are required to achieve the required goals (ACRL, 2006; Nolan, 2019). Accordingly, the frameworks are facilitating more precise control and mindful amendments to the activities and commitments.

2) *Framework Motivations:* To solve most software development problems, Parnas (1972) introduced a concept called "Information Hiding". Conceptually, information hiding is a series of activities required to hide the software artefact's design and implementation decisions, but its interface reveals the functionality (Parnas, 1972). Then, within the software, the code blocks were reused, hiding design decisions to reduce development, testing, and modification costs. The concept was extended to the software system

levels, and with time, it reuses the predeveloped software with modifications to solve the new problem. In reusing, the reusable component of the predeveloped software may be a set of source codes or a required functionality providing software modules or software units with required inputs and outputs.

*Design Patterns:* However, with the rapid growth of technology in many dimensions the nature of the problems to be solved was got complex. Then professionals must pay more attention to the problem domain; hence, the solution implementation needs to be carried out with less effort. Therefore, the reusable software artefact becomes popular, but with the advancements in technology more sophisticated solutions were developed. The researchers, Gamma et al. (1993), suggested to express successful design structures using the concepts in object oriented (OO) design paradigm. The design patterns provide clear guidelines for practitioners to arrive at decisions through alternatives and trade-offs when integrating the reusable software artefacts (Gamma et al., 1994, 1993).

*Object-Oriented Framework:* Even higher-level design patterns are catalogued the development experience for easy teaching and communicating, the software frameworks provide more concrete, practical implementation capability (Gamma et al., 1993). Generally, the software frameworks are reusable semi-finished architectures which can be utilised in the different application domain. The reusability of software is an essential requirement that initially fulfils with call-back procedures, then functions and Abstract Data Types (ADT). However, the object-oriented (OO) concepts-introduced inheritance and dynamic approaches assist in developing powerful frameworks which facilitate the reuse of whole/sub software systems, including the design. Therefore, the frameworks could standardise the internal parts to a specific domain (Schmidt, Gokhale and Natarajan, 2004). Pree (1994) called this scenario an application framework; however, the programmer needs to develop such after critical examination of the architecture and implementation details of the software artefacts. Therefore, he suggested utilising the meta-patterns where it identifies hot spots (the flexible components in the framework), white spots (template method: defines the abstract definition

of the algorithm - Gamma et al., 1993), and grey spots (hook method: provide communication between classes - Wirfs-Brock et al., 1990). This hot-spot-driven approach of Pree has made a foundation for object-oriented software frameworks (Pree, 1994, 1995; Pree and Sikora, 1997).

*Component Framework:* At the OO involve, it found that one main problem associated with the concept as, OO depends on the language and sometime compiler. Then it required to redevelop objects when needs to implement in another programming languages. Therefore, to independent from the language foundations, the component framework was evolved. The componentwear concept abides by the object-oriented concept as its encapsulation is regarding the data and methods amalgamation (Smith, 1997; Pree, 1997). Then component framework describes the capability of language-independent components utilisation to remove the barrier with the OO software framework. However, from the design, the components are language-independent groups of classes, but carefully developed to provide functionalities that users see as a black box and language independent (Scherp and Boll, 2005).

*Aspect-oriented Framework:* Further, the development efforts required to cater secondary set of user requirements such as optimisation of resources (memory, network, processor). Then, this opens another dimension of requirements that exceeds the need for reusability. Then Kiczales et al. (1997), suggested the Aspect-oriented programming concept. There the "aspects" are properties of the system while those behave like classes on OO design. This concept was influenced to develop an aspect-oriented framework based on the system's non-functional aspect and business rules (Silva, Braga and Masiero, 2004). These frameworks are dependent on the fundamental hook method, then even today, these frameworks are appearing in practising (Kant and Gupta, 2015).

*Metadata-Based Frameworks:* This extended the limitations of a small number of functional variabilities in the aspects-oriented frameworks. The use of metadata allows the extension of the behaviours, and the framework facilitates dealing with a large number of functional variabilities.

However, the framework describes the code level implementation and metadata process (Guerra et al., 2013).

*Service-oriented Frameworks:* This encapsulates the deployable component models which provide the service independent to the platform and server. The components are built on the OO architecture, but those benefit distributed computing where inter-process communication is required (Bieber and Carpenter, 2001).

*Application Frameworks:* This is not a diversified concept, and it refers to the primary OO /component frameworks describe earlier. However, the application frameworks are concerned with more abstract architectures regarding the complex business units or application domains (Fayad and Schmidt, 1997). Then, all frameworks described up to this point explain the code level implementation of the frameworks. There the frameworks provide quality software through four inheritances. First, the modularity of frameworks stable and standardise the volatile implementation requirements, and secondary, reusability reduces the programmer's effort in repeating the reconstruction of developed solutions. The third is expendability of the framework achieved through the popular hook method, while the fourth is runtime architecture which ideally hooks the domain-specific process to the invoked event by implementing the reactive dispatching mechanism.

2) *Frameworks Classification schemas:* When reviewing the above literature findings, frameworks are described under multiple schemas. Out of those, "scope" is one of the schemas which mattered in the evolvment of different frameworks. Then Fayad & Schmidt, (1997), classify the application frameworks into three considering the scope as (1) System infrastructure frameworks: a developer-oriented local software architecture to standardise language processing tools (2) Middleware integration frameworks: A distributed and commonly available software architectures of distributed applications and components (3) Enterprise application frameworks: A comprehensive software architecture for enterprise-level business application. Accordingly, the middleware and enterprise

architectures are taken more time to develop from scratch, but users can commercially acquire. Further, the enterprise framework provides the entire application's infrastructure and functionalities, which is absent at system infrastructure and middleware integration frameworks (Mili et al., 2002). Then the decision of selecting a suitable enterprise framework is dependent on the stability, adequacy, and economy of the framework. In the same way, Krajnc & Heričko, (2003) summarised seven schemas including "scope", such as approach (the approach taken to develop framework such as OO, component, aspect describe above), Extensibility (framework facilitation of Whitebox, Gray box, Blackbox, glass box), Standardisation (based on the availability of standardisation and/or standardisation authority), Granularity (the simplicity of the implementation and utilisation), License (free or commercial) and Format (framework is either logical, physical, source code or binary code). Then present work found this classification schemas is substantial to the present work.

*Well-known Frameworks:* However, apart from the technical descriptions and classification, most software engineers simply practice frameworks in their day-to-day developments. Then these frameworks technically available via an application programming interface (API) and supported by software development kits (SDKs). Then using these frameworks, developers automate the business logic of the solutions without bothering the fundamental activities related to communication, system software and hardware. There are popular framework groups suite with the need of the developers, such as (1) Framework for web applications: These frameworks are developed to handle the internet-inherent characteristics such as unstructured-big-dynamic data management, interoperability, cross-platform management, communication and interconnection (Jazayeri, 2007). These frameworks are fundamentally built on different language frameworks such as Angular on JavaScript, Django on Python, and Larval on PHP. (2) Data Science Frameworks: These frameworks assisted the engineers to change the data into action by facilities to data science-related activities of Ask, Acquire, Assimilate, Analyse, Answer, Advise, and Act (Andrade, 2015). Examples are Apache Spark (multi-language

support analytical engine framework), PyTorch (open-source machine learning framework) and TensorFlow (end-to-end open-source machine learning framework). (3) Frameworks for Mobile Development: These frameworks are proving the point to point (P2P) data management with platform-specific and hybrid mobile app development capabilities (Spindler, Grossniklaus and C.Norrie, 2009). Ionic (open-source framework for cross-platform native app development), Xamarin (.net platform-based framework), and Kivy (Python-based embedded and enterprise applications framework) are few examples of tons. (4) GIS Application Development Frameworks: These frameworks provide spatial data manipulation and geoprocessing facilities to automate the nosiness processes (Luaces et al., 2005). Few examples are ArcGIS Web Application Developer Framework - ADF (enabled Java and .NET to integrate GIS functionalities) and QGIS Framework (open-source framework for developing GIS functionalities and its applications).

*3) Framework Related to Water Resource Management:* As the present works main intention is to classify the water resource software frameworks, it critically reviewed seven water resource modelling software framework and two general environmental modelling software frameworks to understand how those are explaining under the term framework.

*Water Resource Modelling Frameworks:* This section summarised the seven water resource-related articles, with the major components include in described framework.

Andreadis et al., (2017) developed a framework for hydrological modelling and data assimilation software framework, which can nowcast and forecast using the hydro model. The framework named Regional Hydrologic Extremes Assessment System (RHEAS) is constructed with the concepts related to data, GIS model, Hydro Model, Crop model, and the users.

Sood et al., (2018) Smart flood management framework is developed to integrate IoT, big data and High-performance Computing for smart flood management. The framework describes the IoT layer, Fog layer, Data Analysis and Presentation Layer.

Abebe et al.,(2019) developed the Coupled Flood-Agent-Institution Modelling framework (CLAIM) to assess the different scenarios for flood risk effect on human and environment utilising Agents, Institutions, Urban environment, Physical processes, and External factors as the essential components.

Tightly couple Hydro and GIS modelling framework (PIHMgis) is developed by Bhatt et al. (2014), for construct the water management user interface. The Data development, Hydrological model, Data analysis, Domain composition, Data access library, and Shared geodatabase are the framework's building blocks.

Wang et al., (2018) integrated the different information sources to construct a high-resolution urban flood model when developing a water resource modelling framework. The fundamental concepts in the framework architecture are DEM Revision, Flood modelling and, Flood information extraction (multiple data sources)

The Groundwater Visualisation System (GVC) is a software framework that displays data and animate the water information utilising a conceptual hydrogeological model and third party inputs. Cox et al.(2013) developed this framework unitising the layers of Database, Data collection, GVC package, Simulation outputs, 3D Geo-model, Analysis, and Image/video.

Welsh et al., (2013) Source Integrated Modelling System (IMS) is a framework that integrates the models in river systems using layers such as Graphic interface, command line, service, application services, the simulation engine.

Web-based flood forecasting system (WFFS) is an online multiuser-multi-expert interacting framework for flood forecast whilst in an emergency. Li et al., (2006) used Data conversion, Flood forecast model, Calibration of the model, Forecasting and Flood analysis as the main components of the framework.

*Environmental software frameworks:* Apart from the seven articles, three others on environmental software discipline. Out of them, Parker et al., (2002) developed Integrated assessment and modelling (IAM), a framework that integrated the major components of environmental modelling such as Stakeholders, Scales, Issues, Disciplines,

Models. Further, Object Modelling System Version 3 (OMS3) is a software-oriented environmental modelling framework developed by David et al., (2013). The framework components are described as Products, Development Tools, Knowledge base, and Recourses.

### III. RESULT AND DISCUSSION

#### A. Software framework construction

Then when considering the software artefacts frameworks, it can observe interdependent concepts when developing different types of frameworks. However, all the software frameworks fundamentally describe how the software artefact codes and behaviour should be handled as a thumb rule. Figure 2.0 shows the amalgamation of all the considered software framework concepts.

Accordingly, it could review that the software development industry's software frameworks are always documenting and describing the software artefacts' internal construction and implementation details. Then the depth of the different fireworks is varying from call-back procedures to enterprise-level architectures. Further, as those can be commercialised, standards and licence types developed by organisations.

#### B. Classification through schemas

Then it reviewed how the studied ten environmental and water resource modelling frameworks are describing those software frameworks. According to the available descriptions, it attempted to categorise them utilising the seven schemas of Krajnc & Heričko (2003) describe above. Then it found RHEAS, WFFS and OSM3 frameworks are constructed based on the software artefact-based frameworks. As well as all frameworks could be categorised into the same subclasses of five schemas as extensibility: black-box, standardisation: absent, granularity: simple, license: free and format: logical format. However, apart from RHEAS, WFFS and OSM3, all other frameworks show only somewhat relativity to the characteristics of subclasses. For the "approach" and "scope" schemas, frameworks were classified only considering the

conceptual relativity to the sub-class. See Table 1 for the classification analysis.

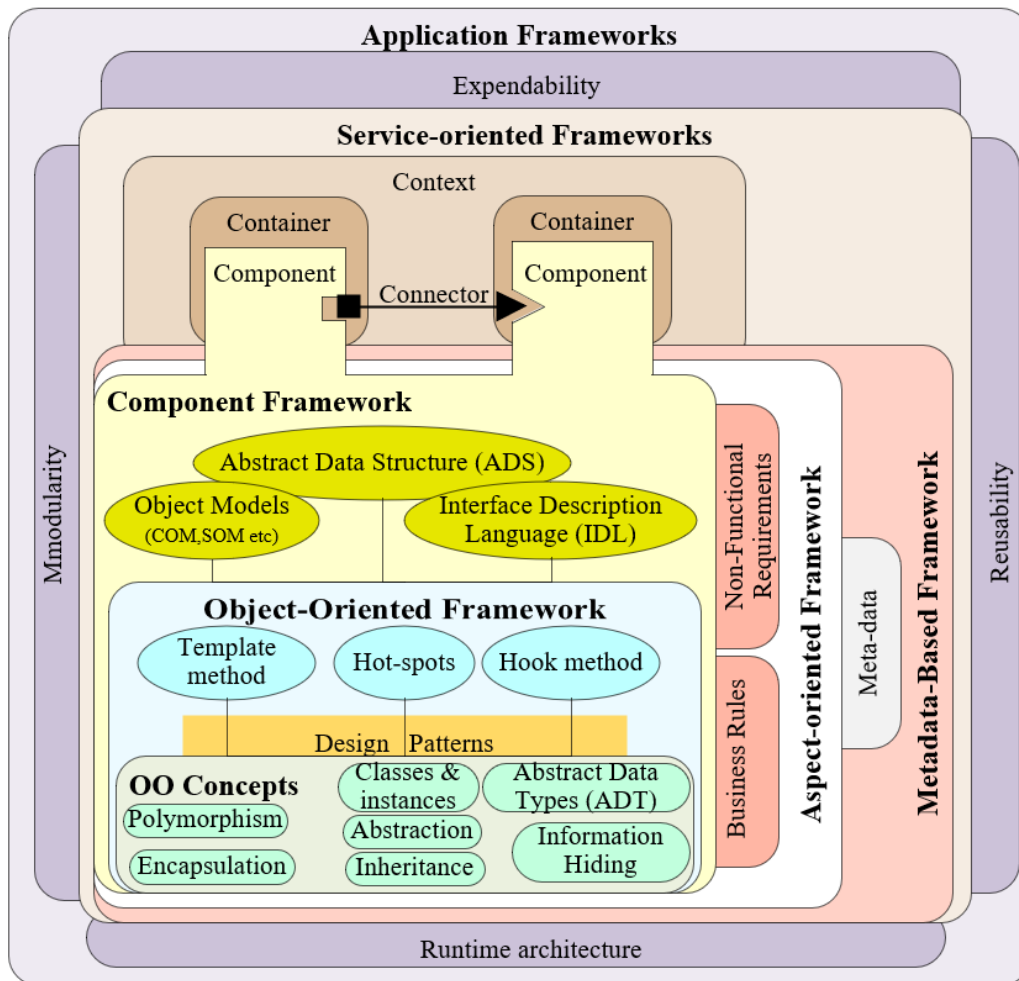


Figure 2.0 Interdependencies of Software Frameworks



Table 1: Environmental/ water resource Software Framework Vs Software framework classification schema

Environmental/ water resource Software Framework	Software framework classification schema		Developed or utilised Software Framework
	Approach	Scope	
Smart flood management framework (Sood et al., 2018) IF 2.79, Cites 49	Aspect*	Middleware*	No direct software framework described. A conceptual framework
CLAIM (Abebe et al., 2019) IF 4.8, Cites 25	Agent-based*	Enterprise*	
PIHMgis - (Bhatt, Kumar and Duffy, 2014) IF 4.8, Cites 107	Component*	Enterprise*	
Urban flood modelling FW (Wang et al., 2018) IF 4.8, Cites 71	Aspect*	Enterprise*	
GVS - (Cox et al., 2013) IF 4.5, Cites 43	Aspect*	Enterprise*	
IMS (Welsh et al., 2013) IF 4.8, Cites 167	Aspect*	Enterprise*	
IAM (Parker et al., 2002) IF 4.8, Cites 315	Aspect*	Enterprise*	
RHEAS (Andreadis et al., 2017) IF 2.74, Cites 23	Object-Oriented	System infrastructure	Developed through OO Software framework
Web-based flood forecasting system - WFFS (Li et al., 2006) IF 3.88, Cites 46	Web-Based	Enterprise	Enterprise JavaBeans (EJB), CORBA, DCOM, and Java RMI-IIOP
OMS3 (David et al., 2013) IF 4.8, Cites 165	Component	Middleware	Modular Modelling System (MMS), OMS1
Note: *relates conceptually only Environmental/ water resource Software Framework column contain impact factor (IF) of the journal and citation received (Cites) figures of the article			

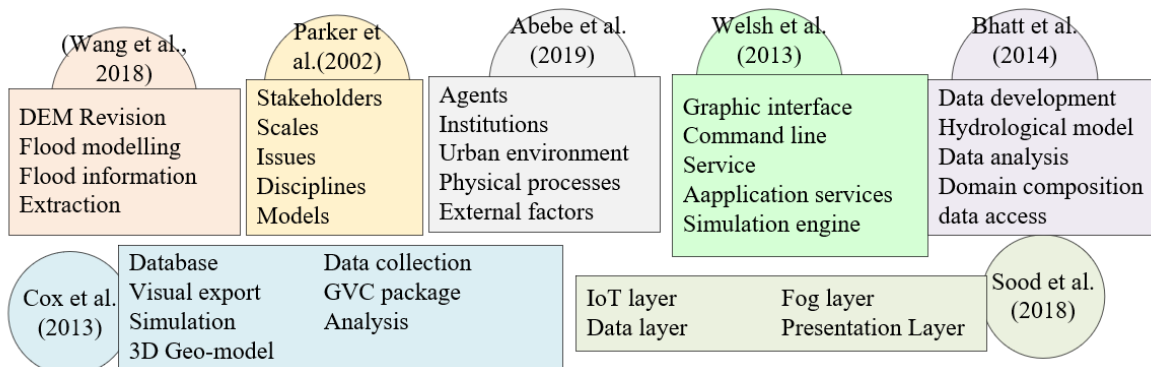


Figure 3.0 Water Resource Modelling Framework Components in studied literatures.

### J. Water Resource Software Framework components

The first seven frameworks of Table 1 only showing the general characteristics of the software framework schemas. Hence, the present work mapped the components identified as the main building blocks of the framework by the authors (Figure 3.0). Then it can observe all the components are describing the tools, method and techniques related to water resource data

capturing, processing, and visualising. Then described components can be categorised as “business objects and logics” in the water resource and environmental modelling discipline.

### K. Water Resource Modelling Framework Classification

Generally, the software frameworks enable integrating all the required reusable components to the problem/solution domain and explain the interoperations and communication between the components (Petty et al., 2014). According to the present analysis, these components vary from functions, procedures, ADTs, hotspots, object models, ADS, IDL, containers, context, services, non-functional requirements, business rules and meta-concepts in different explanations. Then it can realise that both the software and environmental software frameworks are considering both the software architecture and system architecture (Gacek et al., 1995; Medvidovic and Taylor, 2010). Nevertheless, most of such frameworks describe the conceptual framework of the system architecture. Those consist of system components, connections between them, stakeholders, functional and non-functional needs with specific needs, such as IoT, 3D visualisation/simulation (need to fulfil to attain the business requirements).

Then reviewing all these findings, it developed the levels of the software frameworks as shown in Figure 4.0. The dark colour rounded boxes show the conceptual components for each level, and White colour rounded boxes show the examples. Each level's conceptual ingredients become the part of ingredients of the next higher level. However, the utilisation of such a part is optional and depends on the construction of the upper-level framework.

Note:

- DODAF: Department of Defence Architecture Framework of USA
- MODAF - Ministry of Defence Architecture Framework, UK
- NAF: The NATO Architecture Framework

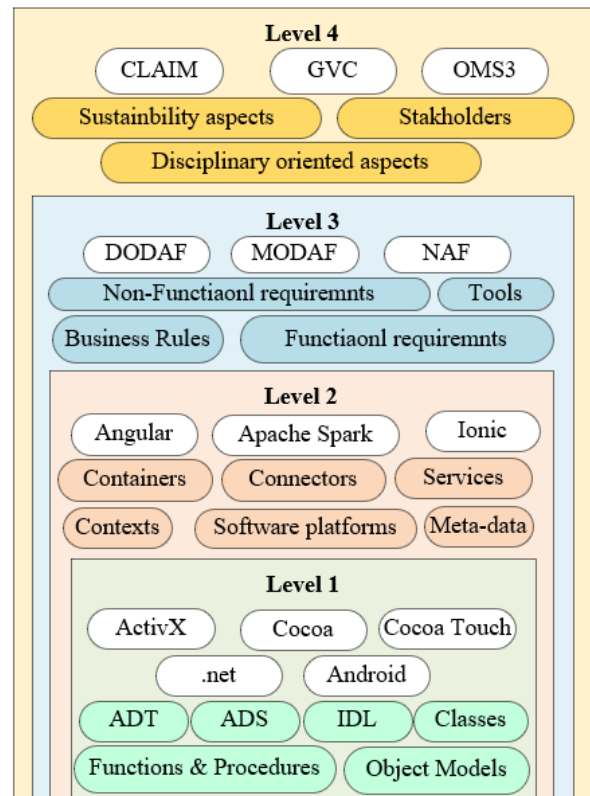


Figure 4.0 Classification of Water resource management Software Frameworks

According to these levels, the conceptual components of practical water resource modelling software frameworks have appeared in Level 3 & 4. Examples of two such software requirement scenarios are shown in Table 2.0.

Table 2.0 Examples for Level 3 and 4

<b>Scenario 1: Optimise the urban watershed culverts</b>	
Level	3
Conceptual component	Non-functional requirement
Specification of the Conceptual component to the scenario	<ul style="list-style-type: none"> <li>The maximum diameter of the culvert should be less than 4 meters.</li> <li>When placing multiple culverts in the same location, maintain at least one culvert diameter gap in-between</li> </ul>
Considerations for the above Conceptual component	<ul style="list-style-type: none"> <li>Related functional requirements.</li> <li>What tools needs</li> <li>Most suited Hydro model</li> </ul>
<b>Scenario 2: Urban runoff management</b>	
Level	4
Conceptual component	Stakeholders
Specification of the Conceptual component to the scenario	<ul style="list-style-type: none"> <li>The list of stakeholders in according to disciplines</li> <li>Non-functional requirements of each stakeholder</li> </ul>
Considerations for the above Conceptual component	<ul style="list-style-type: none"> <li>Manage the conflict requirements among the disciplines.</li> <li>Arrive the sustainable solutions</li> </ul>

Table 3.0 Classification of Water Resource Modelling Software Frameworks

<b>Class (Level)</b>	<b>Main undertake</b>
Software Language foundation (Level 1)	Establishes software foundation that includes elements of the software language. It provides the facility to coding the libraries via API. Develop Software Components
Software on platforms (Level 2)	Interrelates the classes/modules to the processes in technological platforms. Develop Software Packages
Techno-Business platforms (Level 3)	Integrates the processes and component which required to interact withing different technological and business objective. Develop Software Systems.
Building blocks (Level 4)	Assembles the major components need to be integrated to construct multidisciplinary systems. Develop Models of software systems.

However, Level 1 & 2 describe the full technical details that align with the software engineering aspects. Then available frameworks can be directly used, sometimes with delta addons. Therefore, level 1 & 2 frameworks are independent of the discipline-business rules and aspects.

Then it can observe Level 1 to 4 are dependent on each other but, Level 1 & 2 dominated by technical aspects while Level 3 & 4 by management/scientific aspects. Further, the Level 1 framework is dominated by individual software programming language foundation, while Level 2 is the platform where the software operates. In the same way, Level 3 frameworks explain both the concerns on the individual discipline (business model) and technical tools, while Level 4 conceptualise the building blocks of interdisciplinary aspects.

Reviewing all these empirical findings can classify the software system frameworks for water resource management as shown in Table 3.0.

#### IV. CONCLUSION

The term framework is utilising with different meaning at different activities in the software automation process. In the analysis and design stages, it referred to the architecture of the software. When in the coding stage, the programming modularisation and construction of optimised code blocks represent the frameworks. However, when system automation, the attention of the framework exceeds the software automation to the conceptual optimisation of the input-processes-outputs with the business rules.

Then in water resource management software automation, it required to build integrated environment model. For that it needs to properly plan the sustainable decision-making software systems, utilising the optimised code blocks. A close review of the present work in such approach, it could isolate four framework levels in construction of integrated environmental model-based water resource management software.

These levels are starting from the highly technical descriptions- the concepts related to foundation of the software construction. Then in the following by level to level, frameworks collaborate with the system's managerial and/or scientific perspectives reducing the technical details. The final level describes the managerial and scientific concept integrations with less or no technical detail. Then it can be considered as a conceptual foundation of the software system.

Then with such understating, present work contributes the framework-level classes as (Level 1) Software Language foundation, (Level 2) Software on platforms, (Level 3) Techno-Business platforms, and (Level 4) Building blocks frameworks.

Then, the system designers and environmental software modellers will be able to utilise this classification as the fundamental guideline to select or build the suited frameworks for their water resource management problem/solution. Then, it will reduce the conflicting determinations on the frameworks.

However, as this classification is mainly based on the conceptual relation of “software” and “system” differentiations, the defined framework

levels are more valuable to software and system developers in the environmental modelling discipline.

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# A Machine Learning Approach for Detecting Credit Card Fraudulent Transaction

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**Abstract** - The world is reaching a cashless society with the increment of non-cash transactions. E-commerce has become an essential factor in every organization in global trade. Since financial institutions co-operate with billions of online transactions per day, identifying fraudulent transactions has become a challenge. This research was mainly focused on identifying the best intelligent adaptive authentication technique for credit card fraud detection. Areal-world transaction dataset of European credit cardholders and a synthetic dataset were used to extract the historical transactional patterns using Artificial Neural Network (ANN). Different classification algorithms, Logistic Regression, Decision Tree, Random Forest and XGBoost were also used for a comparative analysis to classify a real-world dataset. Among all, ANN and XGBoost have shown the highest performance in the binary classification of fraud and legitimate transactions. ANN has shown an accuracy of 99.94% and high adaptability in handling large datasets, by giving zero misclassification of fraud as a legitimate transaction by reducing the risk to its minimum.

**Keywords:** *fraud detection, ANN, adaptive authentication, random forest, decision tree, XGBoost, logistic regression*

## I. INTRODUCTION

Financial fraud can be defined as “A deliberate act that is contrary to law, rule, or policy with the intent to obtain an unauthorized financial benefit”. It was reported \$24.2 billion was lost worldwide in 2018 due to credit card fraud. As there are millions of credit card users in the world, gross losses from credit card fraud are expected to reach \$40 billion in 2027. The

Federal Trade Commission (FTC) of America is an organization that protects American consumers and deals with the issues of economic lifestyles. According to the statistics provided by Consumer Sentinel Network Data Book of FTC in 2019, the fraud rate has increased considerably. The FTC has received nearly 271,000 reports from Americans about information misused on an existing account or to open a new credit card account. Figure 1 shows the increment of number of frauds, identity theft, and other fraud reports from 2001 to 2019.

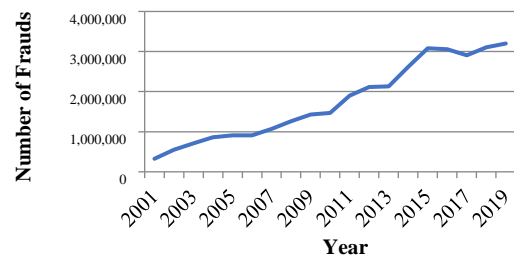


Figure 1 Increment of fraud reports by year  
Source: FTC, Consumer Sentinel Network Data Book, 2019

According to the categories of identity theft fraud, credit card fraud, loan and lease fraud, phone and utility fraud ranked the top three for several years. Figure 2 shows the statistics of those top three frauds from 2015 to 2019

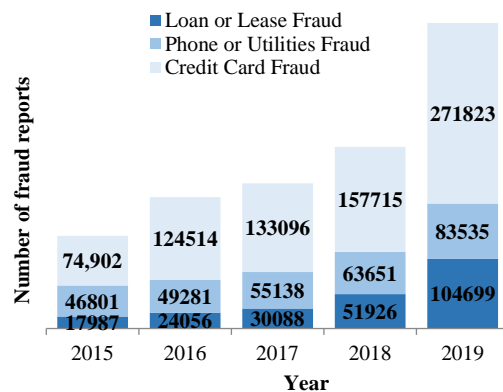


Figure 2. Top three theft reports by year  
Source: FTC, Consumer Sentinel Network Data Book, 2019

The reported number of Credit Card Fraud has shown a significant increment from 2015 to 2019. Financial institutions have taken many countermeasures to avoid credit card fraud. Different techniques like credit card authorization, Address Verification Systems (AVS), and rule-based fraud detection systems have been used by banking sector for fraud detection. The verification and authentication methods involved in fraud detection cannot identify frauds while they were occurring. The challenge in fraud detection was the dynamic behavior of the fraudsters. Many fraudsters try to behave like legitimate users. So the predictive systems should be constantly updated with the transaction behaviour.

By conducting this research, it is expected to identify credit card frauds by considering large historical data of the user's transaction behavior. The system should be intelligent to identify highly changing fraud styles using data mining and machine learning techniques with the help of historical transaction datasets.

Different machine learning approaches and classification algorithms were used by many researchers for credit card fraud detection based on probability. Naïve Bayes classifier, K-Nearest Neighbor (KNN), Fuzzy Logic, Bayesian Network, KNN, SVM, Decision Tree, Hidden Markov Model (HMM), and Logistic Regression was commonly used in fraud detection. Many classification algorithms are not much capable of identifying novel transaction patterns. Also, found that they are not capable to process or not scalable to large

datasets when compared to neural networks. Many researchers have focused on developing credit card fraud detection systems using neural networks. It was identified that ANN has shown better results in credit card fraud detection and they are highly adaptive and perform well in detecting novel credit card frauds.

## II. METHODOLOGY AND EXPERIMENTAL DESIGN

The methodology used in this research mainly consists of 3 parts. Data acquisition and pre-processing, Comparative analysis of classification algorithms, and the ANN model development. Different pre-processing techniques like data cleaning, encoding, feature scaling, data balancing, correlation, outlier removal, dimensionality reduction and clustering were used. Exploratory Data Analysis was used to identify the distribution and relationships of data. The main part of the methodology is the ANN model building for prediction. The other part is the comparative analysis of different classification algorithms. Logistic Regression, Decision Tree, Random Forest, and XGBoost were used and analyzed to identify the best classification technique. Figure 3 has shown the flow of used methodology.

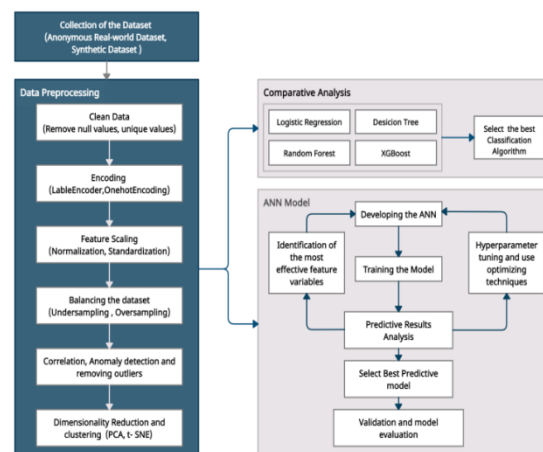


Figure 3. Methodology

### A. Dataset

In this research, mainly two datasets were used, a real-world dataset (Dataset 1) and a synthetic dataset (Dataset 2). The dataset (1) has real-world transactions that were previously transformed into Principal Component Analysis (PCA) due to confidentiality. Those transactions

were done by European Credit Cardholders in 2013 within 2 days. It has 31 attributes where 28 attributes are anonymous. The dataset contains a total number of 284,807 transactions. The number of legitimate transactions was 284,315 which was 99.83% and the number of fraudulent transactions was 492 which was 0.172% from the whole dataset. It consists of 31 features and only 3 features were disclosed. The following Table 1 gives the information on the dataset (1).

Table 1. Details on the attributes of dataset(1)

No.	Attributes	Description
1	Time	The seconds elapsed between each transaction
2	Amount	Transaction Amount
3	Class	Target Variable (Fraud or legitimate)
4	Other 28 features. (V1, V2,..V28)	Anonymous variables which were transformed into PCA

Dataset (2) is a synthetic dataset that is artificially generated and created algorithmically for research purposes. It consists of 2627 legitimate transactions and 448 fraudulent transactions. This dataset has 11 attributes. Following Table 2 gives details about attributes in the dataset and their description. Dataset (2) is a synthetic dataset that is artificially generated and created algorithmically for research purposes. It consists of 2627 legitimate transactions and 448 fraudulent transactions. This dataset has 11 attributes. Following Table 2 gives details about attributes in the dataset and their description.

Table 2. Details on the attributes of dataset (2)

No.	Attributes	Description
1	Merchant_id	Unique identity.
2	Average_amount	The average transaction amount.
3	Transaction_amount	The transaction amount
4	Is_declined	Whether the transaction is previously declined or not (yes/no)
5	TotalNumberofdeclines_day	Total number of declined happened within a day.
6	isForeignTransaction	Whether the transaction is a foreign transaction or not (yes/no)

7	isHighRiskCountry	Whether the transaction is started from a high risk country (yes/no)
8	Daily_chargeback_avg_amt	Average chargeback amount per day.
9	6_month_avg_chargeback_amt	Average chargeback amount per 6 months.
10	6_month_chargeback_freq	Chargeback frequency within 6 months.
11	isFraudulent	Target Variable

### B. Data Preprocessing

Different feature engineering techniques were used to preprocess the datasets. Handling of missing values, encoding strings into numerical, applying scaling techniques like normalization and standardization, and data balancing was mainly used. Both datasets were highly imbalanced as the number of fraudulent transactions was very low when compared to the number of legitimate transactions. To reduce the skewness of the model towards the highest data population the dataset should be balanced using sampling techniques. The Undersampling techniques are not suitable as they reduce the sample size of the dataset. Therefore Oversampling techniques were used to synthesize the number of fraudulent transactions. The highest accuracy was reached when the imbalanced nature of the dataset was handled by using the Synthetic Minority Oversampling Technique (SMOTE).

### C. Exploratory Data Analysis(EDA)

The balanced datasets were further processed to identify the relationships among feature variables, to visualize the distribution of variables, to identify correlations, and to identify clusters. The Pearson correlation distribution was used to measure the statistical relationship, or association, between two continuous variables. Positive and negative correlation of a feature with the target class was used to learn which features heavily influence the identification of a specific transaction as a fraud. The following Figure 4 shows the Pearson correlation heatmap obtained for the dataset (1).



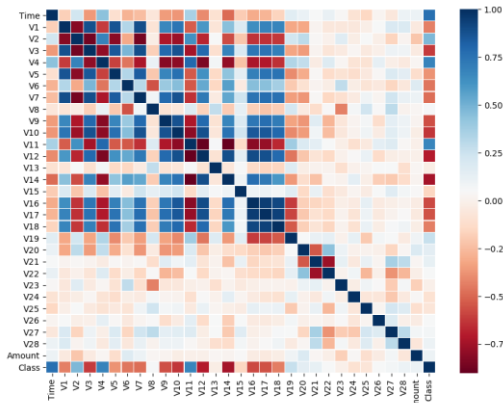


Figure 4. Correlation heatmap for dataset (1)

According to the correlation heatmap, the variables V2, V4, V11, and V19 have shown strong positive correlations with the target class. This means that the higher the value for one of these features, the more likely it will be a fraud transaction. Features V10, V12, V14, and V16 have shown strong negative correlations with the target class. This means that the lower the value for one of these features, the more likely it will be a fraud transaction. The following Figure 5 shows the Pearson correlation heatmap obtained for the dataset (2).

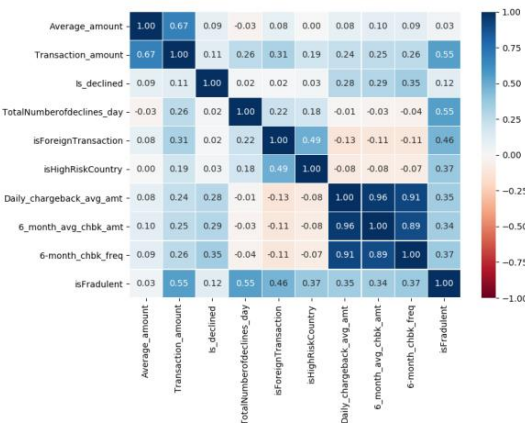


Figure 5. Correlation heatmap for dataset (2)

#### D. Detection and Treating Outliers

As these highly correlated variables have a high impact on the prediction of the target class, the extreme outliers in these selected variables should be identified and removed to improve the accuracy of the model. The presence of outliers can be determined by observing the distribution of selected feature variables which are positively and negatively correlated with the target class of both datasets. The following Figure 6 shows the

distribution of positively correlated features of the dataset (1).

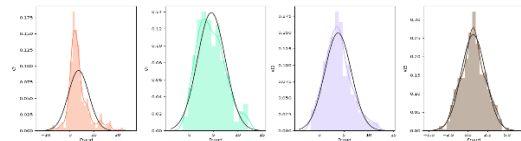


Figure 6. Distribution of positively correlated features (Dataset 1)

According to the above distributions, the V2 variable was having data points with a huge difference from the normal distribution of other data points. The V4, V11, and V19 variables show few data points which are deviated from the normal distribution. To observe the extreme outliers of the variables boxplot diagrams can be used. Figure 7 shows the boxplots for the visualization of present outliers of dataset (1).

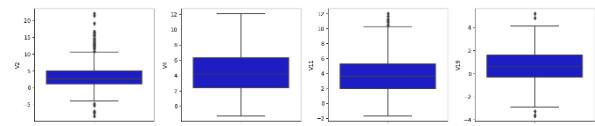


Figure 7. Boxplot of positively correlated features (Dataset 1)

The above boxplots of variables V2, V4, V11 and V19 shows some outliers of faruds positioning more above third quartile and more below first quartile. These extreme outliers were removed from these variables as they can affect the results in machine learning. The following Figures 8 and 9 show the distribution of negatively correlated features and the boxplots of the dataset (1).

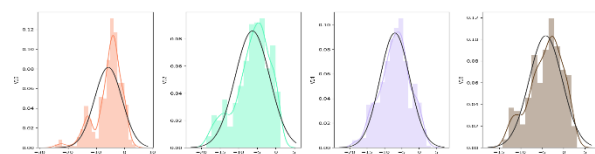


Figure 8. Distribution of negatively correlated features with fraud class (Dataset 1)

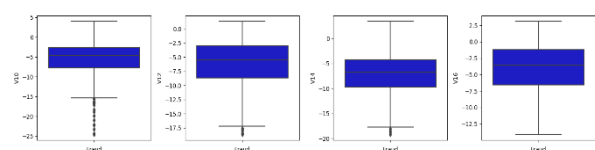


Figure 9. Boxplots of negatively correlated features with fraud class (Dataset 1)

Among the above distribution of V10, V12, V14, and V16 variables, V10 shows many data points which are deviated from the normal distribution. Those outliers may effect in misclassification and that should be removed. The following Figure 10 shows the distribution of the features which have a strong positive correlation with the target class of dataset (2) and Figure 11 shows their boxplots representation.

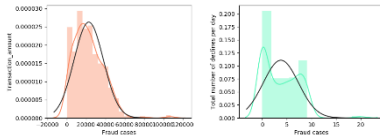


Figure 10. Distribution of positively correlated features (Dataset 2)

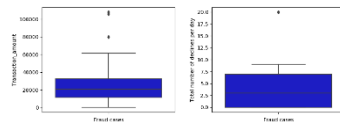


Figure 11. Distribution of positively correlated features (Dataset 2)

According to the above distribution both variables have extreme outliers and those should be removed before using them in machine learning model.

For removal of outliers, Interquartile Range Method (IQR) was used. It measures the variability by dividing the dataset into quartiles. The quartiles were identified by dividing the dataset into 4 equal parts after sorting into ascending order. The four quartiles Q1, Q2, and Q3 represent the 25th percentile, 50th percentile, and 75th percentile of the data respectively. The IQR is calculated using the difference between the 75th and the 25th percentiles of the data ( $IQR = Q3 - Q1$ ). The IQR was used to identify outliers by defining limits on the sample values that are a factor  $k$  of the IQR below the 25th percentile or above the 75th percentile. The common value for the factor  $k = 1.5$  was used for the calculation. The data points which are below  $Q1 - 1.5 \cdot IQR$  or above  $Q3 + 1.5 \cdot IQR$  were considered as the outliers of the dataset. The identified outliers for the selected features were removed from the dataset to increase the quality of the dataset. Using the IQR method total number of 121 outliers from dataset (1) and 6 extreme outliers from dataset (2) were removed.

## E. Cluster Identification Using Dimensionality

Reduction t-distributed stochastic neighbor embedding ( t-SNE ) was used to identify the clusters of the dataset by dimensionality reduction. t-SNE measures the euclidean distance between two points and then plots that distance on a normal curve that is centered on the point of interest. Lastly, it takes the distance between point 2 and where it is on the normal curve. Figure 13 shows the t-SNE distribution of the dataset (1) and Figure 14 shows the t-SNE distribution of the dataset (2) respectively.

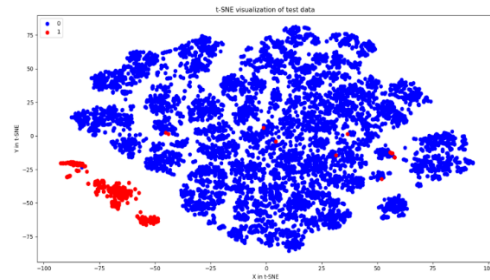


Figure 15. t-SNE distribution of dataset (1)

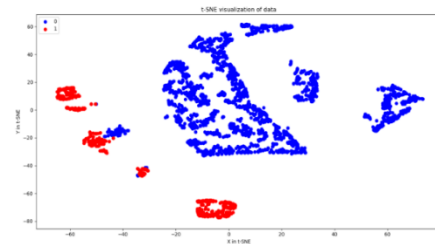


Figure 14. t-SNE distribution of dataset (2)

According to the distribution of data points, and the available clusters, it can be observed that the target classes are clearly separable in both datasets. Therefore it can be used for further processing with machine learning models and classification algorithms.

## F. Artificial Neural Network (ANN)

An ANN was used for the prediction of transactions by extracting the hidden patterns. The Keras sequential model was used to create the network architecture. The Dense class was defined to create a fully connected network structure with layers. The input layer has the exact number of input features. The input dimension was set according to the number of feature variables that were ready to feed into the neural network. In this research, the input

dimensions were set as 29 and 8 for dataset (1) and dataset (2) respectively. Each layer has a specific number of neurons and a defined activation function. The Rectified Linear Unit Activation function was used (ReLU) on the input layer and hidden layers. The sigmoid activation function was used to ensure the network output is between 0 and 1. The classification was done using a default threshold of 0.5. The loss function was used to evaluate the set of weights and the optimizer was used to search through different weights. The cross-entropy was used as the loss argument defined in Keras as “binary\_crossentropy”. The optimizer was defined as the efficient stochastic gradient descent algorithm “adam”. The model evaluation was done using evaluate() function. It returns the loss and the accuracy of the model on the dataset. The predict() function was used to get prediction probability in the range between 0 and 1 as the sigmoid function gives in the output layer.

### III. RESULTS

#### A. Predictive Analysis of ANN

The ANN has generated the results for dataset (1) with an accuracy of 99.94% and loss of 0.0032. The confusion matrix for the balanced dataset has given the classification showing an 82877 of True Positive, 103 of False Positive, 83285 True Negative, and 0 False Negative cases. For the whole dataset, the confusion matrix has given 276862 of True Positive, 246 of False Positive, 371 of True Negative, and 0 False Negative Cases. Classification of fraud transactions with zero false negative cases has reduced the risk of identifying a fraudulent transaction as a legitimate transaction with 100% accuracy. Identification of a legitimate transaction as fraudulent is also can be used in further processing as their risk of being a fraudulent transaction is high to a certain extent. That can be added to a flagged fraud list to use in future predictions. Following Figure 15 represent the learning curves of accuracy and loss graph obtained from the ANN of the dataset (1).

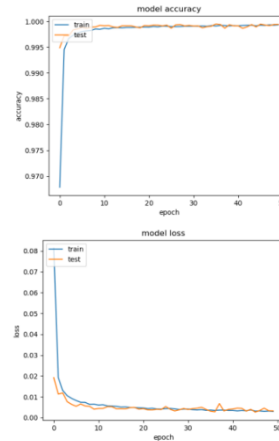


Figure 15. Model accuracy and loss curve for dataset (1)

For the ANN of dataset (2), the balanced dataset has given the classification of binary classes showing a 758 of True Positive, 32 of False Positive, 778 True Negative, and 9 False Negative cases. For the whole dataset, it has given 2520 of True Positive, 107 of False Positive, 435 of True Negative and 7 False Negative Cases. When the batch size and epoch combination were 10 and 100 it has given an accuracy of 96.83% and a loss of 0.114. When increasing the batch size from 25 to 32 and keeping the range of epochs from 50 – 100, the highest accuracy was obtained when the batch size was 30 and when the number of epochs was 75. The accuracy was reached up to 97.40% and able to reduce the loss up to 0.07485. Following Figure 16 represent the learning curves of accuracy and loss graph obtained from the ANN of the dataset (2).

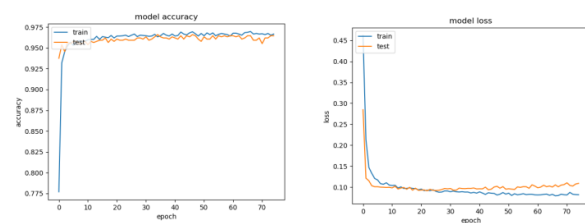


Figure 16. Model accuracy and loss curve for dataset (2)

For comparative analysis mainly four classification algorithms, Logistic Regression, Decision Tree, Random Forest, and XGBoost were used with dataset (1). The following Table 3 gives the information of the classification report that was obtained when using each algorithm.

Table 3. Classification report

	Logistic Regression	Decision Tree	Random Forest	XG Boost
<b>Accuracy</b>	97.16 %	96.35 %	96.43 %	99.94 %
<b>Precision 0</b>	0.96	0.95	0.94	1.00
<b>1</b>	0.98	0.98	0.99	1.00
<b>Recall 0</b>	0.98	0.98	0.99	1.00
<b>1</b>	0.96	0.95	0.93	1.00
<b>F1-score 0</b>	0.97	0.96	0.97	1.00
<b>1</b>	0.97	0.96	0.96	1.00

For Logistic Regression 52 of false negatives, for Decision Tree 50 of false negatives, for Random Forest 62 of false negatives, and for XGBoost only 6 of false negatives was recorded. The XGBoost has shown the minimum number of false negatives with the highest accuracy of 99.94% and it can be identified as the best classification algorithm for credit card fraud detection.

#### IV. DISCUSSION AND CONCLUSION

According to the obtained results, adaptive authentication using ANN has shown a 99.94% accuracy with zero false negative cases for dataset (1). It can be concluded that the risk of misclassification of fraud transactions as legitimate has reduced by 100%. The false positive cases can be used in future prediction as they can be categorized into flagged fraud transactions. The ANN for dataset (2) was able to 97.40% with only 7 misclassified false negative cases. The Logistic Regression has shown 97.16% accuracy, Decision Tree has shown 96.35% accuracy, Random Forest has shown 96.43% accuracy and XGBoost has shown 99.94% accuracy, which is equal to the accuracy of ANN. But the value in ANN was increasing with the use of huge datasets, as the classification algorithms are not capable of handling and adapting to the huge datasets.

Using obtained results of the research and comparative analysis of classification algorithms, it can be concluded that the developed ANN has the highest capability in providing adaptive authentication for credit card fraud detection with the highest accuracy of 99.94%. As future

suggestions, this model can be improved and used if the real world dataset is more disclosed to easy access and if it is not anonymous.

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# Information Management for Sri Lankan Vegetable Farmers: Effectiveness of ICT Applications

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**Abstract-** The paramount scenario behind Sri Lankan agriculture is that one-third of the country's population which engages in agriculture contributes to only 7% of the GDP. The distribution of smaller amounts of income among large communities increases poverty among farmers in Sri Lanka. This limited income shrinks further due to sudden price drops, wastage, damages and oversupply. Various types of ICT-based solutions have been provided to eliminate poverty among farmers in Sri Lanka. However, research findings and literature show that most farmers are still suffering in poverty in the information age with the availability of many forms of information sources required for farmers. Due to some issues or reasons, farmers do not continuously use information systems and available information systems become obsolete within a short period due to lack of continued use. The research explores reasons for the low use of information and communication technology-based agricultural information systems among Sri Lankan farming community. The research collected data using literature review, questionnaires and interviews from 76 farmers in four districts of Sri Lanka. Weekly average prices of three selected vegetables and selling offer received for a digital classified AgriApp was observed for one year and collected data was analysed to identify farmers' and market behaviour patterns. Research findings will help increase ICT practices in agriculture, reduce wastage, control price fluctuation and eliminate oversupply. It will ensure a continuous supply of vegetables and food security to the nation.

**Keywords:** *ICT, agriculture, Sri Lanka, vegetable farmers*

## I. INTRODUCTION

Sri Lanka is a country with 33% of the population engaged in agriculture or agriculture-related live hoods and only contributes 7% for the Gross Domestic Production (GDP) (Sandareka et al., 2020, Sivagnanasundaram et al., 2019). The Sri Lankan agriculture sector consists of several subsectors and vegetable subsector directly influencing the entire population since it is mainly for consumption (Samarasinghe et al., 2013). The main stakeholders of vegetable cultivation are farmers and they require various types of information throughout the crop cycle. The accuracy level of information must be higher for successful crop selection, preparation, cultivation, maintenance, harvesting and post-marketing activities in agriculture. Cultivation will be profitable with proper use of information at the right time in correct way (Welisadeera et al., 2015). There are many ICT-based agricultural information systems available in Sri Lanka dedicated to farmers, with objectives such as eliminating vegetable wastage, controlling price fluctuations, the prosperity of farmers, and minimizing poverty (Weerasinghe and Priyadharsan, 2017). Findings of published literature and preliminary research show that critical issues in the Sri Lankan vegetable sector continue even though there are various types of information systems. Excess stocks generation, non-controllable price fluctuations and vegetable wastage have become everyday situations in the sector (Pushpakumara, 2011). This indicates that functioning information sources are not adequate, their contribution is not substantial enough for the sustainability of the vegetable agriculture sector in Sri Lanka or farmers have rejected using provided systems.

## II. RESEARCH PROBLEM

A large number of information systems are available in Sri Lanka to assist farmers in

obtaining information required during the crop cycle. These systems have been developed by government organizations as well as private sector companies. However, the lifetime of interactive informational systems has become very short due to underutilization. The main problem investigated in this research is “What are the factors which lead to refuse by farmers continuous use of interactive agriculture information systems in Sri Lanka.”. Interactive information systems become more robust and reliable with increasing use and interactions. Agriculture information systems have been established after researches with considerable investment. The research aims to identify reasons behind rejecting the continuous use of interactive information systems by Sri Lankan farmers.

### III. LITERATURE REVIEW

According to Welisadeera et al., (2013), farmers required various types of information during their farming activities. The nature of information required depends on the stage of the crop cycle (Lokanathan et al., 2012). Farmers in Sri Lanka obtain information via formal information sources such as AI (Agricultural Instructors), informal sources such as family members and neighbouring farmers, digital information sources such as online systems and traditional information sources such as TV, radio and newspapers (Rajapaksh et al., 2017). In addition, most Sri Lankan farmers have access to mobile phones and use mobile-based information systems mainly to obtain crop advices, market information, and weather details (Wijerathna et al., 2020).

According to Sivagnanasundaram et al., (2019), a large amount of food produced for human consumption gets wasted annually due to many basic errors of farmers. The volume gets wasted about 1,300,000,000 (1.3 billion) tons of foods per year. It is almost 33% of annual production, and the reasons behind it identified as pest, disease, crop losses with excess use of pesticides and incorrect handling. The situation in Sri Lanka also does not much different than the typical situation in the world and a large amount of food wastage is reported every year. Sri Lankan farmers used to cultivate vegetables without using proper information sources. They used to

cultivate as they wish with a very little amount of unreliable information, leading to cumulating less demanded products in the marketplaces during harvesting seasons. Farmers used to gather information via neighbouring farmers, expert farmers or agrochemical merchants. They used to contact agricultural offices for pest and disease information via very basic ways. Farmers use pesticides and fertilizers according to their experiences, without having any expert advice. It causes a high cost of production as well as crop losses. It was found that incorrect agricultural practices lower the quality of products and production (Van Buggen et al., 2015). Farmers fail to make the right decisions at the right time due to a lack of information or not utilizing available information accordingly. This increases nondemandable commodities in the marketplace and increases vegetable wastage (Sivagnanasundaram et al., 2018). Finally, farmers face difficulties selling their products and suffer with financial losses (Silva et al., 2012). According to Ginige et al., (2016), farmers suffer losses due to incorrect crop selections, lack of professional advice, technologies, seeds, best practices and proper agricultural knowledge. This situation may occur due to financial issues, marketing difficulties, cultural or social problems, unreachable locations or transport issues and poor literacy levels (language and ICT) (Sivagnanasundaram et al., 2018).

Further to Sivagnanasundaram et al., (2019), there is a considerable knowledge gap between farmers and researchers. Therefore, the knowledge gained out of researches must be diverted into practice through farmers and other stakeholders. Unfortunately, this academicindustrial collaboration is not visible in Sri Lanka, but most developed countries have formed strong field-level collaborations and have proven results.

Not only developed countries but developing countries also use ICT in the agriculture sector with positive results. According to research done in Tamil Nadu state in India, farmers use a system that provides pest information and details about the disease (Phiri et al., 2018). Tologbonse et al., (2009) have mentioned that Nigerian farmers also have an ICT-based information system to obtain details regarding crop losses and pests. A

research done by Hashemi et al., (2009) in Iran have described that they have identified farmers have multiple kinds of ideas of pests/disease and effects of them. They have further identified that farmers required proper training to handle situations.

The Sri Lanka paddy marketing board developed [www.pmb.lk](http://www.pmb.lk) and DOA developed [www.goviya.lk](http://www.goviya.lk) are two systems available for farmers to obtain information regarding cultivation (Ekanayake et al., 2016). Silva et al., (2013) mentioned that Govinana, a system introduced by the Department of Agriculture, Dialog Trade Net of Dialog mobile and 6666-Agri price index of Mobitel are active agriculture information systems available in Sri Lanka. These information systems provide timely price information for farmers, but farmers are reluctant to use these information systems since they need much efficient and timely information to make most suitable decisions. The information system developed and introduced by Sri Lanka paddy marketing board was not popular among farmers due to lack of basic ICT knowledge among farmers, unavailability of signal and other ground-level facilities and the non-user-friendly nature of the system (Ekanayake et al., 2016). Welandapola, Badumila and Govipola are classified AgriApp as available for farmers to directly access the vegetable market by overcoming intermediates (Sandareka et al., 2020). Further, as per Ekanayake et al., (2016), Dialog TradeNet and Mobitel price index provide only price information. The price becomes a non-important matter after harvesting since they have to sell at any price as soon as possible. Therefore, farmers use systems very really.

Jayathilake et al., (2015) mentioned that the high cost of information is a barrier to accessing ICT systems in the agriculture sector of Sri Lanka. Narmilan (2017) describes that due to constraints such as infrastructure facilities, training, research priorities, skills, community and political issues, farmers may be reluctant to use ICT information systems in Sri Lanka. Subashini and Fernando (2017) also mentioned that lack of knowledge is the biggest constrain for ICT use in the agriculture sector in Sri Lanka. In addition, language barriers and costs also give a negative impact on ICT use among farmers. As a result, farmers do not use farming information

systems due to lack of awareness, inaccessibility of systems and difficulties of handling systems (Sandareka and Wedasinghe, 2017). Jayathilaka et al., (2015) also say that cost of technology, lower trust regarding systems, no training, infrastructure issues, non-availability of support services resistance and limitations of adoption to new technologies are also some of the constraints for the use of ICT systems for agriculture in Sri Lanka. Pamarathna (2018) added some constraints for not using ICT systems by Sri Lankan farmers as knowledge lack, training issues, problems related to language and unawareness about benefits. Apart from that, complications in the sector, level of outside support, farming experiences, infrastructure, information availability, farmer's personality, ability to learn new things, ICT knowledge, cost of ICT equipment, user-friendliness, trust about ICT systems, training issues, system integration issues and availability of software also have become reasons to not to use ICT enabled agriculture systems in Sri Lanka (Jayathilaka et al., 2015).

According to Wijerathna et al., (2020), government operating information centres are not formally receiving information. Offices in some particular subject areas are not willing to provide information properly. This may be due to the bureaucratic nature and politics of government offices in Sri Lanka. Technical issues such as the nonavailability of systems are also an issue in the access of information. The poor coordination between farmers, economic centers and buyers, is the biggest issue in the Sri Lanka agriculture sector.

#### IV. METHODOLOGY

Published literature was used to identify the nature of vegetable cultivation, associated issues and ICT solutions available in the agriculture sector in Sri Lanka. There were several ICT-based agriculture information systems identified during the literature review. According to literature, [www.pmb.lk](http://www.pmb.lk), [www.goviya.lk](http://www.goviya.lk), Govinana, Dialog Trade Net, 6666-Agri price index, Welandapola, Badumila and Govipola are some of the available ICT agriculture information systems and Apps for Sri Lankan farmers. The research investigated the level of interactions with listed systems by observing the possibility

of direct access to the market using facilities. In addition, it considered the ability to sell vegetables via each of the listed information systems.

The research selected one App for further investigation. The selected App was the only system that facilitates selling vegetables online. The observed App was one of the most promoted agriculture apps in 2019. This App is available for farmers to forward their selling offers and buyers can purchase vegetables through the system without intermediates. The research observed the behaviour of few vegetables. Selected vegetables were Carrots, Cucumber and Brinjal. The number of selling offers received for selected commodities was recorded during 53 weeks of the year 2019. In addition, the research obtained weekly market prices of the same selected three vegetable commodities during 53 weeks of 2019 by accessing the online weekly price index of Hector Kobbekaduwa Agrarian Research and Training Institute (HARTI).

Apart from that, field research was conducted in Wadagolla and Sonuththara villages in Matale district, Hiswalla and Butpitiya villagers in Gampaha district, Magamma in Kegalla Ambagaha Palassa in Mahanuwara district. The questionnaires were given to 105 farmers in Wadagolla, Magamma, Ambagaha Palassa, Hiswalla and Butpitiya villagers and collected 76 with responses. In addition, direct unstructured interviews were conducted with 16 farmers in Sonuththara village to obtain information regarding ICT-enabled technologies. MS Excel was used as the analytical tool since there were no many complicated data to be analyzed. The same package was used to create charts and graphs required for the demonstration of collected data.

## V. DATA ANALYSIS

Average weekly wholesale prices of carrots, cucumber and brinjal during 52 weeks of 2019 were observed and drastic price fluctuations were identified.

Figure 1 describes the average weekly price of carrots in 2019 at Dambulla Dedicated Economic Centre (DDEC).

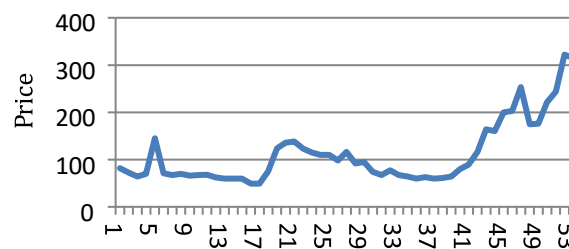


Figure 1: Carrot weekly average price details in 2019 at DDEC

Figure 2 describes the average weekly price of cucumber in 2019 at DDEC. Figure 3 shows the weekly average prices of brinjal during 2019 at DDEC.

There is a similar pattern can be observed in all these 03 commodities during the research period. Price hike can be observed during the 4th week, 16th to 19th weeks and 46 – 50 weeks, while slight drops in the middle.

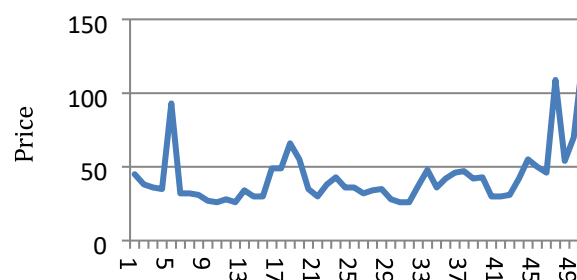


Figure 2: Cucumber weekly average price details in 2019 at DDEC

The survey identified that only 120 selling offers were received from farmers for carrots, cucumber and brinjal

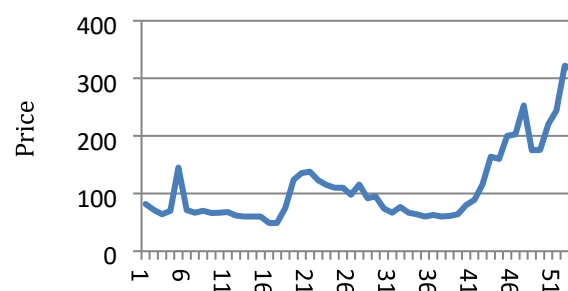


Figure 3: Cucumber weekly average price details in 2019 at DDEC

during 2019. There were 53 selling offers for carrots, 26 selling offers for cucumber and 41 offers for brinjal during the period.

These price patterns show that vegetable prices are fluctuating during the year. Sudden price

drops, as well as extreme price hikes, are also visible within short intervals.

Recorded selling offers for the same commodities during the same period converted into graphs.

Figure 4 shows that it has only received very few selling offers for carrots during the year. There is no much change in other commodities as well. Figure 5 describes the situation of cucumbers.

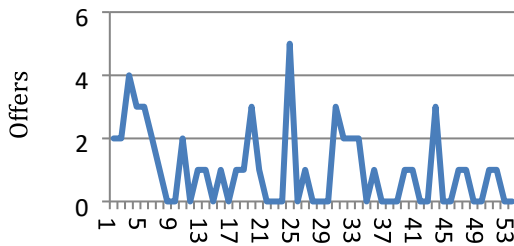


Figure 4: Carrots weekly selling offers in 2019

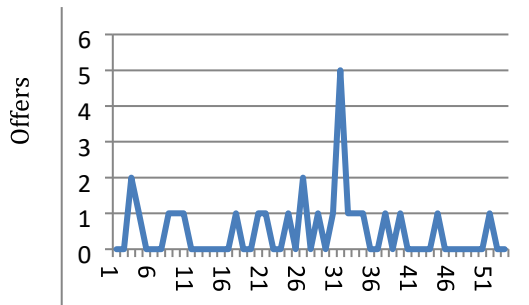


Figure 5: Cucumber weekly selling offers in 2019

Figure 6 presents weekly selling offers received for brinjal during 2019 from farmers for the selected app.

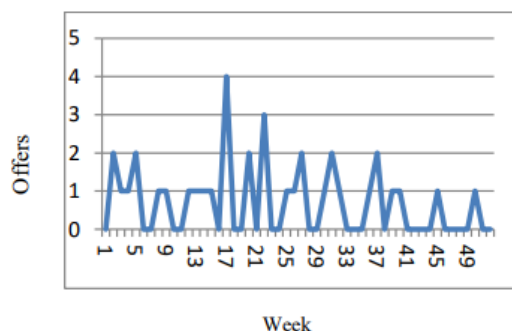


Figure 6: Brinjal weekly selling offers in 2019

Table 1 describes the summary of answers of questioners distributes among farmers.

According to the received response, most farmers are not using the internet but have mobile phones. They are not aware of agriculture

information systems not showing any interest in using them.

The most important factor identified during private discussions with farmers was that they used to contact their regular merchants at DDEC to get price details. If the price is satisfactory, the crop will be harvested and taken to DDEC. Otherwise, they were in the habit of abandoning the crop in the field. Farmers do this because of the difficulty of recovering the minimum harvesting costs and transportation costs in lower price situations.

Table 1: ICT awareness among farmers

Question	Yes	No
Are you using Internet	11	53
Do you know about Agriculture IS	16	48
Have you used agriculture IS	5	61
Do you trust agriculture IS	4	44
Do you have a mobile phone	69	7

The Table 2 shows the summary of the level of interaction in the agriculture information system identified during the literature review.

## VI. DISCUSSION

According to published literature, there is a requirement to introduce ICT-enabled information systems for farmers in Sri Lanka. It is possible to solve most critical issues such as proper crop selection, obtaining the required information, selecting an accurate market, minimizing stock wastage, optimizing prices, and eliminating poverty among farmers theoretically. However, when it comes to practice, the situation is much different. Issues in awareness, literacy issues, ICT skills and many more factors come forward as constraints.

Table 2: Web-based agriculture information systems and Apps



App/Web site	Can sale vegetables?	Observation
www.pmb.gov.lk	No	Informational web site with price details
www.goviya.lk	No	Cannot access
Govinane App	No	Underdevelopment and cannot access
DialogTradeNet	No	Only provide price details
666 AgriPrice Index	No	Only provide price details
Weladapola App	No	Cannot access and very complicated
Badumila App	No	Only provide price details
Govipola App	Yes	Possible to add selling offers

Price details of selected commodities are showing general market patterns in Sri Lanka. This nature of the market shows no impact of provided ICT solution for vegetable agriculture in Sri Lanka. Effective ICT-based agriculture information systems must support market stability. Elimination or control of price fluctuation is one of the main objectives of provided all the information systems. Price increments occur due to high demand, low supply and drops due to low demand and high supply. The demand for vegetables in Sri Lanka increases only during festival seasons. There are no many variations in demand during other periods of the year. According to this scenario, low supply can be considered the most influencing factor for vegetable price increment. Same as the oversupply leads to price drops in the market.

The level of interaction is very low with the selected App and farmers during the year. Farmers showed no much interest in selling their products via Apps. Therefore, the number of interactions becomes low and the level of reliability of the system also becomes low. This

may wipe the system from the user within a short period. It is not because of the non-availability of mobile devices. This is due to mainly non-awareness, not trustworthiness and lack of ICT skills.

Farmers consider the use of ICT-based interactive information systems as an overhead. They do not face any difficulties during high price periods but suffering low price periods. They do not have any reason to use ICTbased information systems during demanded situations. Farmers need assistance only when price drops situations. It is required to use systems continuously to increase reliability. Since there is no motivation or reason to use systems, farmers were neglecting them within a short time.

Table 2 describes the nature of available web-based agriculture information systems and AgriApps. A stranger can interact only with Govipoala App. Govinane is still under construction, Weladapola App and www.goviya.lk are not accessible. All the other systems are providing only information.

## VII. RECOMMENDATIONS

Most of the farmers use mobile technologies just for communication purposes. Therefore, there should be strong awareness campaigns as well as ICT skill development programs launched along with the promotion of agriculture interactive information systems. Farmers must be empowered with benefits that can be obtained from such systems. Simple, straightforward systems with native language will increase interactive mobile systems in farmers' communities. . It is recommended to use innovative marketing strategies during the introduction and research further the nature of factors that can be influenced to increase the use of ICT systems among farmers in Sri Lanka.

## VIII. CONCLUSION

Farmers are suffering in poverty due to low income. Their income levels become lower with price drops, wastage, marketing issues and crop damagers. Incorrect crop selection, wrong agricultural practices, pest and disease, non-availability of timely information lead to these issues. The use of a proper agriculture information system can solve these issues, but

most farmers are reluctant to use them due to non-awareness, low-level ICT skills, language barriers, and lack of trust in ICT-based information systems. It is not possible to obtain benefits from ICT-based agricultural systems without using them. Awareness programs, ICT skill development programs and systems with native languages will increase ICTbased information systems among farmers in Sri Lanka

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# A Novel Personalized Mobile Application for Systematically Monitoring Cash Transactions

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**Abstract-** Today many people face difficulties in having no proper method or technique to monitor their daily personal expenses, which finally lead to great wastage of money unknowingly. This has been a problem due to people's busy lives. They do not have time to manually record personal expenses and even if manual methods are there, they may not be efficient and reliable. At present, many systems to manage expenses exist such as web applications, mobile applications software, and other financial management systems. However, the question arises as to whether these applications give the required output for the user and if they are secure for the user to use. The proposed system works as a solution for this problem. With this system, the user can monitor financial expenses with the use of receipt images, without providing delicate information like credit card details or any other bank account details. Simply, the user does not need to link their bank or credit card accounts to analyze their transactions. The only thing needed to be done is to take an image of a receipt and upload it to the application. With the use of various image processing techniques, the text in the uploaded image is recognized and further processing is done to the recognized text to obtain details such as total cost, date of purchase, and receipt category. The user will receive a display of all these details in the mobile application and also an alerting system that would warn if one's expense goes beyond limit.

**Keywords:** *Natural Language Processing (NLP), information extraction, image processing, receipts, mobile application.*

## I. INTRODUCTION

Nowadays, the Sri Lankan people carry out a busy life working throughout the day. They do not

have time to focus on their daily expenses. Thus, they become more stressed out once they see their monthly or yearly expenses in bills. It has become necessary to have some sort of a financial tracking system with

them or they will face immense financial problems. So, they need a more efficient system that will automatically calculate and show their daily expenses to them. We can see a lot of such systems present now like web platforms, mobile applications, software, and so on. But most of them do not provide an effective solution for the user. Some apps keep track of sensitive data like credit card details, bank account details, and other financial information which the user may refuse to provide. The user may not feel safe to use such platforms though they automate the process of financial flow management and make their task easy. Also, in some apps, the user must enter all the transactions manually to obtain analyzed expenses results. It is a waste of time for the user. The proposed solution will not only automate the process of managing cash flow but also will safeguard the user's privacy. The user will not need to expose such sensitive data and can rely on it without any discontent. The app will only deal with snaps of receipts from the user as inputs and provide him/her with the analyzed expenses. This proposed solution is a mobile application that when a user uploads an image of a receipt, this app will convert the image into a text file using Image processing. Then using Information Extraction in Natural Language Processing, the specific information like total cost, date of purchase is extracted from the text and categorized into various categories as Food, Transport, Fuel, etc. The expenses for each category are shown and the user can even see the overall expense. The user can set a limit of

expenses that he likes to spend for a day, month, or year. Then if the expense for a particular day, month, or year goes beyond the limit, the user is warned about that. Some features like image uploader, letting the user customize his list of expenses, a dashboard to show analyzed budget spent daily, monthly, or yearly (also statistically in graphs), Notification tab to notify about over-limit expenses, and Category-wise view of budget spent can be seen in this app. The overall process is to input a receipt and to get the budget analyzed for the user to make reliable decisions.

## II. RELATED WORKS

Most individuals fail in achieving their financial goals and several methods are implemented to help them sort out their financial problems and to make precise decisions. Several works have been successful, but they still have their flaws, and their effects may dissipate in the long run. One such work is a mobile app using fintech nudges sends the recipients overspending messages and showing them how to manage finance. They alert the users through these messages of how much their spending on a particular date deviate from their usual spending patterns. This study states how the sending of these overspending message alerts will cause a change in household behaviors. The researchers use a regression discontinuity design to compare the overspending message recipients and non-recipient and find out that the recipients have reduced a significant amount of overspending on the next day of the use of this app than the non-recipients. The overall cumulative spending gap between these people has been increased by a two-day horizon according to what is stated by the researcher. But with the increase of days, this gap has been negative. The use of nudges as stated has affected much of the new users and the old, wealthy, highly educated people. Also, this effect has been spread from one app user to another app user in the same household. But this effect only long lasted until there is a lower likelihood of logging into the app. This work concludes that the power of nudges can be amplified if it is integrated with technological advancements when building the app (Lee, 2019). Another work 'Design and Implementation Money Management Web-Based Application for personal and family proposed for

CV.X' states about an easy and quick money management software for the Indonesian people. This software has 4 main features: Sub-account and transaction management, financial plan calculation, investment calculation, and money management and financial statement. The development process is done using a rational unified process framework. This is a cheap, fun, and smart way to manage personal finance and helps customers to reach financial goals by providing accurate information about personal finance (Mumpuni and Sukarno, 2014). 'Stulogger' a multi-functional application is a time and financial management application for students who are unable to plan their time and money simultaneously. It aims to improve student's knowledge and promote self-reflection which encourages the students to give attention to their time spent and allows them to track financial activities easily. It allows the user to set expenses and income from various categories like food, transport, etc. Other features like the availability of a calendar, notes, and reminders for the user to organize their daily activities. (Yeo et al., 2020) A Proposed System for Forecasting of Personal Cash Flow and Saving Prediction was studied upon, and the aim is to develop an interactive and effective application that will help the user to regulate expenditure and encourage them to save money. They aim to estimate the forward cash flow by obtaining information like personal regular and irregular historical financial data, future full or partial specific data, and they aim to estimate the dynamic date of when a person will reach the target for accumulation after a long term. In the first stage, to estimate the forward cash flow they have designed a fast microservice-based architectural system that collects instant data. In the second stage, they have adapted the most often used neural network algorithms and applications to estimate the dynamic date. This prediction helps the user to save their cash as well to plan a loan. Personal Financial application based on a hybrid mobile platform (utilize social media activity) is another application which is developed to help people manage their finances, utilize social media activity like update status photo sharing, location sharing as a trigger to record the financial transaction and support mobility of user online and offline. Using



HTMLA5 and web service, the developer can cut out wasted effort and build a cross-platform app that works on all current mobile devices, this technology is called a hybrid mobile platform. The process in this work is it records financial transactions and processes data into financial reports. The app can operate in iOS, android, windows phone, and web browsers. It uses social media sharing to share public content to social media while saving financial content automatically to the app database. Using this app users can monitor financial transactions and use their money in the right way. Future work proposed in this work is to develop personal financial analysis based on recorded financial transactions data to give users the best information and best advice on how to use money. The article (Gafrikova et al., n.d.) states about some mobile applications which serve as financial management apps. One app is 'Mint'. It manages cash flow, budgets, bills via computer, tablet, or smartphone. There is also a web platform and a mobile app for iOS and Android. On the signup page, the user must provide information about bank account and credit card. Features like allowing the user to store financial account information in one location, keeping track of their spending, creating budgets, setting up reminders, and accessing their credit score and credit report for free are present. This app automatically updates bank, credit card, and retirement account information and uses that information to make recommendations to find savings and unnecessary fees. Calculates average spending, displays pending patterns, adjusts budget to respond to actual changes. User can see their available cash and credit limits before paying bills, receive reminders to pay bills and schedule bill payments and receive alerts when account balances are low. Another app is 'Future Advisor' which offers to invest information on its website and mobile app. The goal of this app is to make investments management available to average investors. It also provides services for investing, retirement planning, college savings. Design and implementation of a personal cash flow program using MS Excel (Bhar, 2019) is another work which is an easy, highly intuitive method of tracking financial dealings, budgeting, and forecasting persona; financial expenditure using MS Excel. Following are the features it

provides:

- Aids in implementing financial strategies designed to meet specific goals based on percentages in specific categories.
- Can make predictions and build mathematical models
- Helps any business. Two main parts are there in this app: Money-in and money-out. Analyzing is done using graphical trends that summarize entries for a year. From the curves produced realized mathematical models. These models were then used for effective forecasting purposes, prediction helps in accommodating future expenses and sacrificing non-mandatory expenses, helping a person to achieve personal or cooperate financial goals. They recommend modifying this app with easy based on individual desires as future works. A Personal financial management system, method, and program using programming methodology (Wood, n.d.) is serving to model past and current spending and budgeting, It enables the user to match the current activities with the planned activities, then it identifies and corrects the differences and shortage in projected activities. It provides the user with a to-do list with reminders of pre-planned actions to be done. The objects represented in his are the entities like accounts, loans, assets/expenses, and financial activities like withdrawals, transfers, or deposits. The user can create customized objects to fulfill special financial requirements. The graphical user interface allows the user to create objects and place them on a graphical timeline providing a financial activity from all selected objects within a selected period. Another study was conducted on 8 financial apps; YNAB (You Need A Budget), Mvelopes, Mint, Quicken, CountAbout, MoneyDance, and Personal Capital. (Balance et al., n.d.) Here Mint was gone through on a paper mentioned above. YNAB is a solid budget practice teaching finance app. It allows the user to share budgets among multiple users as there is a function that lets many devices be connected at once like laptops, tabs, smartphones, and even can connect to Amazon Echo for verbal budget reports. This can run on Windows and Mac devices. It was designed for budgeting beginners. They provide signups for classes with live instructors for the people who need help. Also, there is an accountability partner to indicate a red flag if a person goes beyond the budget they created. Mvelopes is also an app that uses digital

envelopes to put your cash and mark those envelopes with what the cash is for. When the cash in that envelope is gone then the user cannot spend any more on that category. Example: - if the clothing envelope is consumed already the user cannot burrow it from the grocery envelope. When the envelope is empty the app will light up red. The user can sync to the bank accounts and credit cards. This app can be installed on both android and mac. Quicken is a bit old fashion app. It provides the usual management like an overview of your banking, credit card accounts, retirement, and investment, in one place, and keeps tracking your spending categories for you. CountAbout is a browser-based app and provides features like connecting automatically to a person's financial institutions and download the transactions and allows the customer to manually import transactions from other sites. MoneyDance is an app that provides many functionalities like helping the user to set a budget and sounding alarms when a bill is coming due. It allows the user to create charts and graphs for them to track their spending. It is compatible with windows, mac, and Linux. It keeps track of user's investments and alerts them about monthly changes in their total worth. But it is not appropriate for budgeting beginners and can deal only with more experienced personal money managers. Personal Capital is a software app that provides a lot of free tools. It allows the users to import transactions from various accounts. But it won't let the user create custom budget categories. Can create several charts for both spending and savings and do comparing of budget from one week or month to another.

### III. DESIGN AND IMPLEMENTATION

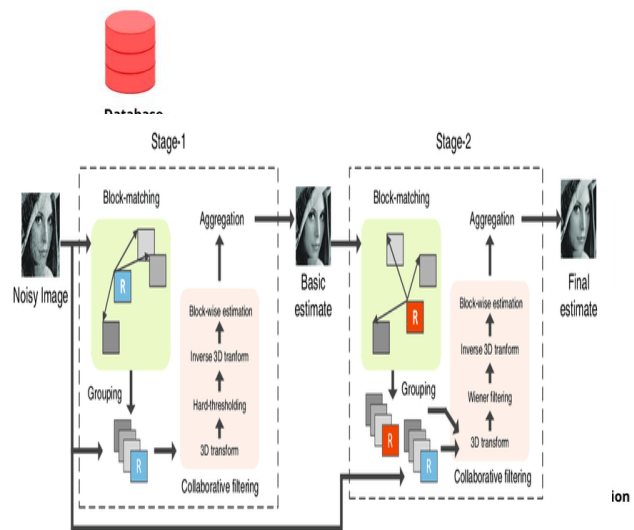


Figure 1. Overall System Design

#### A. Image Acquisition

In the proposed solution, the image of the receipt should be acquired from the mobile camera. The mobile application has an inbuilt camera and lets the user upload the image from the phone's gallery. Normally in image acquisition procedure, the optical signals are converted into electrical signals and then it is converted to digital signals to be readable by the digital device.

#### B. Image Pre-processing

Normally in the image acquisition process, various fluctuations may occur for the signal, and it may get disturbed by unwanted signals called noise. Here the resulting pixels may result in added values for their intensity. This reduces the quality of an image and becomes a barrier in the process of image detail recognition. Therefore, before further processing the image we should recover the original image to the best we can applying various image pre-processing techniques.

1). Denoising using Block Matching 3D Filtering: After a comprehensive research study (Alkinani and El-Sakka, 2017) done on noise removal techniques, we found out that BM3D (Block Matching and 3D) filtering is a good noise removing technique that can be used for the proposed research. BM3D filtering is comprised of 2 algorithms. The 1st algorithm is estimating the denoised image by doing hard thresholding in

the stage of collaborative filtering. The 2nd algorithm takes both the noisy image and the estimated image and applies Wiener filtering. In this stage, it matches blocks of the image with a reference block and stacks these 2D image blocks which are similar grouping them into a cylinder-shaped 3D array. Then for every group, filtering is done.

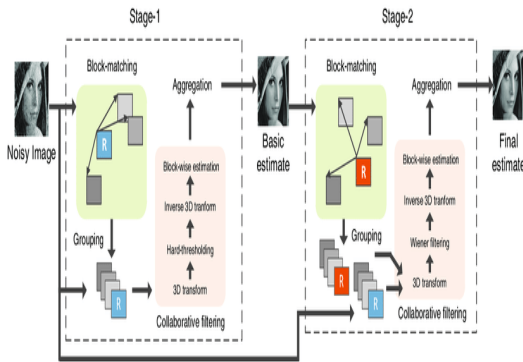


Figure 2. Working process of BM3D Filtering

Source: Internet

2) *Gamma Correction*: After an image is captured and displayed on a screen, its actual luminance is not shown on the display. Luminance is the brightness level taken by averaging r, g, b pixel values. To correct this, we have applied gamma correction.

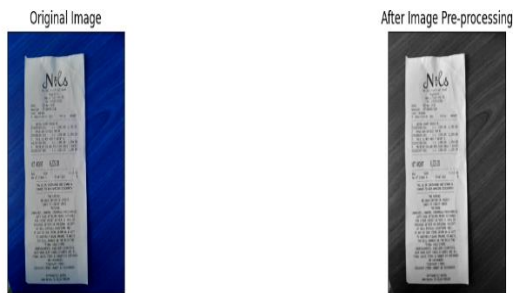


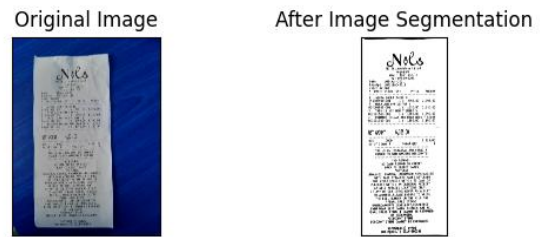
Figure 3. Original Image vs Image after Pre-Processing

### C. Image Segmentation:

The pre-processed image is then segmented to take the receipt object separate from the whole image. This makes the task of text recognition very efficient with fewer barriers. To do this, first,

edge detection should be performed. Then We have used Canny edge detection because it is a multistage algorithm that can detect many types of edges. Afterward contour detection is applied to the edge detected image to identify the receipt. An assumption was made when doing this. The receipt is having four corner points and it is the largest rectangular object in the image. Lastly, before cropping out the image, perspective transformation is performed to prevent any misalignments

Figure 4. Image after segmentation of the image.



### D. Text Detection and Recognition

1) *Optical Character Recognition (OCR)*: Here the process followed in OCR is, transforming 2D images into text that can be read by a computer. We have used Tesseract-OCR which is an OCR tool that has been developed using deep learning technologies and upgraded with the latest comprehensive research done in OCR.

### E. Receipt Categorization and Information Extraction

Using the Natural Language Tool Kit (NLTK), the extracted text in the text files can be processed to extract out the relevant information we needed like the total, date of purchase, and receipt category. The first step is to remove all the unwanted characters from the text file like special symbols. Then the text is sentence tokenized and then word tokenized. After this, all the words relevant for different categories that can be found commonly in each category are put into arrays which are defined for each category. We are using three categories in this research as Grocery, Clothing, and home appliances. Then for each receipt, it matches the tokenized words of a new text file of that receipt with those arrays and identifies for which category it belongs to. The total amount is taken by getting all the floating-point numbers are into an array from the text file and selecting the largest one out of it. If any discounts are given, it is subtracted from that

total value to get the net amount. The date of purchase is extracted with the use of regular expressions.

#### F. Database

The database which is going to be used is firebase. The image is stored in this database after acquisition. Then it is accessed from the database to do further processing. The result is also stored in the database.

#### G. Output

Following is a sample image taken to test the results and its results are also displayed below.

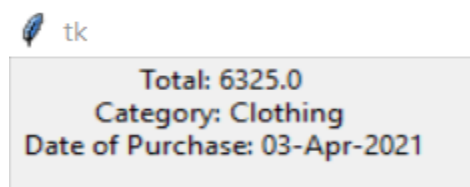


Figure 5. Results after extracting total amount, category of receipt and date of purchase from a receipt

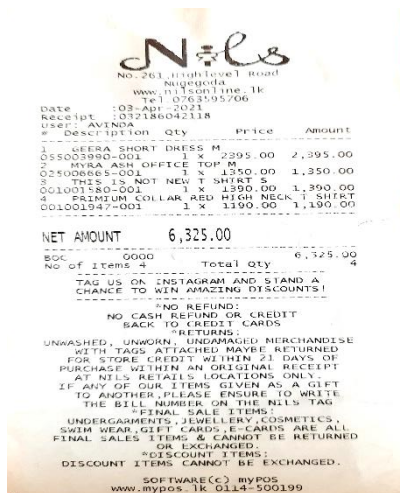


Figure 6. Receipt image from which the results were taken

### IV. CONCLUSION & FURTHER WORKS

This paper presents a solution for the personal cash monitoring problem faced by people. From an image captured from the phone camera, the receipt object is recognized and extracted through image segmentation. Here the main aim is to detect and extract the relevant information like the total amount, date of purchase, and category to which the receipt belongs. The main

techniques used here are image processing, Optical Character Recognition, and Natural Language Tool Kit (NLTK). To build the mobile application Android studio is used. The user can get an effective interaction as the interactions can be done using a mobile app. There are some limitations in this research work. The first one is that there is no finance guidance given to the user. The user can only monitor their transactions. Secondly, the app is made only for personal use and will not be suited for businesses. Another limitation is that there is no web application for this mobile app. As further works, we would recommend improving this mobile application with many more categories for receipts and also improve the above-mentioned limitations.

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# Smart Hospital Diabetic Clinic Patient Management System

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**Abstract** – Sri Lanka provides health facilities freely for everybody and most individuals benefit from these free health services. One of the main problems captured with the significant ongoing clinical process is lots of time-wasting, because of the manual paperwork system. This research aims to automate hospitals' clinic patient management system and develop a diabetic prediction system using machine learning algorithms. The main objectives of this study are to make this manual clinic process an automated, time-saving and efficient one, and to add more value to this significant process of the health sector, with a newly added feature – the diabetic prediction system. This proposed system is highly beneficial for doctors in the process of updating or retrieving patients' records. The main focus here is to automate the diabetic clinic as the first step. This paper presents a clearer clarification of the objective of this study and the relevance and motivation of the study. The proposed solution is a web application with multiuser login. The backend of the web will relate to the MySQL database, which is created by PHP MyAdmin. Initially, it is kept at localhost and build by using Xampp server software. A smart ID card that contains barcode technology is used for the authentication process, and there is no need of maintaining manual records. Fingerprint scanning is used at a sudden admit of a diabetic clinic patient, who does not have to bring the clinic ID. The recommendation system included on the web can be used by both clinic patients and normal users.

**Keywords:** *smart hospital, diabetic clinic, web-based patient management system.*

## I. INTRODUCTION

Every hospital in Sri Lanka holds clinics for patients under various categories as diabetic, heart, paediatric, dermatology and mental. Here is the normal process which is going on the present; When a patient is admitted to the

hospital due to any disease, if that patient is needed to be treated continuously, then that patient is assigned to a monthly clinic of the hospital. When a patient is assigned to some clinic, is given a registration number which is used to identify and a booklet that includes the details of the patient such as register number, clinic type, clinic date, clinic time, details of diseases, and the medicines assigned by the doctors. The patient is assigned a specific date and a time to attend the clinic and must bring the record book otherwise cannot attend the clinic. Then the record book is handover to the staff members. Then the hospital staff search for the clinic cards according to the patients' identification number and they record patient details to the relevant cards and hand over the record book and card to the patients. Then the patients are directed towards the doctors and the doctors record the patients' pressure levels, diabetic levels or other check-ups and the medicines assigned in the record book. Then patients are directed to go to the pharmacy and obtain medicines by hand over the cards. This process takes at least 4 hours per patient according to the research done with some selected patients at selected clinics. It means the patient must wait and spend at least 4 hours to meet the doctor and take medicine. This manual based paperwork system is extremely time-consuming. This study aims to automate the ongoing manual clinic process in case of saving time and to propose a methodology for the process, when a clinic patient is admitted to the hospital due to a sudden severe condition there is no way to identify he/she as a clinic patient if he/she has not brought their clinic record book as it is impossible to remember the clinic's register number for most of the patients.

This paper has selected the diabetic clinic to automate as the first step. because the diabetic

clinic has an outstanding speciality when comparing to other clinics. According to the prevailing statistics, Sri Lanka is seeing a huge increase in diabetes cases regardless of age range. At present one in 12 adults in the country suffers from diabetes, which totals 1.16 million of the total population ('talkingeconomics - Beat Diabetes in Sri Lanka: Too Much Sugar is Not that Sweet', no date).

## II. LITERATURE REVIEW

### A. *Regarding the architecture of clinic patients' management system*

The Design, Implementation and Evaluation of Computerized Clinic Patient Management and Clinician Order Entry Systems in a PMTCT Clinic in Uganda (Kavuma, 2011) is a research and in that they proposed a computerized clinic patient management system (CCPMS) and a portable clinician electronic order entry system designed for the HIV/AIDS PMTCT research and programme activities at Mulago hospital which positively impacted on the patient care. The objectives of them were important improvement of patient load handling among the analysis clinic by providing information to help to supply designing and clinic management, impact on patient care, drug management, knowledge management and reduction of report missing. Challenges with their implementation enclosed synchronous running of the paper-primarily based systems and processed solutions throughout piloting, rotation of clinicians amongst units. The project showed that acceptable and cheap technology solutions will be developed and integrated into health care and analysis to boost method potency in patient care and temperament by clinicians to adopt these technologies.

The Recommender System for a Cloud-Based Electronic Medical Record System for Regional Clinics and Health Centers in China (Hu et al., 2017b) is a research and in that they proposed a cloud-based EMR system integrated with recommended functionality. Drug recommendation and decision support in diagnosis are featured with this counselled. In their research, experiments to test the ranking of

drug recommendation and the auxiliary diagnosis support are presented.

Automated clinic record management system, a case study of Ahmadu Bello university sick-bay (Ahmed, no date) is a research and in that he proposed to design & introduce the use of an automated clinic record management system to improve the services of Ahmadu Bello University sick-bay. A qualitative analysis was adopted and additionally interviews, questionnaires and observations were. And at the top of the analysis, the findings were analyzed that led to the comiproducing same system. However, the study has disclosed the issues related to the manual methodology of record-keeping like difficulties in sorting, retrieving and change records, lack of security of records, loss of relevant info and then on. The program developed for this project is employed to handle the right storage of all records and connected info during a clinic, the patients' treatment reports, date of treatments, doctors answerable and different relevant info are going to be entered into the system.

Advanced Hospital Database Management System (Yadav et al., no date b) is a research and in that, they proposed this system in case of reducing paperwork as well as saving a lot of time and for computerizing the working in a hospital. The distributed information is going to be transferred from hospital to hospital and each patient can have the access to their personal information. The system takes care of all the wants of a mean hospital and is capable to produce straightforward and effective storage of data associated with patients that return up to the hospital. The system is additionally distributed so creating it accessible for each individual. therthere islikelihood of loss of information| since having a backup of every data. This projected system has utterly reduced the paperwork so reducing the workload of operating workers.

The Role of Information System in Hospital Management and its Developing Process (Mazanec, 2014) is research and in that they describe how the quality of the implemented information system influences the management of a hospital with the focus on the risk resulted from working with bad information & the possible ways to implement new current

information in a hospital and the advantages and disadvantages of them.

“Automated Hospital Clinic Maintaining System for Government Hospitals in Sri Lanka” (Gunarathne and Wijethunga, no date) is research-based on the difficulties of the existing manual hospital clinic management system and the way it upgraded to the automated computerized system. The methodology which they have been used is a qualitative and quantitative-based nonprobability sampling survey methodology to conduct their research. Their research aimed to explore the regression of the existing system for maintaining hospital clinics and to upgrade the ongoing manual system to the automated and computerized government hospital clinic maintaining system.

*B. Regarding the technologies used*

Clinics management system (CMS) based on patient-centric process ontology (Jayaweera et al., 2006) is a research and in that they proposed to develop a clinics registration system for the General Hospital, Matara, based on the proposed ontological framework which has done in a 3 layered process in case of providing value-added services to the patients. There are five interfaces to the CMS knowledgebase. Three of them are to interact and to monitor the process layers. The remaining two interfaces are to provide value-added healthcare services to patients and administrative services to relevant authorities.

A Clinic Ontology Construction Method in Distributed Hospital Information Systems (Boyi Xu, Hongming Cai, and Lihong Jiang, 2013b) is a research and in that they proposed an ontology construction method. In this, they aimed to help users in integrating clinic data for decision making. Finally, this approach is demonstrated in a clinic data analysis project. The result shows that the method is efficient in ontology engineering. During this approach, to support the complete method of information analysis, they build ontology from information schema semi mechanically to explain the information sources.

Intelligent and Convolutional-Neural-Network based Smart Hospital and Patient Scheduling System (Rajakumari and Madhunisha, 2020) is a research and in that they proposed a new Decision-Support environment to help patients

to be relaxed while waiting at clinics without any hardness to consult a doctor for their respective needs. This focuses on developing a system to boost the potency and quality of delivering an online based mostly appointment system to scale back waiting time. To rectify these difficulties, this planned system uses Convolutional Neural Network (“CNN”) for a clinician's schedule analysis via experimental setup. within the proposed system, the data-driven prototypal model is dependent on method discovery, patient arrival rate “analysis, and repair time analysis. Likewise, a progression of steps to infer the best improvement technique from the prototypal investigation is remembered for the system.

Hospital Management System Using RFID (Radio Frequency Identification) " ('International Journal of Advanced Research in Computer Science and Management Studies', 2015) is research and in that they describe; this system is meant to cut back the manual intervention to the utmost level potential and Identification of patients WHO (World Health Organization) area unit unable to speak is completed with efficiency by the employment of RFID cards. The most purpose of this method is to form data management tasks easier and to develop a software package that replaces the manual hospital system with the automatic hospital management system. Having RFID tracking suggests that hospitals will use RFID-based HMS to trace whether infant’s area unit even within the hospital that is beneficial if they lose track of patients. A similar idea is often applied for the aged-care management victimization RFID-based HMS.

The summary of the literature review is as follows.

Table 1: Summary of Literature review

Paper Title and Year	Methodology Used	Objectives	Drawbacks
The Design, Implementation and Evaluation of Computerized Clinic Patient Management	Both computerized systems were used in parallel with existing	Improves efficiency in clinic processes. Reduce patients’ clinic	Didn’t entirely cover the aspect of improvement of quality of care received

nt and Clinician Order Entry Systems in a PMTCT Clinic in Uganda. (2011)	paper-based systems.	attendance time.	by patients
The Recommender System for a Cloud-Based Electronic Medical Record System for Regional Clinics and Health Centers in China(2017)	A notion utilizing is used to associate on rules to find the relations between certain diseases & drugs	The system aims at recommending the widely used drugs to the manager of stock via analysis.	The database is still in the testing phase, it can't support such a large amount of data.
Automated clinic record management system(2015)	Qualitative research was adopted.	Investigate ways of providing a standard record storage & management system.	Does not do away with paperwork completely. Problems in data collection
Advanced Hospital Database Management System(2016)	Data distribution from hospital to hospital and ability to access records by patients.	To computerize working in the hospital. Provide easy & effective storage of information.	The pharmacist is not added to this database as he is a key person in the hospital system.
The Role of Information System in Hospital Management and its Developing Process(2014)	Describes how the quality of the implemented information system influences the management	The management of the hospital can be done in a highly effective way.	When incorrect information is used in the process, it may result in a bad product

	ent of the hospital.		of this process.
Automated Hospital Clinic Maintaining System for Government Hospitals in Sri Lanka (2020)	The methodology used is a qualitative & quantitative base survey. The online review flowed through email.	To explore the regression of the existing system for maintaining hospital clinics. To upgrade existing systems to automated systems.	Based on only one aspect of the government hospital system.
Clinics management system (CMS) based on patient centric process ontology(2006)	Patient-centric process ontology has been adapted in the development.	To provide a more secure and flexible environment to all the participants.	Not a completely automated system, associated with the manual based existing system.
A Clinic Ontology Construction Method in Distributed Hospital Information Systems(2013)	The semi-automatic ontology construction method is adopted in clinic ontology development.	To recognize the equivalent concepts in different databases.	Complex to be built.
Intelligent and Convolutional-Neural-Network based Smart Hospital and Patient Scheduling System(2020)	Information driven prototypical model is built dependent on process discovery, patient arrival rate analysis, and service time analysis	Formed to help patients to be relaxed while coming to the clinic without any hardness to consult a doctor for their respective needs.	

RFID-Based Hospital Real-Time Patient Management System(2015)	Uses Web service interfaces to support standard electronic health records.	To create standards-based secure access to patient's data and medical records.	Prohibitive costs, technological limitations, and privacy concerns.
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### III. METHODOLOGY

The first step is targeted to automate the diabetic clinic. The proposed methodology is; When a patient is admitted to the hospital or a patient comes to the outpatient department, if that patient is detected with diabetes, should be examined, and treated regularly, those diabetic patients are registered to the diabetic clinic at the hospital. Patients' profiles are created on the web while registration. National ID numbers are used for the authentication process. The clinic patients' fingerprints are also captured at registration to use in case of an emergency like; when a diabetic clinic patient is admitted to the hospital due to a sudden severe condition without bringing the clinic ID, instead of bothering the patient for clinic details, by scanning a fingerprint, patient's clinic information can be retrieved quickly from the web and can quickly start and continue treatments easily and efficiently.

After the registration at the diabetic clinic, they are given a clinic ID card and it contains a barcode. This barcode is used for quick identification and authentication of patients. And, that ID card contains the months, dates, and times for the clinics for a year. The ID card is supposed to annually update as it contains clinic dates and times for a year only.

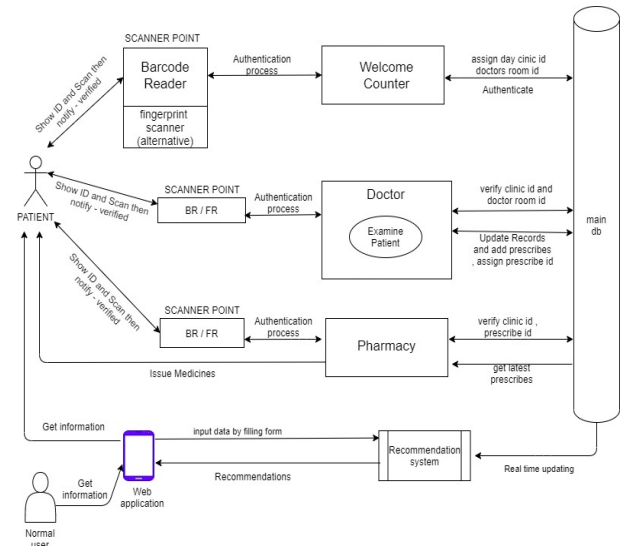


Figure 1: Methodology of the System

Source: Author

This system has a multi-user type of login. The admin panel is the hospital staff. They are authorized to view, retrieve, or update patients' profiles. Hospital staff also have their profiles in the system. They are authorized to update general clinic details, relevant clinic dates, times, and hospital staff details. Diabetic clinic patients are another level of users. At their registration to the clinic, they are given a paper printed with URL, their username & password to log in to the web. Clinic patients can view and retrieve their clinical records, reports, or doctors' prescriptions also by log in to their profiles using the given username & password. And others are normal users. Normal users mean any person who wishes to use this. They can log in to the system after the registration. They can obtain general details about the hospital, clinics, and doctors. And through this web, they can request to register at the diabetic clinic of the hospital, and the hospital staff is in charge to work on such requests. And there is a recommendation system that includes diet plans, exercise schedules and lifestyle suggestions for users under categories diabetic, pre-diabetic and non-diabetic. Both clinic patients and normal users can use this diabetic prediction system and the recommendation system.

### IV. RESULTS AND DISCUSSION

As Sri Lanka is still a developing country, the hospital clinical procedure is still a manual



process, and it contains many issues. The research aims to automate this manual procedure to save time and make it efficient. The following is the proposed clinic patient's ID card issued at registration which includes the clinic dates and time for a year and a barcode that would be used for the authentication process. This ID card is supposed to annually update.

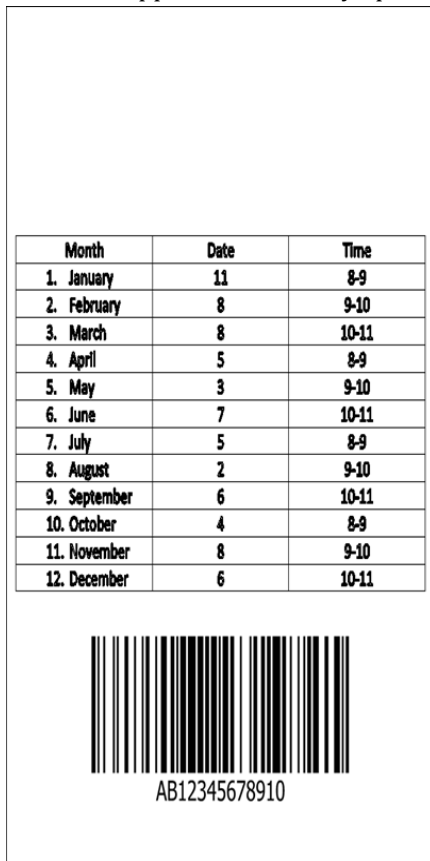


Figure 2: The proposed clinic ID card  
Source: Author

Following is the top-level architecture diagram, and it depicts the architecture that would be used in developing the proposed clinic patients' management system.

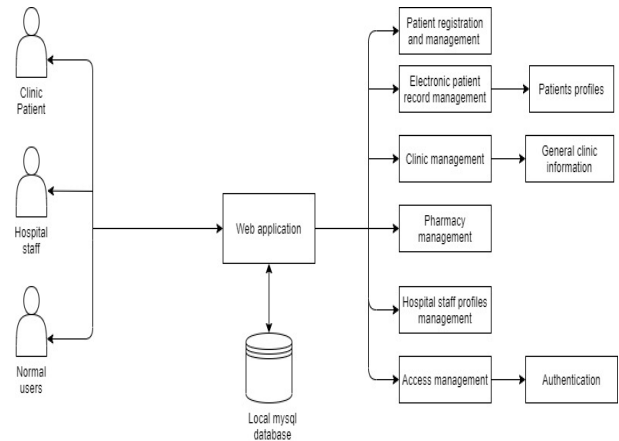


Figure 3: Top Level Architecture Diagram  
Source: Author

There are 3 main user types in this system as clinic patients, hospital staff and normal users. These users have separate access types to the system. All the user types are authorized to access general details on the web. Diabetic clinic patients and hospital staff are only authorized to access patients' profiles. Patients' profiles are managed under the task, electronic patients' record management. General clinic information is maintained under the task, clinic management. Authentication is handled by task, access management. When a patient is registered at the diabetic clinic their profiles are created.

The following shows some user interfaces of the web system.

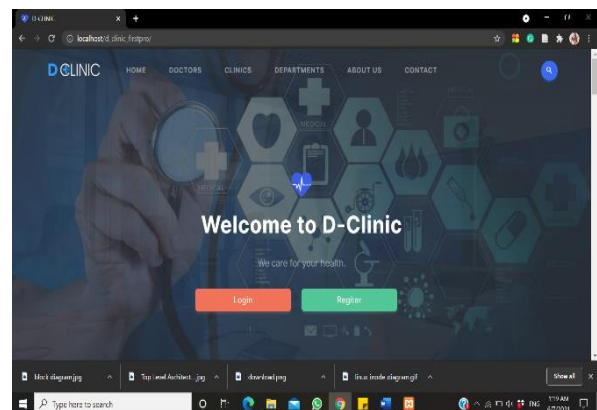


Figure 4: The user interface of the system  
Source: Author

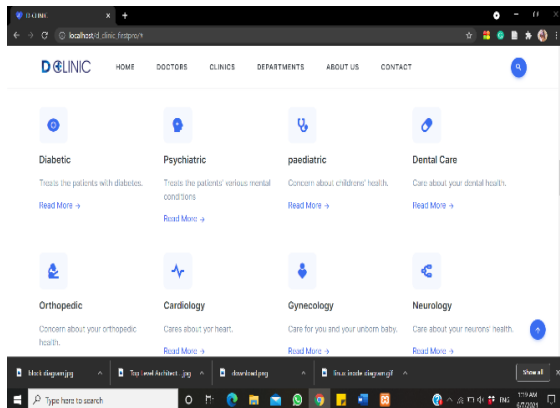


Figure 5: The user interface of the system

Source: Author

## V. CONCLUSION & FUTURE WORKS

Could identify diverse types of solutions proposed at diverse types of matters that arise in hospital clinic patient's management systems by using the literature review. Government hospital clinics are delivering huge invaluable service that is benefited by many folks. However, there are many issues related to this manual clinic process. This analysis primarily aims to create this in progress method associate with economical well-functioning. There are various kinds of issues within the hospitals concerning clinic patients' management from different views. The main drawback captured is that the time wastage. As a special step within the clinic patients' management system, propose to introduce a smart patient ID card rather than manual record books and an automatic management system that can be straightforward for the clinic patients and the hospital staff. This proposed system will be highly beneficial for doctors in the process of examining clinic patients and keeping records because with this automated system it will be extremely easy to update or retrieve patients' records in real-time. And at a sudden admit of a clinic patient, without bothering the patient for clinic details, by scanning the patient's fingerprint, clinic details can be easily retrieved from the system and can continue quick and efficient treatments. This automated system will be a better substitution for the ongoing manual clinic process. And both clinic patients and normal users can get huge benefits from the recommendation system which contains diet plans, exercise schedules and lifestyle

suggestions for the levels diabetic, pre-diabetic and non-diabetic.

As the future continuous development of this project, it is proposed to add a new feature a diabetic prediction system to this web application that could be used by both clinic patients and normal users by log in to the system. If this system is compatible with the users, it is proposed to improve this for the rest of the clinics also.

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# Neural Network Based Weight Prediction System for Bariatric Patients

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**Abstract** – Obesity has become an epidemic condition in Sri Lanka as well as around the world. It is proven beyond doubt that Bariatric Surgery (BS) is the most effective option in treating morbid obesity patients, whose Body Mass Index (BMI) is greater than 40.0. After undergoing surgery, it is required to monitor a patient's weight for eighteen months until they reach a healthy weight that falls within the normal BMI range (18.5-24.9). This study has analysed records of bariatric patients registered at Colombo South Teaching Hospital, Kalubowila under three surgery types. Records show that due to the inability of tracking their weight loss throughout the post-surgery period and lack of continuous assessment after BS, majority of patients have lost their track of weight before reaching the eighteenth month. Therefore, some patients have to go through the same operation more than once, which creates a threat to their lives. This study aims to remotely track pre-and post-surgery bariatric patients and allow them to keep track of their weight loss until they achieve their expected weight using a web-based weight prediction system based on artificial neural networks. To predict the final weight bariatric patients might get after the surgery, pre-surgery and post-surgery data are taken as inputs. Mainly three predictions are aimed to be given as the outputs; namely pre-surgery, post-surgery and monthly weight. Machine learning algorithms like artificial neural networks provide an average of 85% accuracy in predicting the weight until the patient achieves the expected result in the final month.

**Keywords:** *Bariatric Surgery (BS), Body Mass Index (BMI), obesity, morbid obesity, telemedicine, neural networks, machine learning, artificial intelligence*

## I. INTRODUCTION

According to the World Health Organization recent statistics the 5th most risk factor that causes death is obesity (Obregón, 2020). When referring to the statistics 4.72 million deaths have been recorded under this obesity factor and about 1.9 billion of adults were considered to be overweight ("Obesity and overweight," 2016.).

It is clear that reducing the obesity and guiding the morbid obesity Patients to fall back into the healthy BMI range should be addressed in the current world. In Sri Lanka prevalence of overweight and obesity is 37% and 15.8% respectively, which is a considerable amount and a prevailing issue in Sri Lankan Health sector. (Somasundaram et al., 2019). Risk conferred by obesity can be reduced by sustained weight loss, but this is difficult in a majority. Bariatric surgery (BS) has proven to provide an excellent answer to this problem. (Bulugahapitiya and Muthukuda, 2014). It is clinically and scientifically proven that bariatric surgery is one of the most effective long term solutions in treating morbid obesity patients (BMI>40) with weight reduction. (Wijetunga et al., 2019).

The only Government Hospital that provide the Bariatric Surgery in Sri Lanka is the Colombo South Kalubowila Teaching Hospital. Number bariatric operation types are performed globally. Among all the operation types performed worldwide only 3 main types of bariatric surgeries are performed in srilanka according to the Sri Lankan body type.

- I. Laparoscopic Roux on Y Gastric bypass
- II. Laparoscopic Sleeve Gastrectomy / Vertical Sleeve Gastrectomy

### III. Laparoscopic Mini-Gastric Bypass / Single Anastomotic Gastric Bypass

All type of surgeries are performed 100% Laparoscopic (Key hole) manner by the medical team with only very small incisions on the abdomen to reduce the weight of patients.

After the bariatric surgery, every patient has to go through a separate continuous assessment for a period of eighteen months. It should also be accompanied by a yearly visit to the doctor until they achieve the desired result which is considered as a healthy BMI (18.5—24.9)(Zhang et al., 2015). The current follow up process of each BS patient is done manually and there is no any common platform for both Bariatric patients and Medical Officers to track the weight loss. Due to a lack of attention during this period and other physical and mental facts, results may change and Patients might have to undergo the same process from the beginning. Figure 1. clearly shows at the end of 18 months, most of the patients have lost a considerable amount of weight but haven't achieved the goal of a healthy BMI.

Moreover, a lesser number of data available of postoperation BMI values show that majority of the patients have lost their track of recording at the end of 18 months. These patterns explain that lack of follow up and tracking patient's weight throughout the 18 months period is one of the major problems in the current system. This is the reason for not getting the expected results at the end of 18 months.

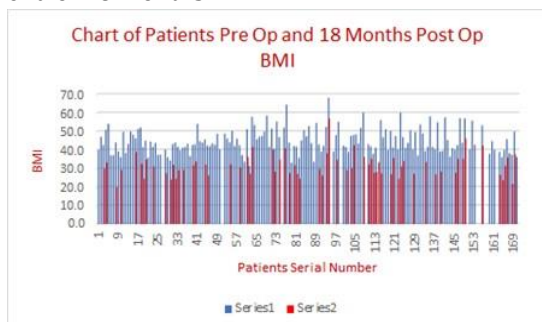


Figure 1. Histogram of 170 patient's pre-operational and postoperational (after 18 months) BMI values. Source: Colombo South Teaching Hospital, Kalubowila

Due to this current manual system there is no way of getting an idea about the final weight and the weight they can achieve after the surgery. To overcome this issues in the current manual system in Kalubowila Teaching Hospital Developing this system shows a positive path towards the Bariatric Patients and Medical Officers. This application can offer a number of important advantages to both patients and medical officers. The application is designed to give three achievable weight predictions for patient's.

- I. Ability to predict the final weight(18 month) of patient before undergoing the surgery.
- II. Ability to Predict the final weight of Patient (18 month) after undergoing the surgery.
- III. Ability to predict the weight of patients for each clinical visit
  - i. 2 weeks
  - ii. 1month
  - iii. 3months
  - iv. 6months
  - v. 9months
  - vi. 12months
  - vii. 15months
  - viii. 18months-final month

In all cases prediction is done by involving artificial neural network which is one of the deep learning technique. Also, in this system it can produce an achievable plan to attain a healthy BMI in 18 months. If there is a difference in the actual weight and the desired weight, this system is able to detect it and guide them to follow the correct path to achieve the desired weight. It will minimize the number of patients undergoing the surgery again. Moreover, this provide physical and mental support to patients to succeed in their weight loss journey. Also, it allows patients to add health assessment records on their own and update the medical officers.

This system provides telemedicine support in any pandemic situation too. Also Automated system will help the medical officers identify the patients with completed health assessments to conduct the BS. They will receive a proper track of their patient who has/has not completed their



assessments, which will provide a better understanding of the patient's weight loss journey. We have analyzed records of more than 500 bariatric patients registered at Colombo South Teaching Hospital, Kalubowila. This application will also provide direction to get into expected weight during the post-surgery period. This will prevent them from repeating the BS again.

## II. LITERATURE REVIEW

Bariatric surgery is done for patients suffering from morbid obesity (BMI over 40.0) within Sri Lanka. After undergoing the surgery, it is needed to keep assessment of patients for 18 months until they reach to a healthy weight level, which falls on the healthy BMI range. These patients need more support after undergoing surgery to continue to lose further weight or to maintain a healthy weight that falls on the normal BMI range, which is the main target of undergoing the Bariatric Surgery.(Bulugahapitiya and Muthukuda, 2014.) Remotely tracking the physical activity of such patients and predicting their weight may give health professionals a more clear image of the activities of these patients and provide more personalized support.(Wijetunga et al., 2019)

### A. Current System

Currently, there are applications in other countries for bariatric patients but in Sri Lanka, there are no systems or a mobile application designed to automate this bariatric process and track bariatric patients' weight. When considering the current manual system there are mainly two parts as pre and post-surgery, every patient should undergo four medical assessments in the pre surgery part as Endocrine, Respiratory, Endoscopy, Nutrition so after completing them pre-operative assessments can be recorded before the surgery will take place.(Mundi et al., 2015) The post-operative management. Two weeks after the operation undergoes, each and every patient should visit the endocrine clinic in the hospital with 8 main reports.

1. TSH report
2. Lipid Profile

3. Fasting Blood sugar
4. HbA1c Report
5. Se Ionized Ca <sup>2+</sup>
6. Se Protein/ALT/AST
7. 25-Hydroxy Vit D level
8. Full blood Count.

will be measured at the clinic.(DeMaria, 2007) Every 4 weeks, 3 months, 6 months, 9 months, 12 months, 15 months, 18 months after the operation date should take the above reports and should visit the hospital. At the end of 18 months, patients should get to their expected weight. In some cases if they were unable to achieve that, weight the patient has to go through an alternative way to get into the expected weight, so these patients have to go through the Bariatric surgery again.

### B. Existing Systems

Currently there are applications designed to track the physical activity of the bariatric patients after the surgery. And when it comes to weight loss most of the apps focus on the exercises, meal plans, Nutrition and Water Tracking, diets and Bariatric Specific Recipes for them to lose or continue their weight.(Murphy et al., 2020) However, these systems are unable to predict the weight of the patient after all, which is the main functionality of our planned system.

Few researches have been focused on predicting the weight of BS patients using different of methods. A few of researches obtainable in the literature are explained below.

When predicting the weight after the BS (Abu Dayyeh et al., 2011) has proposed a system which focuses on the Weight regain after Roux-en-Y gastric bypass (RYGB) and evaluated whether gastrojejunal stoma diameter is a risk factor for weight regain after RYGB using ML. RYGB is one of the surgeries out of BS performed in Sri Lanka. They looked at data from patients who were sent to a tertiary care bariatric facility for upper endoscopy following RYGB over the course of four years. The relationship between the gastrojejunal stoma diameter and weight recovery was investigated using linear regression analysis. To construct a prediction

rule for weight increase following RYGB, they have used a logistic regression model including clinical and endoscopic characteristics. 59% of the 165 participants in their research exhibited significant weight gain while 41% did not. They used a 7- point scoring system that included the gastrojejunal stoma diameter, race, and percentage of maximal body weight lost after RYGB to develop a simple prediction rule for weight regain after RYGB; a cut-off score of 4 or more points had an area under receiver operating characteristic curve of 0.76 and a positive predictive value of 75%.

ANN to Predict Long-term weight loss success following the BS using pre operative and short term data was discussed by ("Neural Networks to Predict Long-term Bariatric Surgery Outcomes," 2017.). They have trained and tested eight ANN that relies on linear regression to predict the long term weight status one year after the surgery. Which outputs a single weight prediction. Here they have considered data of patients eight different surgery types.

### C. *Weight Prediction Systems*

Here our aim is to give a whole plan about how the weight loss will occur during the 18 months. When predicting weight of the patients it is needed to identify the most appropriate technology to predict the weight. Several researches have reviewed number of weight prediction systems using different emerging technologies, among them few of the researches have discussed as follows.

(Babajide et al., 2020) and the team have discussed a Machine Learning Approach to Short-Term Body Weight Prediction in a Dietary Intervention Program. This program was carried out for 10 weeks to get the data. Machine Learning models that were utilized was Linear regression, Support vector machine (SVM), Random Forest (RF), Artificial Neural Networks (ANN). Among all these models RF was able to provide the highest accuracy level of 96% when comparing to other models. Since RF is much better than other machine learning algorithms due to its ability to handle small data sets. able to generate a minimal error.

Emmanuel O. Salawu Et.al and the group have developed a ANN based weight prediction system to predict body weight of rabbits and they focus on the same breed and same age group of rabbits. ANN model was trained with 75% of the data sets from the same age groups, and the model's effectiveness was measured with 25% of the data sets. (Salawu et al., 2014) Five predictor variables were used viz, breed, sex, heart girth, body length and height at wither as input variables and body weight was considered as dependent variable from the model. In terms of predicting body weight, ANN models are found to be more efficient than Machine Learning models. We do understand, however, that fitting an ANN model needs more computing resources than fitting a conventional Machine Learning model.

As a result, according to the above analysis, ANN are the matching technology to get accurate results when predicting body weight by considering other similar factors. Deep learning approach to link weight prediction which was reviewed by (Hou and Holder, 2017) using R model which is an ANN model created to provide a deep learning approach to link weight prediction problem. When predicting the weight model R shows an accuracy of 73 percent when comparing to stochastic block model and its derivatives.

When reviewing all the above researches it is concluded that ANN models are more powerful than Machine Learning models in predicting body weight. Nonetheless, we recognize that fitting an ANN model requires more computation resources than fitting a traditional Machine Learning model. Therefore, according to the above study to predict the body weight by considering other related factors ANN is the most matching technology to get the accurate results.

Table 1. Analysis of Existing Systems

Existing System	Technology	Accuracy	Limitations
Weight regain after Roux-en-Y gastric bypass (RYGB)	-Linear Regression, -Logical Regression	75%	-Focused on only one type of surgery. -165 data records
ANN to Predict Long-term weight loss success	-ANN	85%	only one type of output was predicted.
Deep learning approach to link weight prediction	-ANN - Model R	73%	Comparatively low Accuracy
ANN based weight prediction system to predict body weight of rabbits	-ANN -Feed forward network	71%	needed more computing resources than fitting a conventional Machine Learning model.
A Machine Learning Approach to Short Term Body Weight Prediction in a Dietary Intervention Program	-ANN -Linear regression -Support vector machine -Random Forest	96%	minimum mean absolute percentage error produced from RF in predicting body weightloss is still high.

### III. METHODOLOGY

#### A. Dataset

Bariatric Surgery Patients dataset consist of 500 Patients clinical data who have registered at the Kalubita teaching hospital. The data set is composed of 361 clinical record columns which is taken before the surgery and after the surgery. To get the most accurate results most

appropriate clinical data are selected for each prediction. For the Pre surgery weight prediction only the pre surgery clinical data records are considered and for the post surgery prediction both the pre and post clinical records are taken into consideration. To get the most accurate results only the most relevant clinical data are taken while the personal details of each patient is not taken and their personal data are not considered since each patient is addressed by their serial number to ensure their privacy.

#### B. Approach

The users of this system are Bariatric Patients and Medical Officers. ANN module and the Web system are the main two parts of the system where the Medical officers gets to add,edit or remove records while the Bariatric Patients can only view their records and progress which is the predicted weight. The input data will be used to train the ANN. After training the network, it will produce a model which can be used to predict the weight of each Bariatric Patient. This model can then be deployed into a Web system so that Bariatric patients who are registered at Kalubovila Teaching Hospital and the Medical Officers when monitoring Patients can use it. Figure 3 is a schematic illustration of this process.

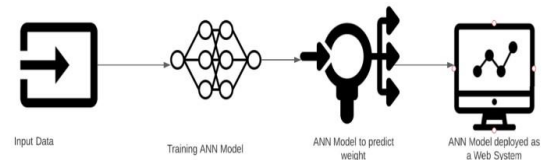


Figure 2. Process of Implementing the Application  
Source: Author

#### A. Technology Adopted

As this system composed of mainly two modules as the Web application and the ANN module are implemented using several technologies and programming Languages. The ANN was developed using Python in Jupyter notebook. Web application has been implemented using selected programming languages Html, CSS, JavaScript and Python in android studio. For the database firebase is used. The technology that suits for the system development should be decided by considering the domain and the requirements for the system.

It is important to identify most appropriate technological methodologies to satisfy the functional requirements and the non-functional requirements of the system in the system development procedure.

*B. Deep Learning Modules of the proposed system*

Artificial intelligence includes ANN, which are mathematical representations of the human brain. ANN have the ability to "learn" in the same way that the human brain does. ANN is represented by a sequence of neurons arranged in layers. Weights are used to connect each neuron in a layer to other neurons. The direction and strength of the connection between neurons are described by the weight values. The information supplied to the ANN is represented by an input neuron. Our brains receive information from our senses in a similar way. A prediction generated after synthesis within the ANN is represented by an output neuron. This is related to how our brain makes a decision based on information received through our senses.

Under three ANN predictions weight has been predicted. The first ANN relied on solely 19 pre-operative inputs of surgery types 1 to 3. A value output which is the final weight of a patient after 18 months was predicted using 70 percent of the data. The model was independently tested on 30 percent of the data, which was not used for model development.

The second ANN again relied solely 101 pre-operative measurements and post operative measurements to predict the 18 month weight after undergoing the surgery. Similar to the first model, A value output which is the final weight of a patient after 18 months was predicted using 80 percent of the data. The model was independently tested on 20 percent of the data, which was not used for model development. The model was independently tested on the remaining portion of the data not applied for model development.

Finally The third ANN used pre-operative and postoperative inputs of surgery types 1 to 3, depending on the last clinical month the patient have visited to predict the next upcoming month

weight. A value output was predicted for each monthly weight prediction using 80:20 percent of data in training and testing.

The Bariatric patients dataset is trained using a ANN from scratch. The data set was divided into two parts as training set and testing set in the ratio of 70:30, 80:20 and 80:20 in each three predictions.

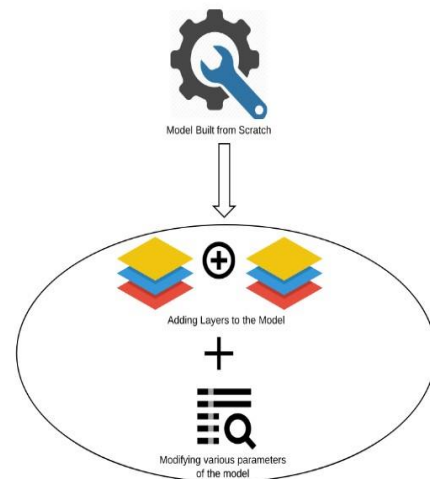


Figure 3. Design of the model built from scratch  
Source: Author

Figure 4 shows a graphical visualization of how new layers are added to the initial Source and how the parameters are modified experimentally to obtain the best model.

All the data has been preprocessed in each three predictions to a get a cleansed dataset. In all three weight predictions we have used feed forward algorithm because it gives an output without going in loops. The RELU activation function is used because it directly outputs if it is positive otherwise it will output zero. Four ANN are used in predicting the weight in each prediction. The network was trained for 200 times as the data was sent 200 times through the network to obtain models. After completing the training part testing is done.

The model was created via transfer learning and fine-tuning, as seen in the diagram above. The pre-trained network is subjected to transfer learning first, followed by fine-tuning, as illustrated in the diagram. The final model is obtained after both of these steps are completed, as indicated.

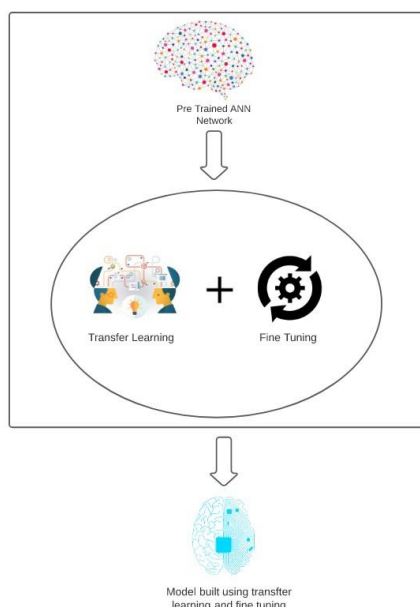


Figure 4. Design of the Model using Transfer Learning and Fine-Tuning Source: Author

#### IV.RESULT AND DISCUSSION

The overall weight prediction presented by this work adheres to an experimental procedure. First the Bariatric patients dataset is trained using a ANN from scratch. The final accuracies are then compared to use the best model in the web application. The comparisons of the 3 models are shown in the table 2 below.

Table 2. Analysis of System Results.

ANN	Input Neurons	Output Neurons	Accuracy	Training & Testing
Pre operative	19	Final weight	83%	70:30
Post operative	101	Final weight	85%	80:20
Monthly	Depending on the month	Monthly weight	75%	80:20

Classification of weight loss success using only preoperative markers ANN can correctly identify patients result in successful weight loss after 18 months from surgery with 85 percent accuracy. In post operative prediction 83 percent of success rate and monthly weight prediction accuracy of

75 percent. Here the highest accuracy is achieved from the post operative ANN which consists of more inputs and highest records of patients which can increase the accuracy.

When selecting the most suitable model among the above three architectures not only the better accuracy is considered. Other non-functional requirements like efficiency, size, compatibility and power consumption are also taken into consideration. Non-functional requirements which are considered can be taken to later examination when fine tuning the system to get the highest accuracy by changing the batch size.

#### V. CONCLUSION AND FUTURE WORK

In conclusion, this study shows that after a BS, the main aim of achieving the desired weight in a healthy BMI range of patients does not improve significantly. The lack of postsurgery follow-up and the insufficient physical activity and mental health complications of patients are several reasons why most patients struggle to achieve optimal weight loss after undergoing BS. (Buchwald et al., 2004) This study further shows, developing effective and non-invasive remote technologies to help track the physical activity and weight loss of patients may allow medical officers to support patients who are not on the correct track. Also by continuously tracking the patients' weight loss and predicting the weight, will minimize the number of patients undergoing BS again. Mainly this will help to achieve a healthy BMI range, which is the ultimate goal. Although the technologies of web apps have not yet reached that point of growth, the current study offers suggestions to enhance the usability of the mobile applications along with ensuring the secure level of the system.

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# Special Event Item Prediction System for Retails - Using Machine Learning Approach

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**Abstract** - In the modern era, marketing, which can be defined as selling and buying, has expanded in a number of technological fields. Marketing becomes fruitful when it achieves its key points, which are called sales and profits. A most common place to see this selling and buying process is retailing. Information technology involves in various marketing fields such as in prediction processes, data analysis, item designing and profit calculations. In this study, a prediction process is primarily developed using machine learning approaches. Sales item data is analyzed to predict which items give maximum or expected profit margins and those which satisfy the customer the most. There are various machine learning approaches for aspects such as sales item prediction, prediction for item features and item price prediction. The novelty of this research is that it mainly focuses on special event items, such as those available in the Christmas season, items specialized for mothers' day, lovers' day and Vesak festival. The research process is divided into two main sub-parts; item classification and item prediction, while both processes are carried out using several machine learning approaches. Item classification is done using four supervised learning classifiers: linear support vector machine (svc), logistic regression, multinomial Naïve Bayes, and random forest classifier. Results prove SVC has maximum accuracy for classification section, accomplished using SVC machine learning approach. The prediction process has been done using the linear regression approach and according to the preferred data set, its results prove that database attribute directly affects the prediction accuracy and precisions.

**Keywords:** *item classification, item prediction, special event items, retail, machine learning.*

## I. INTRODUCTION

Machine learning is a centralized technological field for accomplish several tasks: data prediction, data mining, data optimization, data classification, clustering, dimensionality reduction and etc. It is an accelerated growing area of computer science and it reached applications are very complex with other technologies (Dey, 2016). Among them Data Prediction is highly influenced with machine learning approaches. There are several areas of data prediction done using machine learning technology such as sales item prediction, item design prediction, sales profit predictions, medical diagnosis prediction using it symptoms (Cancer, Virus and etc.), Bankrupt's predictions, Personality prediction using textual data, Item popularity prediction (Ex; Car popularity prediction) and etc. This prediction process prescribes using past analyzed data. Major objective of this research is retail sales item prediction for items which are sold during special events, days, or seasons. Today sales items have become a key component in business industry and sales item data growing rate is very high. There are several types of retails: clothing retails, vegetable and fruit retails, retails with all essentials, cosmetic retails and etc. In this study, two types of retails are considered: retails only with gift items and retails with both essential and gift items. Sales items gain profit for retails or retailers.

Nowadays sales item prediction is an important process. It increases the sales profit, reduces the cost overruns, and helps to fulfill the customer expectations. Day by day, the customer expectations are updated with new features. In retailers, there is an item management team specialized for the identification and analysis of

customer expectations. Because of the busy lifestyle, people tend to buy everything from one place. Examples for most famous retailers in Sri Lanka are “Arpico Super Center”, gift Shops such as “Vondy Party City”. In this research study, items under the category of special events, seasonal festivals, and calendric days are considered. For each and every date mentioned above has a number of specific gift items such as cakes, chocolates, flowers, ornaments, teddy bears having various kinds of features with different colors, shape, taste, number of flowers in the bouquet, band and etc. Special events relevant to retails can be classified into three categories: calendric days, seasonal festivals, and special functions.

Retail special events can categorize in to three categories. calendric day : These are type of events with a unique date or month such as mothers’ day, fathers’ day, children’s’ day, lovers’ day and etc. Most probably it is an internationally celebrate day but sometimes it is limit to the country such as in Sri Lanka May Day, Independence Day. Most of the people are celebrate these event days as their like or as tradition or as a habit. For such celebrations they used to share gifts or memorable items. It will become an opportunity for retails to increase their sales and profit rate in that time period by selling items relate with specific event. As well as retails can have more benefits by get ready to coming event using item prediction process using past few years data. This proposed “Special Event Item Prediction System” will be very useful for that process. Seasonal festivals : seasonal festivals can define as another type of calendric events because it also has unique date or month in the year. “Christmas”, “Vesak”, “Ester”, “Ramazan”, “Sinhala and Tamil New Year” are some examples for seasonal festivals. People are highly intended to by gift items, decorations, and meals in this event time period. Then these special event type also will be an opportunity to have above mentioned(In calendric day paragraph) advantages. Specially seasonal festivals are type of shopping time period. Then retails should have got ready with their special inventories. Special functions : special functions do not have unique or specific date or month in the year. Birthdays, wedding anniversaries are most common examples for special functions.

“Retail event management team” should give more attention to such type events because each and every day they can have sales on that event items. As above mentioned by get ready early to these type events retails can full fill customer expectations and have expected profit margins.

In the proposed work, have proposed a special event item prediction system for retails using machine learning approaches. Item classification and prediction tasks are accomplished using machine learning techniques. This system will help to increase the expected profit margins in specific events and full fill the customer expectations. Key importance and requirements of this system gained by studying about existing systems. As a result of that identified the suitable algorithms and machine learning techniques. Prepare the dataset, design the systems, implement the system, training the model and evaluate the results are the other objectives of proposed system.

## II. RELATED WORKS

Predicting future customer purchases is very important and support to planning the inventory of retail, shop, or warehouse (ndr«es Mart«ōnez, Claudia Schmuck, Sergiy PereverzyevJr., Clemens Pirker, Clemens Pirker, Markus Haltmeier, 2018). In paper “A Machine Learning Framework for Customer Purchase Prediction in the Non-Contractual Setting” proposed an advanced analytics tools to perform above mentioned task. Their proposed application implemented through various machine learning algorithms for binary classification. They had used three types of classification methods called: logistic Lasso regression, extreme learning machine and gradient tree boosting. These methods are totally different one from another, reason to use such methods is to increase accuracy with reasonable computational effort. From the results they had proved gradient tree boosting has highest accuracy. This prediction done for before one month to get the inventory for next month.

In item prediction or forecasting applications mostly used historical data and most important thing is what are the product characteristics chose for prediction process (F. Jiménez, G. Sánchez, J.M. García, G. Sciacvico, L. Miralles, 2016). In paper “Multi-Objective Evolutionary Feature Selection for Online Sales Forecasting ”

had focused on that. They had mentioned number of feature selection and decision-making methods such as ENORA, NSGA-II and RFE. They had done tests with different machine learning algorithms and provide most suitable feature selecting method for each and every algorithm.

In paper “House Price Prediction Using Machine Learning and Neural Networks”: author has done extensive study on predicting housing prices with real factors (Ayush Varma, Abhijit Sarma, Sagar Doshi, Rohini Nair, 2020). The results of research proved that this approach provide minimum error and maximum accuracy than individual algorithms applied. It considered parameters are 'square feet area', 'no. of bedrooms', 'no of bathrooms', 'type of flooring', 'lift availability', 'parking availability' and 'furnishing condition'. As a unique approach to increase accuracy, used that the actual real estate value also depends on nearby local amenities such as railway station, supermarket, school, hospital, temple, parks etc. Author has done this study using number of algorithms such as linear regression, forest regression, bootstrap regression, and neural network.

Regression and classification problems are types of problems in supervised learning which is a paradigm of Machine Learning algorithms (Sunakshi Mangain, Srikant Kumar, Kabita Manjari Nayak, Swati Vipsita, 2018). In paper “Car Popularity Prediction: A Machine Learning Approach” solved a real-world problem of popularity prediction of a car. In this research training data set tested with three types of classification algorithms. Such as KNN (K-Nearest Neighbor), logistic regression, random forest, and support vector machine. Training data set contained number of attributes : buying price, maintenance cost, number of doors, number of seats etc. They successfully calculated the accuracy of above-mentioned algorithms and proved the SVM provide the best result.

In paper “Using textual data for Personality Prediction: A Machine Learning Approach” focused on linear discriminate analysis, multinomial Naïve Bayes, and AdaBoost over twitter standard dataset. Personality is categorized according to the “Big Five” psychological test. This research process has gone through real-time data which can have

significance with real world (Aditi V.Kunte, Suja Panicker, 2019). After preprocessing step dataset trained with above mentioned three machine learning concepts. Author has obtained multinomial Naïve Bayes has highest accuracy, precision, and recall. For sentiment analysis can use logistic regression (LR), support vector machines (SVM), decision tree (DT), boosted tree (BT), and random forests (RF). Among them SVM performance is best and it provide highest accuracy. And also, can use the boosted regression tree model and improved regression model called multilayer perceptron neural network for the item index value prediction (Sai Vikram Kolasani, Rida Assaf, 2020).

In paper “A machine learning framework for sport result prediction” focused on different field with machine learning approaches and it is very useful for system clients (Rory P. Bunker a, Fadi Thabtah b,ft, 2019). They had analyzed research gone through artificial neural network and proposed a new framework called SRP-CRISP-DM’, for sports result prediction. They had obtained data online from publicly available sources. This framework focused on result prediction for team sports rather than individual sport. For classification problems they had used regression techniques which are most common machine learning approaches.

Wangwei presented, injury analysis based on machine learning in NBA data. This article proposed a machine learning model ; random forest method to analyses the injuries of players. As the training data set, he used injuries of two teams in NBA match There for gathered data at player’s level and team’s level. Purpose of this research is decreasing the uncertainty of the risk in the coming match (Wu, 2020). In here mentioned by training past seasons data can predict injury events in the future. As a future work this proposed method can use in one-to— one sports such as badminton and tennis.

In paper “Applying Machine Learning to Aviation Big Data for Flight Delay Prediction” represented a domain used machine learning and big data analytics. Two datasets were used for the research process based on time performance and control quality. They had predicted the flight arrivals delay by recognizing useful patterns of the flight delay from aviation data (Yushan Jiang,



Yongxin Liu, Dahai Liu, Houbing Song, 2020). This research followed machine learning approaches are support vector machine(SVM), decision tree, random forest models and multi-layer perceptron. After testing evaluation authors had obtained multilayer perceptron based on neural network method has better performance with highest accuracy and featuring scaling.

### III. CASE STUDY

Introduction had mentioned several types of special events a retail can have. In every country in the world there are gift shops, decoration shops and retails with both gifts, decorations, and also essential items. In this study as the key physical area, we had chosen Sri Lanka. In Sri Lanka there are several types of retails but it is hard to find a retail which available any type of gift items and decorations. As the primary step we had done a survey on special event items and available shops. When going through more detailed with examples, in Arpico Super Center it has mostly decoration items and gift items. Using survey results we had chosen number of special events people mostly intended to celebrate in Sri Lanka and number of item types relate with that event. Most important fact is these selected items are not pick from same retail or shop due to the rareness of such kind of shop.

### IV. METHODOLOGY

This research study had done in two sections. Section one had served for dataset creation item classification using machine learning approach and section two had served for item prediction using machine learning approach. Entire research study had gone through machine learning methods. Figure 1 had given below represent the top-level architecture diagram for this study.

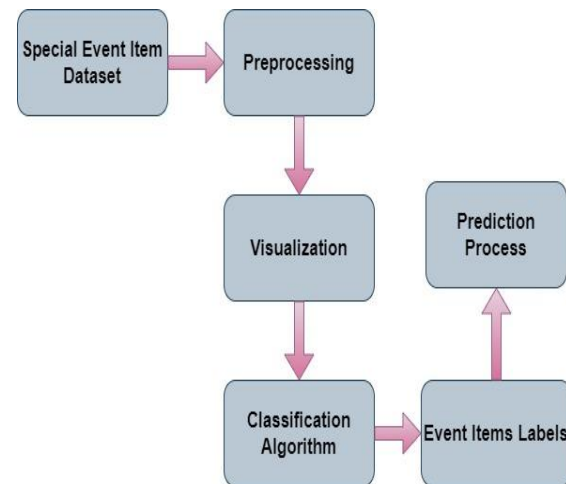


Figure 1 System Top Level Architecture Diagram

#### A. Section 1

##### 1) Dataset creation.

Figure 2 given below is the created dataset using sales data of number of retails. It represented which date each and every item sold which is used to collect real-time item data and it will be useful for prediction part because special event items mostly relate with a unique date.

Item Id	Event Item Id	Item Name	Date	Quantity	Unit Price	Unit Profit
It0567	B001	Birthday Card type 1	1/2/2018	1	Rs. 85.00	Rs. 15.00
It0823	B002	Birthday CandleSet type1	1/2/2018	3	Rs. 65.00	Rs. 15.00
It1017	B004	Birthday Cake type 2	1/2/2018	1	Rs. 1,550.00	Rs. 250.00
It1024	B004	Birthday Cake type 8	1/2/2018	2	Rs. 3,250.00	Rs. 750.00
It1028	B004	Birthday Cake type 12	1/2/2018	1	Rs. 4,150.00	Rs. 900.00
It0826	B002	Birthday CandleSet type4	1/2/2018	4	Rs. 65.00	Rs. 15.00
It1022	B004	Birthday Cake type 6	1/3/2018	4	Rs. 2,600.00	Rs. 500.00
It1153	B005	Birthday BallonSet type5	1/3/2018	3	Rs. 100.00	Rs. 40.00
It0902	B003	Birthday DecoSet type4	1/3/2018	1	Rs. 1,550.00	Rs. 300.00
It0823	B002	Birthday CandleSet type1	1/5/2018	2	Rs. 65.00	Rs. 15.00
It0904	B003	Birthday DecoSet type6	1/5/2018	1	Rs. 1,550.00	Rs. 300.00
It0583	B001	Birthday Card type 17	1/6/2018	1	Rs. 85.00	Rs. 15.00
It0581	B001	Birthday Card type 15	1/6/2018	1	Rs. 85.00	Rs. 15.00
It1023	B004	Birthday Cake type 7	1/6/2018	1	Rs. 3,250.00	Rs. 750.00

Figure 2 Snapshot of Dataset

As given in figure 2 first column is “item Id” which provide unique Id for each and every item in dataset. Almost in retails also item named with unique Id which is easy for managing data. Second Column is “event Item Id”, a special event not only has one item type there are several numbers of item types and this column used to categorize item types in each and every event. As an example, Event name “Christmas Season” it contained items with event item Id “ Christmas Tree - Xm001”, “ Christmas Deco Balls - Xm002”. Rest of columns represent the “Item name”, “Date”, “Quantity”, “Unit Price” and “Unit Profit”.

## 2) Item Classification.

After creating the dataset, built up the item classification part. Classifying items is an important task in this study. For prediction process need to identify what are the items sold in specific event. There are number of machine learning algorithms for item classification which are almost contained under supervised learning algorithms. For the current work we had used four types of classification algorithms: linear support vector classification (SVC), logistic regression, multinomial Naïve Bayes, and random forest classifier. As input data for classification part used “Event item Id” and “Item name”. Classify the each and every event item with its specific event is the output of this classification process.

### a) Linear Support Vector Classification.

SVMs (Support Vector Machines) are a useful technique for data classification. If simply describe the classification process of SVM, transform data to the format of an SVM package (Martin Kappas , Phan Thanh Noi , 2017), randomly try a few kernels and parameters and Test. This method most effective in high dimensional spaces. This classification had gone through multi class classification. Briefly can talk with X and Y coordinates, X – number of samples and Y - number of labels.

### b) Logistic Regression.

This method is very productive when the dependent variables are categorical (Mohammad Ali Mansournia, Angelika Geroldinger, Sander Greenland, Georg Heinze, 2018). In this study dependent variable is item name. It had done by naming an item with its event name. Example: event name “Birthday”, item type “Birthday cake”. In this method multiclass classification also same as binary classification. In classification specific event item Id denoted – “1” and other event item Id s denoted – “0”.

### c) Random forest Classifier

Random forests are enhancement of decision trees, those are consisting with bunch of independent decision trees (Dragutin Petkovic, Russ Altman, Mike Wong and Arthur Vigil, 2018). There are number of methods for get outcomes from this classifier. This study had focused on

permutation feature importance. This is selecting a column (i.e., feature) in the validation set, then shuffling it randomly, for destroying the correlations between that feature and all the other features used by this model to make its predictions, and finally measuring the model’s performance on this freshly shuffled validation set.

### d) Multinomial Naïve Bayes.

This is a type of Naïve Bayes classifier. This is a probabilistic machine learning model and based on the Bayes theorem (NimaShiri Harzevili, Sasan H.Alizadeh, August 2018).

Bayes Theorem:

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)}$$

Figure 3 Equation for Bayes Theorem

According to this study A – class variable (Event Item Id). Variable B – represent the item name.

## B. Section 11

After item classification process next step is item prediction. Prediction task feature effectiveness had discussed using linear regression machine learning technique.

### Linear Regression Algorithm.

Regression is a way to modelling a target value based on independent predictors. This method is based on independent variables and find out relationships between independent and dependent variables (Amand F.Schmidt, ChrisFinan, 2018 June). If the relationship between these two variables is linear it is known as linear regression. In this study according to preferred data set “Unit Price” is independent variable and dependent variable is “Unit Profit”. When give the amount of items want to select it provide items which are in first set.

## V. RESULTS AND DISCUSSION

### A. Section 1

For the given dataset focusing on above mentioned four classification algorithms. Results of these are discussed below.

#### a) Comparison of Accuracies.

By comparing the accuracy results can proved linear support vector classification(SVC) has the highest accuracy.

Linear SVC): 0.895234, Logistic Regression.: 0.868313, Multinomial Naïve Bayes.: 0.855413, Random Forest Classifier.: 0.617169

Figure 4 given below represent the data visualization of accuracy with specific algorithm.

Given in the figure 5 is the graphical representation of accuracies for above mentioned four classification algorithms. Here represented only some selected item types.

Given in the figure 6 is the graphical representation of precisions for above mentioned four classification algorithms. Here represented only some selected item types.

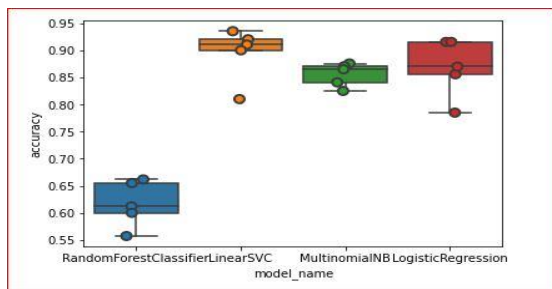


Figure 4 Accuracies of Applied Algorithms

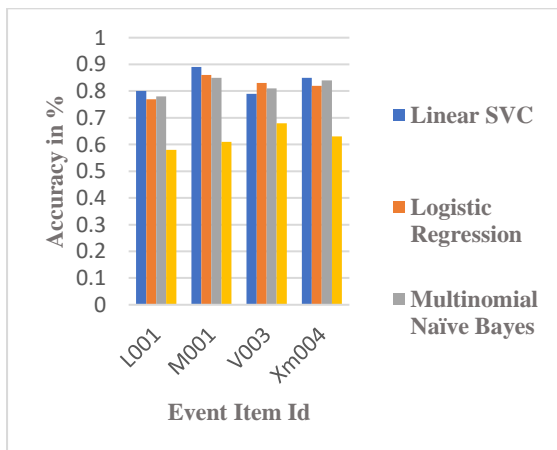


Figure 5 Accuracy Comparison of Classification Algorithms

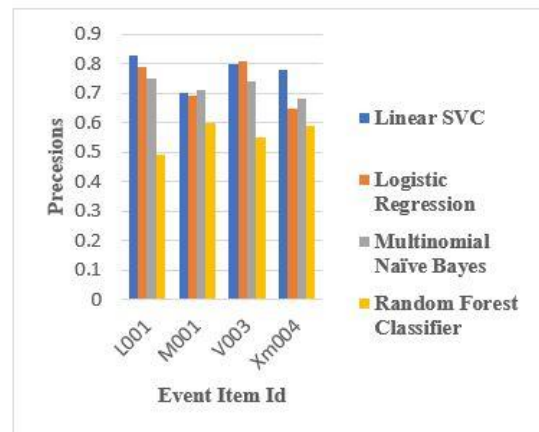


Figure 6 Precision Comparison of Classification Algorithms

a) Classification model evaluation.

When straight forward with best model (SVC) it can represent using confusion matrix and show the discrepancies between predicted and actual labels. The vast majority of the predictions end up on the diagonal (predicted label = actual label). If there are items which are touch more than one event then it caused to have misclassifications. In current data set there is no such kind of issue. But it can solve using python programming knowledge. Figure 4 given below represent the continuous matrices.

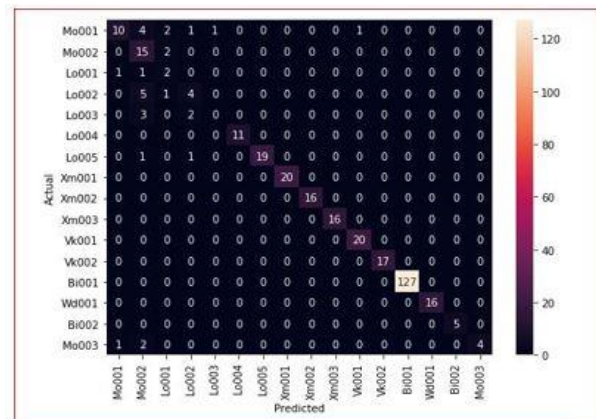


Figure 7 Continuous Matrices of Labels

B. Section 11

After classification next step is data prediction process. As machine learning technique linear regression algorithm has used and it implies numeric data is the most important feature in the dataset to achieve reliable results. For data testing process, 20% data has used and for data

training process, 80% has used. When consider the above-mentioned data set as the independent variable can used two columns which are contained numeric data called “Unit Price” and “Quantity”. But its accuracies are variant from each other. “Unit price” accuracy is 0.94% and “Quantity” accuracy is 0.005%. Then in this study “Unit price” use as the independent variables. Figure 6 provide a clear visualization about accuracies.

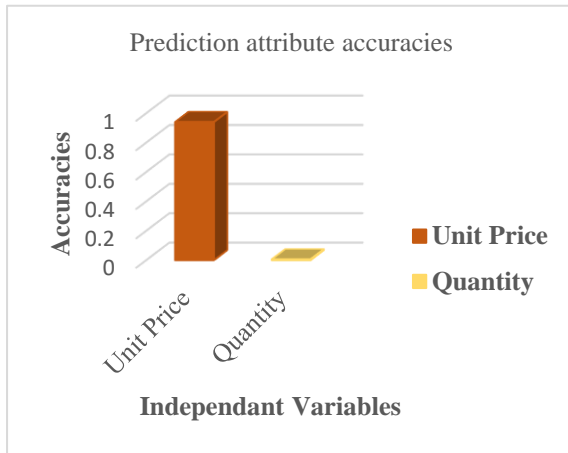


Figure 8 Comparison of Independent Variables accuracies.

After comparing the results can discuss about the accuracies, precisions using performance of algorithms. After executing the machine learning algorithms next tread is to find out the effectiveness of model based on various performance metrics. Different performance metrics are used for different machine learning algorithms. For example: For classification we use different performance metrics such as Accuracy, Precision, Recall, and f1 Score. From the above mentioned four algorithms SVC has the highest accuracy and precision. linear regression technique used for item prediction when use the “Unit Price” as its independent variable prediction accuracy become very high.

## VI. CONCLUSION

Because of unfitted gift item or decorations mostly retails unable to achieve their profit margins and fulfill the customer expectations during special functions calendric days and seasonal festivals. This research study has presented a retail special event item prediction method using machine learning approach. First

step is classifying the special event items for specific event. The item classification tasks accomplished using four supervised learning algorithms called liner support vector classifier(LSV), logistic regression, multinomial Naïve Bayes, and random forest classifier. According to results LSV algorithm gives the maximum accuracy(0.89) and precision(0.83). Second step is prediction process. Prediction Process had followed through linear regression technique and its accuracy highly depend on independent variables. Unit price and quantity are the two independent variables used to test the accuracy of prediction process. According to results unit price independent variable gives the highest accuracy(0.94). As a key result of this study can conclude linear regression algorithm which is use for prediction processes highly depend on numeric data in the dataset. Gained the expected profit margins and full fill customer expectations during special events are the main purposes and advantages of proposed system. As the future work for prediction process can do considering item features or geographical locations.

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## ETU Management and Patient Tracking System

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**Abstract** - The Emergency Treatment Unit (ETU) in Sri Lankan Hospitals runs based on paper-based manual process and results in delays in delivering patient reports, losing them and delay in the treatments. In addition, due to the limited number of beds inside the Coronary Care Unit (CCU), it has become more important to identify the most severe patients to be admitted into the CCU. So, if the correct patient to be admitted is not identified properly, another patient in the unit could fall into a more critical condition. ETU Management System is a web-based system, which automates the current manual process inside the ETU and is capable of identifying the most suitable patient that should be treated inside the CCU, using a specific scoring system calculated by monitoring the symptoms of the patient at ETU assessment. Patient tracking system is a mobile application provided for patients and their guardians, which gives patients the facility to contact his/her guardian and doctor in any case of emergency, as well as enables Guardians to track the patient's location and notifies them via the mobile application, if the location of the patient is changed in any case. The proposed ETU management system helps to take the Sri Lankan medical field into another era by eliminating traditional paper-based manual processes.

**Keywords:** *ETU, CCU, score, hospital, automate*

### I. INTRODUCTION

Accident and Emergency Treatment Unit (ETU) is considered as a clinical treatment department that specializes in the intense considerations of who arrive at the hospital without prior appointments or arrangements either by their own or by ambulance ("Emergency Unit - Asiri Health," n.d.). In such situation ETU department must be fully prepared to provide initial

treatments for broad range of diseases and wounds some of may be perilous and require immediate consideration ("Emergency departments | health direct," n.d.). If anyone end up requiring the services of an ETU, the first thought will be the efficiency as well as the professionalism of the department since in an emergency every second count and each decision has potentially life-changing outcomes. In Sri Lanka, the department will provide initial medical treatments for the patients who arrive at the tirage area of the Accident and Emergency Treatment Unit and will be directed to CCU (Coronary Care Unit), ETU (Emergency Treatment Unit) and PCU (Preventive Care Unit) based on their severity ("Ministry of Health - HOME," n.d.). The most severe patients will be admitted to the CCU, and least severe patients will be admitted to PCU wards and the patients with medium severity will be admitted to the ETU, respectively. All the above processes inside the ETU are done manually. As a result, there are so many difficulties in finding the most severe patient and most rightful patient who should be treated inside CCU. All the patient's records, past records are stored in manually using papers, files, records, and bills. Hence, these documents were most likely to be lost or misplaced when moved around by various hospital personnel who handle them. Consultants must wait for an extended period to treat his patient until the hospital attendant carry out his reports from a certain laboratory which may find far off from the A-E department. Consequently, the patient's condition may get worsen and his life may be threatened. So, it is quite conspicuous that the Accident and Emergency Treatment Unit in Sri Lanka should be handled efficiently as well as precisely to provide a maximum service to the patients who require emergency treatments. In addition to the above problems when focuses on the side of the patient, there is no proper facility

for the patient to view his medical report when necessary other than go through all the report papers stored in his personal medical file. It is also difficult for the patient to find facilities to contact his caregiver or doctor in an emergency as well as there is no proper facility to notify the guardian of the patient if the location of the patient such as, ward or hospital is change due to an emergency happens to his patient.

The intended ETU management system will be a web application implemented to help the prevailing circumstances of the manual system utilized in current general hospitals in Sri Lanka by finding the next most suitable patient to be admitted to the CCU and guarantees more security, speed and information storing techniques to show high quality of the AE Department. The aim of the web application is to automate the current accident and Emergency treating unit to assist doctors and staff by kicking off the traditional paper-based process and find the most critical patient to be admitted to the CCU and the mobile application to make the daily lives of patients and their caregivers easier by maintaining social well-being of the patient as well. The main objectives of the ETU Management and Patient Tracking system is as follows.

1. Study the existing manual system and identify major stakeholders.
2. Interview the specialists and identify major requirements.
3. Study the existing system's documentation and identify pros and cons.
4. identify suitable software process model (e.g.- waterfall, spiral etc.) and technologies for the development.
5. Design the system.
6. Implement the system.
7. Evaluate the results.

For the development of the intended system iterative and incremental development model (Nguyen-Cong and TranCao, 2013) is utilized. Node.js is used in server-side development of the web application and MySQL is used as the database. For the mobile application development Java is used as the programming language and Google APIs (Application

Programming Interfaces) for the location tracing.

This web application will be of acceptable use to the overall general hospitals hectic circumstances may arise when a pandemic happens in the country as well as mobile application will be helpful in real-time tracking of the patient as well as this ensures eliminating mental burden of the patients and their caregivers.

## II. RELATED WORKS

This section will illustrate the review of existing systems and technologies related to hospital management and with score prediction as well as mobile application developed for patients.

### A. Severity Prediction Systems

A comparison of risk scoring systems in predicting clinical outcome at upper gastrointestinal bleeding patients in an emergency unit. They compare Admission Rockall score (RS), full RS, and Glasgow-Blatchford Bleeding Score (GBS) which were gathered and calculated during patient's ED assessment to identify the most accurate score on order to predict the outcomes at upper gastrointestinal bleeding patients in Romanian ED (Dicu et al., 2013) Authors have mentioned that this comparison permitted them a more accurate and effective confirmation patients in ICU, ordinary wards, or ambulatory management of the patients.

A combination of a Smart Priority Recommendation and Patient Control System as well as a Hospital Emergency Smart Band was introduced in which the smart band was placed in each patient's hand permitting to detect changes in the fundamental indications of patients who are waiting that may demonstrate that they require immediate attention and care (Lima and Faria, 2018). Their system has addressed the issues that happen in medical clinics when there is a peak in the quantity of individuals utilizing the emergency service, increasing the time of waiting. By obtaining the advantages of Hospital Emergency Smart Band (HESB) which consists of sensors for measuring body temperature, heart rate, blood oxygen level and blood pressure the system continuously

stores and analyzes the patient's information on crucial data being ready to generate real-time alerts for the responsible nurse in the triage process.

B. Patient registration and hospital management Fist in First Out Algorithm where patient who came first to the first is the one who enrolled first in patient registration was utilized in Management Information Systems Development for Veterinary Hospital. Authors have mentioned that this information system is considered as extremely helpful since it reduces the time when processing the data of the patients (Hapsari et al., 2016). And the data storage can be validated properly to decrease the utilization of paper. However, authors also have mentioned that there are some drawbacks where the sub-system registration information are unable to offer priority for the patients with emergency cases.

Leitos which is a Web-based Information System for the Management of ICU Beds During the Coronavirus Outbreak was carried out (de Morais Barroca Filho et al., 2020) which does effective management of ICU beds as well as semi-ICU beds which are assigned to Covid-19 patients. Agile scrum was used as the development methodology they have used Java platform as well as Spring framework as technologies for the implementation process. They have carried out unit tests and acceptance tests as the testing techniques.

Comparatively the ETU management web application will be using a special algorithm to calculate and predict the severity of the patients and compare each score of the patients to find most accurate patient who must be admitted inside the CCU and automate the current manual process inside A-E department which increases the efficiency and security of the processing of patient's medical information. Figure 1.1 illustrates the comparison of the sample related work when compared to functionalities of the proposed system.

Research work	Patient Registration	Score calculation	Severity Prediction	Update records	Severity alerts
Comparison of risk scoring systems in predicting clinical outcome at upper gastrointestinal bleeding patients in an emergency unit	✗	✓	✗	✗	✗
Towards Real-Time Patient Prioritization in Hospital Emergency Services	✓	✗	✓ Initial Severity prediction	✗	✓
Management Information Systems Development for Veterinary Hospital Patient Registration	✓	✗	✗	✓	✗
A Web-based Information System for the Management of ICU Beds During the Coronavirus Outbreak	✓	✗	✗	✓	✗

Figure 1.1 – Comparison Table

### C. Mobile Health Record Systems

Mobile app and a web GIS-based health care system in Ampang district in Malaysia assist people with disabilities to reach nearest health care centers. This is a Web-GIS based system consists of two main components which are PWD Monitoring system which is a GIS – web system and PWDsupport2U which a mobile application (Rasam et al., 2018). The mobile application proposed was expected assist the people with disabilities and their guardians by providing functions like, requesting a doctor home visit, requesting an ambulance or medical delivery depending on their existing circumstances and requirements. www.data.gov.my and Google Map were utilized to collect data related to health care facilities. For the creation of the web mapping system ArcGIS online with its app function is utilized.

An analysis about Mobile applications for Alzheimer patients and caregivers (Gupta et al., 2018) stated that the smartphone well assisting the care giver of the patient to take a proper care of patient like receiving the GPS (Global Positioning System) location of the patient by utilization of Geotagging and the requirement of building a relatively simple cross-platform mobile application with an interactive graphical user interface will helps in increasement of the cognitive abilities of the patients. The research work has stated that the Mapigate feature empowers the real-time tracking of the patients This component shares the current location of a patient with the safe zone contacts and produces an alert, in instance of wrong way choice.

The intended mobile application which will be provided to the patient's and their guardians is capable of viewing patient's medical reports, contact his guardian or doctor in any emergency and sending relevant medical information to the

guardian. The guardian will be using this application to detect his patient's current location (Kumar and M., 2018) as well as to keep proper communication process with his patient.

### III. DESIGN AND IMPLEMENTATION

By considering about the main problem existing and reviewing the technologies used, the proposed solution is an automated ETU management web application which will be able to predict the severity of the patients. Figure 1.2 below represents the referral system and Accident and Emergency Department setup in Sri Lanka and Figure 1.3 describes the triage categories represented in the figure 1.2.

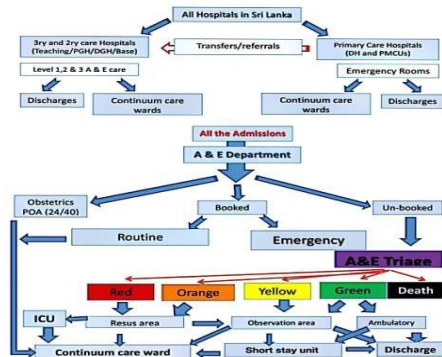


Figure 1.2 – Operational Structure and Patient Care model

TRIAGE CATEGORY	SEVERITY	ACUITY (Maximum waiting time)
Category 1 ( Red) Immediate (Resuscitation)	Life threatening	Immediate
Category 2 ( orange) Emergency	Imminently Life threatening	10 minutes
Category 3 ( Yellow) Urgent	Potentially Life threatening	20 minutes
Category 4 ( green) Semi urgent ( standard)	Potentially serious	30 minutes

Figure 1.3- Triage Categories

The mobile application which will assist patients and their guardians to which will ease their daily routines. The intended web application will be built using node.js (Chhetri, n.d.) and MySQL will be used for the database

and java will be using for the development and Google API(Aldabbagh and Mohsen, 2014) will be used for location detection of the intended mobile application.

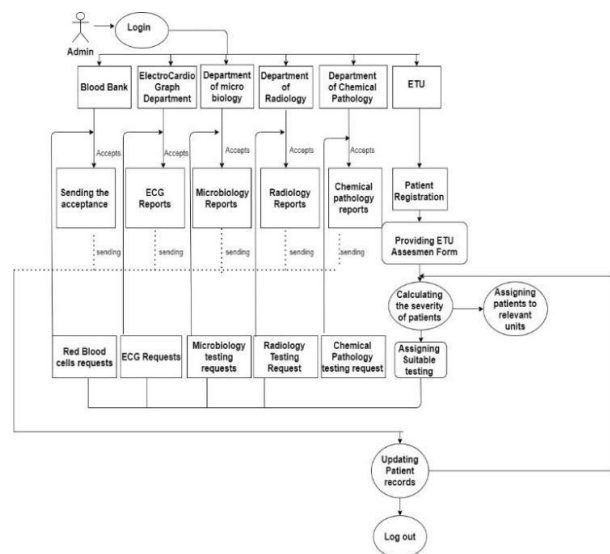


Figure 1.4 – Flow diagram -Web app

To understand the major purposes of the web application in depth main functionalities of the ETU management system is listed below.

#### A. Score Calculation

Specific score is calculated to identify the severity of each patient who arrives at A-E department by using a special algorithm which is constructed by using data values in the ETU assessment which is done by the ETU doctor. For the algorithm, the values given to the Blood pressure, Respiratory rate, Pulse rate, Oxygen saturation and GCS scale which is calculated from scores given to eyes, verbal and motor will be considered. After examination of the medical reports which are retrieved from the laboratories doctors will be able to add a score based on the experience and physically visible symptoms and this score will be added to the current score and after all the final scores will be calculated for each patient. The scores will be calculated as percentages and the percentage values of the patients will be compared to find most accurate patient to be admitted to the CCU or ETU respectively.

#### B. Update Records

This system will provide facilities for the chemical pathology, radiology, microbiology, and Electrocardiograph departments as well as the

blood bank and keeps updated records of the patient’s medical information. The overall scores of the patients will be updated every once in the while, the doctor examines the new reports received from the laboratory testing. So, at each update the scores will be compared and send a notification to the doctor about the patient with the highest score who should be transferred to the CCU. If the score of a patient inside the CCU is lesser than the score of the patient inside the ETU the patients should be interchanged.

**C. Alerts**

The system keeps alerting the responsible medical officer about the severity of the patients. When the severity of the patient in the ETU gets higher than the patient in the CCU system alerts about the critical condition as well as when the severity of the patient inside the CCU lower than the patient inside the ETU systems sends the alerts about the availability inside the CCU.

Figure 1.5 and figure 1.6 below represents the main interface of the ETU nurse and complete checkup interface of the nurse’s module, respectively. The main interface of the ETU nurse represents the details about patients who have been registered and admitted inside ETU as well as the patients who have been discharged from A-E department within a single day. Each patient’s severity level is also stated in front of the patients’ details. Initial checkup form is filled by the nurse in-charge. These details along with the details filled by the ETU doctor in the ETU assessment form after the initial checkup will help in predicting the initial severity level of the patient who registered.

NIC	Name	Age	Gender	Contact No	Severity
19979090909	A.B.Kumara	22	M	078-1234564	Normal
19979090909	A.B.Kumara	22	M	078-1234564	Normal
19979090909	A.B.Kumara	22	M	078-1234564	Normal

Figure 1.5 – Interface of the Nurse

Figure 1.6 – Interface of the checkup form

Figure 1.7 represents the general flow the web application.

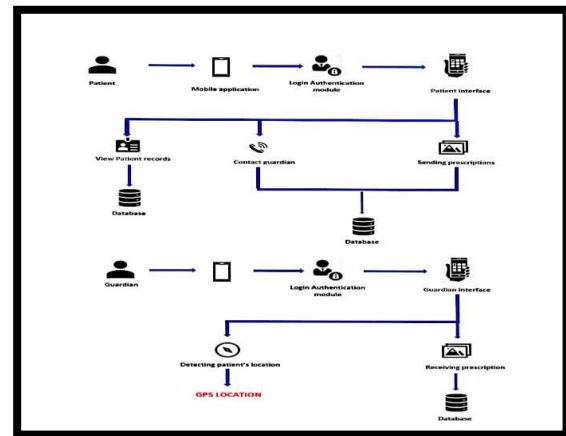


Figure 1.7 -flow diagram-mobile app

Features which need to be incorporated in the mobile application are shows below.

**A. Tracking Patient’s location**

Guardian will be able to track patient’s current location and get notified if the location of the patient is changed in any emergency case (Tang et al., 2016). This feature will be provided by the guardian interface of the mobile application. This feature will be especially useful for the guardians whose patients are suffering from diseases like dementia.

**B. View Medical reports and contact doctor or Guardian.**

Patients will be able to view his own medical reports whenever he wants other than go through the bunches of paper reports. Patients will be able to contact his guardian or doctor



through the speed dial option and send prescriptions or other medical information for the guardian in any case.

The proposed system will be utilized by medical staff, such as, doctors, nurses, and the laboratory staff of department of chemical pathology, Radiology, Microbiology, ECG unit as well as the Blood bank. The ETU nurse logs in to enter the new patients details and personal information. After that the information with respect to the symptoms and indications of the case is recorded (Abraham et al., 2015). These data recorded and put away in such a way would be helpful in this industry as it's time to create has come. Each strategy will be done online very soon; thusly, this system will be of acceptable use to the overall general hospitals hectic circumstances may arise when a pandemic happens in the country. The strategy for assessing the most critical patient in a brief timeframe and automate the laboratory report exchanges within other departments and the A-E department will be the objective of this system. Quickly with the recorded data of the patient the system will be able to make out the following most severe patient who is reasonable to be admitted to the CCU.

Along with the web application, the proposed Patient Tracking system is an android mobile application intended to assist patients and their care givers. The mobile application will be able to View his/her own medical reports, Contact the guardian or doctors in any case of emergency and Sending prescriptions and medical information for the care givers. As well as care givers of the patient will be able to detect his/her patient's location by utilizing this mobile application. This mobile application will be an uncomplicated simple application with a user-friendly interface which will solve most common problems encountered to the helpless, weak and incapable patients and their care givers since the situation of a patient inside the A-E department can be in any point of time.

#### **IV. DISCUSSION & CONCLUSION**

In Sri Lanka, the general hospitals do not have an automated system to be used in an A-E Department. When a patient arrives at the A-E department is severe having many symptoms

and side effects, it is hard to find the most eligible patient for the CCU. The next patient to be selected must be chosen from the ETU which is a manual process as well. All the patient's records, past records are stored in manually using papers, files, records, and bills. As a result, these documents were most likely to be lost or misplaced when moved around by various hospital personnel who handle them. Consequently, the patient's condition may get worsen and his life may be threatened. The proposed ETU Management system is a web-based system which can demonstrate the next most appropriate patient to be transferred to the CCU without any hesitation. Doctors and nurses will be able to manage this system conveniently as it is easy to use, and the system will help in collecting and updating all the patients records efficiently and effectively. The intended system will be an efficient solution for the proper management of CCU beds which are limited in the hospital by deciding most suitable patient to be treated inside the CCU. The proposed ETU management system will be more efficient than the manual system since it guarantees more security, speed and data/information storing techniques to show high quality of the A-E Department. Since the intended web application is designed for the health sector, the accuracy of the system is mandatory So, variety of variables such as Respiratory rate, Sat% on air, SBP value, Pulse and GCS values were considered when predicting the severity of the patients. In addition to these variables a specific score which is based on the experience of the doctor and physically visible symptoms were also taken into consideration when calculating the final severity score. These scores will be updated and compared with the existing scores of the other patients continuously in each testing which will affirm and verify the accuracy of the system, and the system can be improved by using image processing to analyze x-rays and CT scan images to identify the condition of the patient. As well as, as the use of smart phones continues to grow it can be used to aid the daily lives of the patient and their care givers. Patient tracking system will be able to track the patient's location, storing medical records and contact doctor guardian in any emergency which will be essential in any critical situation. So, the patient

tracking system will provide a good support to critical situations by guardians of the patients as well as it can be further improved to as a mobile application which will be capable of enhancing the cognitive capabilities of the patients.

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# Prevention of Cyber Bullying using Machine Learning Techniques

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**Abstract-** Cyber bullying has rapidly increased in the past few years with the growth of social media usage and the COVID-19 pandemic. This study uses a dataset of 65000 tweets, splitting them into training and testing sets. Data pre-processing was done using feature engineering methods such as vectorizing, and Bag of Words to prepare data to test machine learning models or classifiers to build a model. Five different classifiers were tested with dataset and Naïve Bayes Model and linear support vector classification model provided the best accuracy and prediction times in sequence. The Sentiment Analysis System was built using Naïve Bayes Model and it is deployed to the web interface using Flask to get user input and predict sentiment in the three key aspects of negative, positive and neutral. System tested with user inputs and gained accurate sentiment Scores (comment: "listen to my most beautiful friend singing with her beautiful voice" Scores: Compound- 0.97 Neutral - 0.166 Positive - 0.834 Negative - 0.0) with three key aspects. The aim of this research work is to utilize man-made consciousness at a specific level to pre-empt exploitation by recognizing the riskiest clients and accounts.

**Keywords:** *cyber bullying, social networks, machine learning, sentiment analysis*

## I. INTRODUCTION

Cyberbullying is a type of tormenting that happens by means of web associated gadgets like cell phones, PCs, or tablets. Cyberbullying is the utilization of innovation to scare, annoy, undermine, torture, or embarrass an objective. As of this point many people face cyberbullying on daily basis and we look in to where it occurs, when the students were asked to indicate on which social media platforms they had experienced cyberbullying, the results showed

Twitter 9%, YouTube 10%, WhatsApp 12%, Snap Chat 31%, Face Book 37%, Instagram 42%. And the study also revealed some surprising statistics about the number of people that are perpetrators of cyberbullying ("51 Critical Cyberbullying Statistics in 2020," n.d.). 69 percent of people report having done something abusive towards others online. 15 percent of people admit to having cyberbullies someone else online. These statistics are troubling as it indicates a general misunderstanding of definition of cyberbullying.

Over half of students who identify as being LGBTQ have experienced cyberbullying at some point (Affairs (ASPA), 2019). Girls are more likely to be a victim of cyberbullying than boys. Overall, around 36% of girls have reported being cyberbullied, as compared to 26% of boys ("Online Harassment 2017 | Pew Research Center," 2018). 83 percent of those who have been cyberbullied have also been bullied in person, and 69% of those who admitted to bullying online have also admitted to in-person bullying ("Nationwide teen bullying and cyberbullying study reveals significant issues impacting youth -- ScienceDaily," 2018). When we talk about the impacts of cyberbullying 64% of people who have been cyberbullied say it affects their ability to learn and feel safe at school ("Online Harassment 2017 | Pew Research Center," n.d.). Bullied students are twice as likely as other students to experience problems such as headaches and stomach aches (Gini and Pozzoli, 2013).

In this work we collect the group of words that has been used to bully and harass people to recognize such content and analyze those using linguistic analytics and sentiment analytics because with friends we aren't always polite. Also understanding the behaviors of the followers or people who are daily active on these people's account in case of twitter and such

platforms analyze their behavior to prevent them from accessing those accounts and hashtags using machine learning and AI, if they are involved in bullying and harassing the victims in any kind of way. We can reduce the toxicity of these platforms and make many feel safe in their own space by doing that. The aim of this research work is to utilize man-made consciousness at a specific level to pre-empt exploitation by recognizing (and blocking, forbidding, or isolating) the most risky clients and accounts. We are going to achieve this by Understand the key characteristics of cyberbullying and people involved in cyberbullying, Identify risk factors and outcomes of cyberbullying, Clarify what measurement instruments will lead to consistent, Identify existing research gaps on cyberbullying and its prevention, Proposing suitable solution – Machine Learning System. In the second section of this paper we review previous works to prevent cyber bullying using machine learning and also other experiments that has been done to acknowledge the issue and focus on the future directions that this project can be taken and how to make the process efficient and increase accuracy of systems using machine language and sentiment analysis in a more depth level.

## II. LITERATURE REVIEW

As for the existing networking systems or social media portals they sure do take necessary actions to reduce cyber bullying as it is increasing day by day and affecting younger generation a lot and most of the celebrities go through this a lot as their lives get high light attention all the time which general audience try to get involved without knowing many facts or anything about them personally. In America there are organizations that are constantly on watch of such cyberbullying to prevent it in real time in some platforms (“Cyberbullying Organizations,” 2018), but there is always a limit how much they can prevent at a time as Internet is a mass capacity. The facts and statistics of Cyberbullying for 2018-2020 shows that more parents than ever report that their children are getting bullied at school or online. Comparitech conducted a survey of over 1000 parents of children over the age of 5 and they found 47.7% of parents with children ages 6-10 reported their children were bullied, 56.4% of parents with children ages 11-

13 reported their children were bullied, 59.9% of parents with children ages 14- 18 reported their children were bullied, 54.3% of parents with children ages 19 and older reported their children were bullied (“Cyberbullying Statistics and Facts for 2020,” 2020).

Several attempts were taken to find accurate platforms to gather the information to conduct the process of prevention which has been successful to a great level. And there are different technologies used some in different and some in the same experiments to recognise what are the most accurate and efficient in preventing cyberbullying. In the previous reviews they have used gaming platforms to gather data automatically In their chat boxes on the issue which they have been successful to the expected level but could not achieve a solution. Multilingual systems are also in the discussion and a group has done a system review on Arabic language system to detect and prevent cyberbullying. From the review they have gathered all the data for them to come to the conclusion that it is possible preventing cyber bullying in different languages. As the issue getting severe day by day a group in IT field has come up with a causal theory and more effective empirical methods to investigate and mitigate this phenomenon, they leverage the control balance theory and their model examines the causes of cyberbullying from several novel angles. One major drawback to this method is that we did not observe people committing cyberbullying and there has been experiment in Automatic cyberbullying detection which is a task of growing interest, particularly in the Natural Language Processing and Machine Learning communities. In this work, they conduct an in-depth analysis of 22 studies on automatic cyberbullying detection, complemented by an experiment to validate current practices through the analysis of two datasets. They also complemented this approach with an extensive experiment to assess current practices, by using feature engineering. And the experiments to define what cyberbullying actually is also been conducted and their analysis proves its definition vary from one individual to another which sentiment analysis comes in handy in cyberbullying prevention.



Table 2-1. Feature Comparison and novelty of Machine Learning Models for Cyberbullying Detection and Sentiment Analysis

Paper (Research) Author	Technologies	Accuracy
A Multilingual System for Cyberbullying Detection: Arabic Content Detection using Machine Learning	Machine Learning (ML) Natural Language Processing (NLP) WEKA toolkit	58.7% - 61.2%
Systematic review on automatic cyberbullying detection.	Natural Language Processing Machine Learning.	67%
Expert and Machines against Bullies: A Hybrid Approach to Detect Cyberbullies.	Expert Systems Supervised Machine Learning.	68% - 72%
Cyberbullying Detection Using Sentiment Analysis In Social Media	Sentiment Analysis Naïve Bayes, Support Vector Machine and Neural Network	<b>SVM</b> - 89.39% <b>Naive Bayes</b> - 73.0328% <b>Convolutional Neural Network</b> - 48.6404%
Sentiment Analysis of Twitter Data	Naive Bayes, Support vector machine (SVM), and Bagging	<b>cross validation</b> Naive Bayes - 56% SVM 41% Bagging 43%
Sentiment Classification using Machine Learning Techniques	Naive Bayes Support Vector Machine (SVM)	<b>Naive Bayes</b> - 65.57% <b>SVM</b> - 45.71%
A Comparative Analysis of Machine Learning Classifiers for	Multinomial Naive Bayes, Bernoulli Naive Bayes and SVM	<b>BNB 70.75 %</b> <b>MNB 75.77 %</b> <b>SVM 74.09 %</b>
Twitter Sentiment	Unigrams and bigrams	
Sentiment Analysis on Product Reviews Using Machine Learning Techniques	Naive Bayes Support Vector machine	<b>Naive Bayes classifier</b> - 98.17% <b>SVM</b> - 93.54%
Twitter Sentiment Analysis: Lexicon Method,	WEKA Tool, Sentiment analysis Lexico Based Approach,	<b>Decision Tree algorithm</b> - 62% <b>SVM</b> - 66% <b>Naive Bayes</b> - 64%

Machine Learning Method and Their Combination	Machine Learning Approach, Naïve Bayes and SVM	
Machine Learning and Semantic Analysis of In-game Chat for Cyber Bullying, automatic data collection system.	SQL Database Queries, AI-based sentiment Text analysis services.	55.7% - 59.6%
Prevent cyberbullying Using the Design	Better causal theory and more effective empirical methods Control balance theory	54.3% - 57.5%

Cyberbullying prevention attempts has been taking from a very long time but addressing severe and most danger issues has started in the near past. The researches and system reviews proves that the probability of cyberbullying prevention in getting increased as time pass by with technologies such as machine learning, Natural Language Processing, Sentiment Analysis, Linguistic Analysis and some more which makes internet much safer and personal space for the younger or adult generation to use without getting affected by the toxicity of individuals or groups.

### III. METHODOLOGY

#### A. Approach

##### 1) Modern Approach

Ten years prior, Computer Scientists would contact Data Centers and inquire as to whether they could give those huge number of instances of cyberbullying content – which they needed to search through to search for patterns and examples in how damage was dispensed. These days, they don't request information since it's generally accessible for them to web scratch.

From publicly available social media posts in the quantity they need (e.g., there are approximately 500 million tweets on Twitter every day). Alongside the diminished expense of modest

equipment like (nearly) limitless extra room on hard drives and figuring multiprocessors that can crunch and mine information dangerously fast, this has permitted the field to make some astonishing mechanical forward leaps to decrease online abuse.

## 2) Why use Machine Learning

We take posts and use artificial intelligence within a machine learning framework – specifically deep learning to make determinations about them. She might first write multiple algorithms to do specific tasks. Together and collectively, those would form a neural network of layers, each with its own automated job to do.

Automatically, crafted by every one of these layers across the posts in the screen capture above – and a huge number of others, oppressive and not harmful – would be gathered, suitably gauged, and all in all used to acquire man-made reasoning in understanding what presents are undoubtedly on be poisonous. At that point, a calculation can perform sentiment analysis to make a determination of whether the next post is or is not toxic (sentiment polarity), what's more, therefore whether it ought to be hailed, hindered, or erased by a human mediator (whose decision-making is simplified through this system). This can then happen on every new post created by a user, automatically and on-the-fly (“How Machine Learning Can Help Us Combat Online Abuse,” 2017).

There are more layers to consider and evaluate (frequency of third-party reports on the post, use of emoticons, and how old the posting account is. I also know my example is not perfect, but hopefully you get the gist. As knowledge and technology in this area continues to develop, we will be increasingly able to identify what is abusive versus what is not.

negative, or impartial. It is a combination of natural language processing, text analysis and computational linguistics. In this process a sentence is considered positive if it has positive keywords and is considered negative if it has negative keyword. The comparison among the number of each type of contents decides the positivity and negativity of the whole content (“(Tutorial) Simplifying Sentiment

Analysis in Python- DataCamp,” n.d.). This study tends to provide an algorithm that may help in analysis of words that may lead to crime detection especially in social sites. For our research, we are using machine learning sentiment analysis technique. The algorithm that we’re using are Naive Bayes. For Naive Bayes and an initial training data set is required which need to be labelled with positive, negative and neutral sentiment accordingly. For that, we are using the pre-labeled data set from kaggle and e data we gathered and stored in csv file using Twitter API (Hassan, n.d.).

## 3) Technologies

Machine learning,  
Natural Language Processing, Linguistic Analysis, Sentiment Analysis,  
Google API Services

Algorithm – This is a list or set of rules that a PC will follow to achieve some undertaking or methodology by means of its computations.

Machine Learning – we use algorithms to get computer systems to go through content (images, text, whatever) and identify various trends and patterns across all of those data, based on what we have told them to look for. This can actually be done on unlabeled data as well, via what is called unsupervised learning.

Deep Learning – Basically, this is a subset of machine learning, yet, after we get the framework to distinguish patterns and examples across information by examining content, we request it to continually improve its likelihood from precisely grouping that content by persistently preparing itself on new information that it gets.

Natural language processing (NLP) – This includes utilizing machines to take human language in text or sound configuration – with the entirety of its nuances and subtleties including setting, manner of expression, idioms, and tone – and translating what is implied, in a perfect world with the precision that people have in understanding communicated words and expressions.

Sentiment analysis – This involves using NLP to identify and parse out emotions (affect) and other subjective notions within expressed words

or phrases. Within this, there is sentiment polarity and a sentiment score.

### B. Data Gathering

#### 1) Twitter API / Kaggle

In this study data collected from two different sources, Data gathered from an online survey using google form to get an idea about knowledge about cyberbullying of general audience and its impact on them. Datasets were collected from Kaggle: Machine Learning Data Community Service and Twitter API for Machine Learning Models Training and Testing for sentiment Analysis. The dataset is sentiment140 dataset. It contains 65,000 tweets extracted using the twitter API. The tweets have been annotated (0 = negative, 1 = positive) and they can be used to detect sentiment. The SCV file contain 6 fields, which are. target: the polarity of the tweet (0 = negative, 1 = positive). ids: The id of the tweet date: the date of the tweet, flag: The query. If there is no query, then this value is NO\_QUERY. user: the user that tweeted vi. text: the text of the tweet ("Sentiment140 dataset with 1.6 million tweets," 2020). Id, Target and Text Features were used for the research work.

#### 2) Online Survey

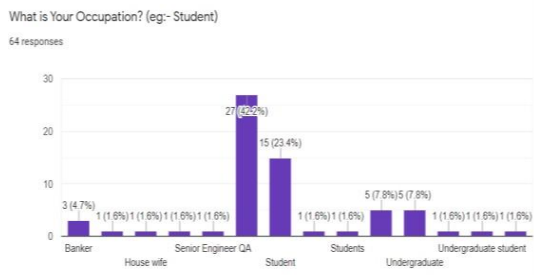


Figure 3.1: -: Occupations

Source: Author

Which Age group do you belong to?

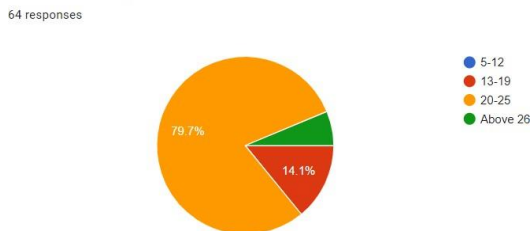


Figure 3.2: -: Age Groups

Source: Author

What's Your Gender?

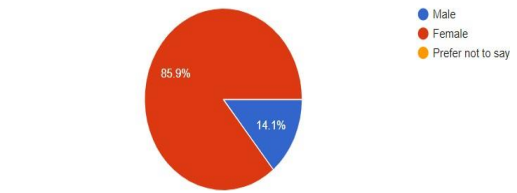


Figure 3.3: -: Gender

Source: Author

Cyberbullying is... (select all that apply)

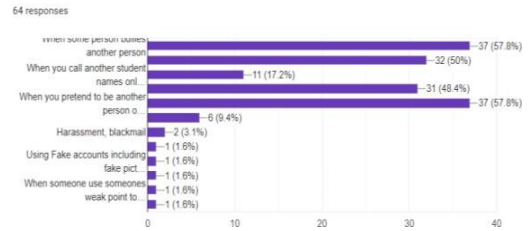


Figure 3.4: -: Cyberbullying Understanding

Source: Author

If you have been cyberbullied, did you report it to anyone?

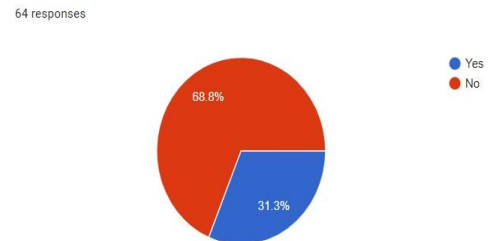


Figure 3.5: -: Cyberbullied Report

Source: Author

How often do you think cyberbullying happens?

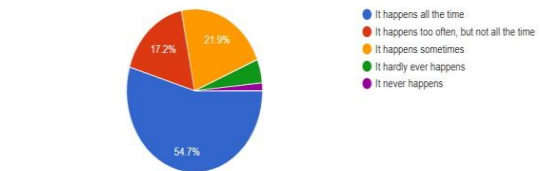


Figure 3.6: -: How often Cyberbullying Happen

Source: Author

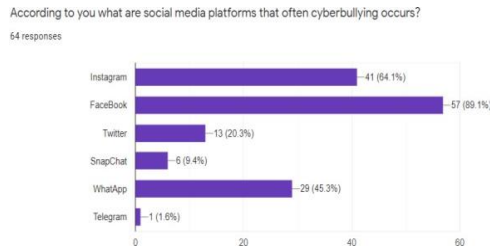


Figure 3.7: - Often Cyberbullying happening Social Media Platforms

Source: Author

Would you prefer if social media apps have APIs to prevent cyberbullying so that the internet would be a safer place for you?  
64 responses

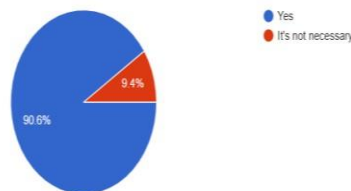


Figure 3.8: - Preference for Cyberbullying detecting api

Source: Author

From the online survey we've conducted 64 responses were gathered. According to data gathered many people don't have a clear idea their root structure. The "root" for this situation may not be a genuine root word, yet a standard type of the first word. Impacts of stemming curved words stemming just possibly helped improved characterization exactness rather than utilizing better designed highlights and text enhancement approaches, for example, utilizing word implanting.

Lemmatization on the surface is very similar to stemming, where the objective is to eliminate affectations and guide a word to its root structure. The solitary contrast is that, lemmatization attempts to do it the appropriate way. It doesn't simply cleave things off, it really changes words to the genuine root. Stop words are a set of commonly used words in a language. The intuition behind using stop words is that, by removing low information words from text, we can focus on the important words instead (Kotsiantis et al., 2006)

whether they've been through cyberbullying or not. People are not still comfortable with sharing their bullying or bullied experiences in detail, and the case is even worse in countries like ours as the victim can get blamed for what they go through. So from these information only can gather a brief idea what generally people know about cyberbullying and the impact of the problem upon themselves.

### C. Data Preprocessing

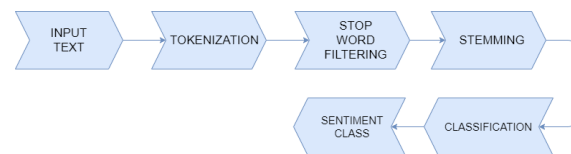


Figure 3.9 -: Data Pre-processing

Source: Author

To preprocess the text simply means to bring the text into a form that is predictable and analyzable for the task. A task here is a combination of approach and domain.

$$\text{Task} = \text{approach} + \text{domain}$$

Lowercasing all text data, although commonly overlooked, is one of the simplest and most effective form of text preprocessing. Stemming is the way toward decreasing intonation in words to

### D. Building Machine Learning Model for Sentiment Analysis

$$P(y|x_1, \dots, x_n) = \frac{P(y)P(x_1, \dots, x_n|1)}{P(x_1, \dots, x_n)}$$

#### 1) Naïve Bayes Classifier

Naive Bayes classifier is based on the Bayes' Theorem and is a supervised learning approach. Specifically, a supervised learning algorithm takes a known set of input data and known responses to the data, and trains a model to generate reasonable predictions for the response to new data. Naive Bayes classifier is used for sentiment analysis purposes due to its high accuracy. Although it is a simple theorem, it performs almost as well as many other complicated approaches. It is essentially a set of supervised learning algorithms based on the application of Bayes' theorem with the "naive" assumption of independence between every pair of features [3]. Given a class variable and a

dependent feature vector through, Bayes' theorem states the following relationship:

For all  $i$ , this relationship is further simplified to:

$$P(y | x_1, \dots, x_n) = \frac{P(y) \prod_{i=1}^n P(x_i | y)}{P(x_1, \dots, x_n)}$$

This means that - the probability that classification  $y$  is correct, given the features  $x_1, \dots, x_n$ , and so  $P(y | x_1, \dots, x_n)$  equals the probability of  $y$  times the product of each  $x$  feature given  $y$ , divided by the probability of the features.

## 2) Experimental Setup

We implemented the python nltk package for Naive Bayes classification. The training sets need to be labelled in order to recognize the category a corpus is classified upon. For our case, we are trying to detect bullying and hence we need to find out if a particular tweet is positive or negative or is opinionated/neutral. The negative tweets are regarded as cyberbullying related tweets. The labelled tweets were then stored in CSV file. If it is positive or neutral, then there is no harm done and we leave it at that. However, if a tweet is negative, we can successfully identify cyberbullying. Now the question remained, how accurate was the detection of this negative tweet. We collected a large data set as mentioned before for training the classifier in order to increase the accuracy.

After the bigram features were extracted and added to the feature vector, we trained the Naive Bayes classifier using the built in package function with the 1 million tweets that were collected and annotated. Then we moved on to testing the polarity of the test data. In order to determine how much precise and accurate our classifier was we also found out some metrics like precision, accuracy, recall and f-score.

### D. Deploying the Trained Model for Prediction

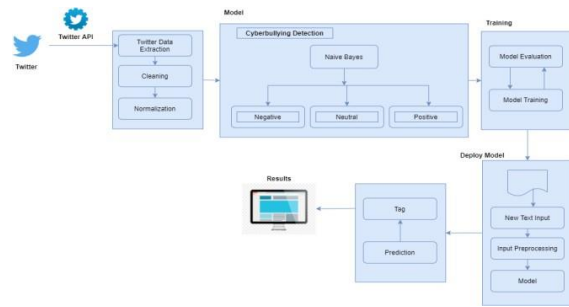


Figure 3-10. Deploy the developed model with Flask

Source: Author

The data is a collection of tweets tagged as 1 as positive or 0 as negative that was collected from twitter API and Kaggle. First, the dataset is used to build a prediction model that will accurately classify which texts are spam. Naive Bayes classifiers are a popular statistical technique of sentiment predicting. They typically use bag of words features to identify negative tweets. Not only Naive Bayes classifier is easy to implement but also provides very good result. After training the model, it is desirable to have a way to persist the model for future use without having to retrain. And we can load and use saved model. Models are persisted in a certain format specific to the language in development. And the model will be served in a micro-service that expose endpoints to receive requests from client.

Having prepared the code for classifying Sentiment of tweets we will develop a web application that consists of a simple web page with a form field that lets us enter a message. After submitting the message to the web application, it will render it and gives us a result of negative or positive. The app.py file contains the main code that will be executed by the Python interpreter to run the Flask web application, it included the ML code for classifying text sentiment.

### E) Results

A comparison study was done in order to conclude what the best Algorithm is to use in Sentiment Analysis Model. Algorithm, Accuracy: Test, Precision: Test, Recall: Test, F1 Score: Test, Prediction Time, Accuracy: Train, Precision: Train, Recall: Train, F1 Score: Train, Training



Time Features were used to analyze the results of the pipeline.

Algorithm	Accuracy: Test	Precision: Test	Recall: Test	F1 Score: Test	Prediction Time	Accuracy: Train	Precision: Train	Recall: Train	F1 Score: Train	Training Time
LogisticRegression	0.893372	0.901663	0.922279	0.920579	0.002992	0.94456	0.990241	0.877282	0.983719	0.895054
DecisionTreeClassifier	0.923214	0.954808	0.927041	0.94072	0.023008	0.998845	0.999943	0.9983	0.999121	3.687034
LinearSVC	0.916732	0.946599	0.92551	0.935936	0.006946	0.997019	0.998298	0.997167	0.997733	0.435515
MultinomialNB	0.926344	0.964089	0.940306	0.942721	0	0.978726	0.956763	0.959039	0.9579	0.003988
KNeighborsClassifier	0.857606	0.895161	0.887245	0.891186	45.926606	0.897727	0.927596	0.915982	0.921753	0.015959

Classification Summary of Algorithm was done by using Accuracy: Test, Precision: Test, F1 Score: Test, Recall: Train Features. The gained results are shown in the Figure 3.4.

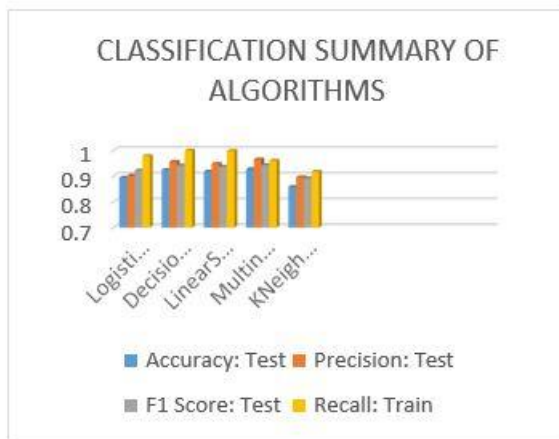


Figure 3-11. Classification Summary of Algorithms

Source: Author

As shown in the figure 3.4

Best Accuracy: 0.926 – MultinomialNB

Best F1 Score: 0.943 – MultinomialNB

Best Precision: 0.964 – MultinomialNB

Best Recall: 0.940 – MultinomialNB

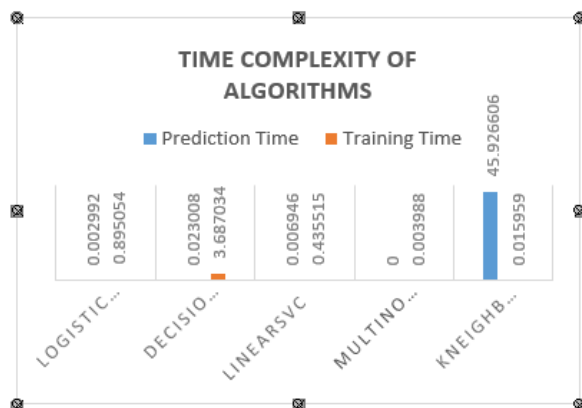


Figure 3-12. Time Complexity of Algorithms

In the figure 3.5 is shown the Time Complexity of Algorithms. According to the results gained

Best training time is 0.004 - MultinomialNB

Best prediction time is 0.0 - MultinomialNB

Worst Training time 3.6870 – Decision Tree Classifier Worst Prediction Time 45.92 – KNeighbors Classifier

Worst Training time 3.6870 – Decision Tree Classifier Worst Prediction Time 45.92 – KNeighbors Classifier

Sentiment Analysis Model was build Using Naïve Bayes Classifier. As out prediction Targets we used Negative, Positive and Neutral states to analyze the tweets Sentiment.

I am happy -> 2.15

I am very bad -> -1.29

this movie should have been great. -> 2.14 great -> 2.14

great great -> 4.28

great great great -> 6.41

great great great great -> 8.55 bad bad bad bad -> -5.18

the above-mentioned results shows prediction Score got from the model. Here 2.15 is positive sentiment and -1.29 is a negative sentiment. And to get more accuracy the words arrays are used to train the system for predictions.

User interfaces are shown below with the user inputs and system outputs.

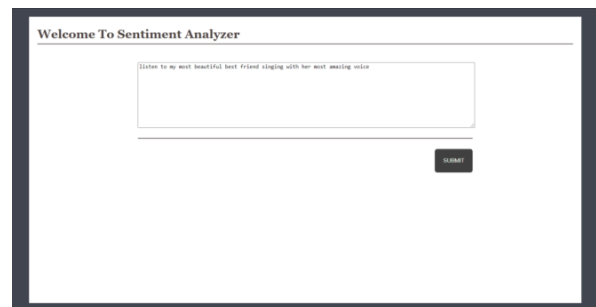


Figure 3-13. Insert Text

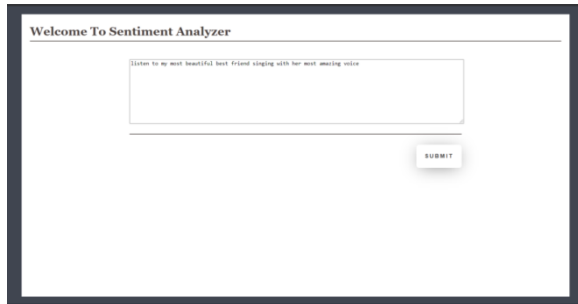


Figure 3-14. Submit the text for sentiment analyze

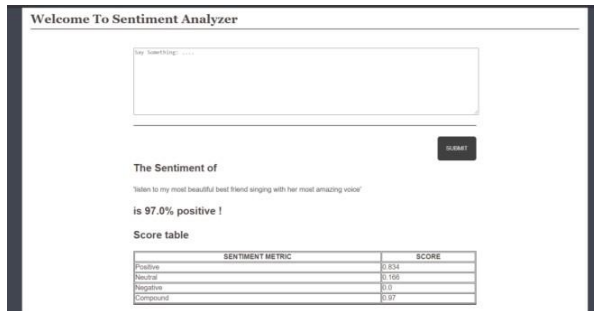


Figure 3-15. Get the results with Sentiment Matrix Scores (Positive)

#### IV. DISCUSSION AND CONCLUSION

Considering the researches that has been done the highest accuracy they have gained are among 70% to 95% percent which claims they are successful at achieving their goal (Birjali et al., 2017). Some researches were there which has good F1 Scores as well. In our research work we did a comparison study to conclude which algorithm the best was considering measurement features mentioned in the results section to analyze sentiment of the tweets with our sentiment analysis model. As the results we gain from the evaluation Naïve Bayes Classifier gives the best accuracy 0.926, Precision 0.964, F1 Score 0.943 of the test dataset and Best recall of the train dataset. The Training time and Prediction Time was also given with Naïve Bayes Model. While Linear SVC, Decision Tree Logistic Regression, Kneighbor Classifiers gives next best results in sequence.

This system was build and trained and tested using Naïve Bayes Model considering the results and the system very accurately predicted the sentiment of the inputs put in by user. The build system was deployed to a Web Interface for user input and predict the sentiment of the input using the Machine Learning model and result is given in a table in three aspect scores which are negative, positive and neutral. The Naïve Bayes

Model trains data fastest compared to other classifiers which makes it easier to use large data sets to increase Accuracy of the system.

#### V. FUTURE WORKS

In our work we build a Sentiment analysis model using Naïve Bayes classifier to predict the sentiment of user input text real time. To extend the research work further the classifiers such as Bagging Classifier, stochastic gradient descent Classifier, Random Forest Classifier and Ada Boost Classifier. Other Feature Engineering Methods also can be used to get the best out of datasets. In our research work cyberbullying prediction will be done using twitter Chabot, but cyberbullying comments deletion can't be done. As a solution for that the user input comments can be translated into decent set of words using Natural Language Process techniques and libraries. As Image Processing is a rising field, can be used to analyze cyberbullying using Screenshots or images detected by the system. If these goals are achieved in the future Internet will be a safe space for every generation, every gender and basically human race.

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# Effort Estimation in Agile Software Development: An Empirical Study in the Sri Lankan Context

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**Abstract** - In responding to the dynamic business environments, most software development organizations have shifted towards the practice of agile methodologies, due to their capability in undertaking change in requirements. Accurate and reliable effort estimates usually assist effective project planning. Effort estimation in agile software development differs from traditional approaches due its iterative nature. In this survey-based study, the main objective is to assess the status of effort estimation by agile software development teams in Sri Lanka. Hence, the investigation focuses on finding out the widely adopted agile effort estimation techniques, effort predictors, accuracy level of each technique, and the factors affecting estimation accuracy. The data was collected from software industry professionals using an online questionnaire and was statistically analysed. According to the results obtained, “Expert Judgment”, “Planning poker”, and “Use Case point” are the most used effort estimation techniques among Sri Lankan agile teams, and it was evident that “Expert Judgment” is the most accurate effort estimation technique among them. Further, a conceptual model on the effect of cost drivers on the accuracy of the effort estimation was proposed based on the results of correlation and linear regression analysis.

**Keywords:** *agile software development, software estimation, effort estimation, effort estimation techniques*

## I. INTRODUCTION

The software engineering industry has been continuously affected by the extreme changes brought by the globalization to the world economies in the 21st century (Britto, Usman and

Mendes, 2014). Software development teams are faced with frequent change in requirements caused due to the highly dynamic nature of the business environments. As a result, lots of software development teams have now shifted towards agile software development approaches. In ASD, software development happens in an incremental manner as small iterations by incorporating the feedback of customers at the end of each iteration (Darrin and Devereux, 2017) (K.R, 2017)(Kim, 2007).

During the planning phase of a software project, a schedule estimate is prepared based on the effort required to complete the project. Usually, effective planning requires accurate and reliable estimates as inputs. Thus, if the project can have a more accurate effort estimate, it will eventually lead to high customer satisfaction. Hence, effort estimation can be considered as an integral step of software project management (Usman et al., 2014)(Nazir, Hasteer and Bansal, 2016). But in contrast to the plan driven software development approaches, estimations and planning in agile approaches happens progressively due to its iterative nature (Canedo et al., 2018). Therefore, in ASD, project planning happens iteratively as three steps: release planning, iteration planning and the current day planning (Cohn, 2005)(Tuli et al., 2014). Accordingly, estimation techniques used in ASD differs from the techniques used in the traditional software development. Expert Opinion, Analogy, Disaggregation, and Planning Poker are some of the common techniques for estimation in ASD (R. Popli and N. Chauhan, 2013).



With the growing number of ASD teams, agile estimation is still an active research area. The objective of this research study is to investigate the status of the practice of agile effort estimation in the Sri Lankan software engineering industry. Hence, for obtaining an in-depth understating of how effort estimation is being performed by ASD teams and the accuracy of estimation techniques used, a survey questionnaire was designed and executed. Further based on the results obtained, factor affecting estimation accuracy was identified and a conceptual model for effort estimation accuracy was proposed.

The remainder of the paper is organized as follows: section 2 summarises the existing works; the methodology and experimental design is presented in section 3 and results are presented in section 4. Finally, discussion and conclusions are given in section 5.

## II. RELATED WORKS

With the popularity of agile, many research studies on different aspects of ASD has been conducted and among them we could identify a few research works conducted on effort estimation practices of ASD.

In the study by (Usman et al., 2014), a literature review has been done, studying total of 25 primary studies on agile effort estimation. Expert Judgment, Planning poker and Use case points estimation techniques identified as most frequently applied techniques in ASD. Use case points and story points has been identified as most frequently used size metrics while MMEE and MRE have been identified as frequently used accuracy metrics. Team skills, prior experience and task size has been cited as three important cost drivers and Extreme Programming and SCRUM identified as only the two agile methods used.

In the research work of (Usman, Mendes and Börstler, 2015), a survey has been carried focusing on a wide range of aspects such as the estimation techniques and effort predictors used in a global context. Among the findings, Planning Poker (63%), analogy (47%) and expert judgment (38%) identified as frequently practiced estimation techniques in ASD. Story point has been identified as most frequently (62%) employed size metric. Team's expertise

level and prior experience has been identified as most used cost drivers.

In the study by (Canedo et al., 2018), a literature review has been done, studying total of 27 primary studies on agile effort estimation. This study's result shows that Planning Poker is the most popular technique for agile teams in the planning phase, Story Point and Point of Function are the most used metrics in agile projects for estimating size, time, effort, productivity and cost.

(Usman et al., 2018), has performed an exploratory longitudinal case study through archival research and semi-structured interviews. As key findings they have suggested that a two-stage effort estimation process can improve effort estimation accuracy and seems to address some of the challenges in large-scale agile software development. Also, it has been found that team maturity, team distribution, requirement size and requirement priorities play a vital role in improving the accuracy of effort estimates.

With respect to the existing literature, it is evident that no study has conducted on the practice of agile effort estimation in Sri Lankan ASD teams. Thus, this study narrows the aforesaid gap through carrying a survey-based study among Sri Lankan agile software development teams.

## III. METHODOLOGY

A survey-based research methodology was followed in the study conducted. This section describes on formulation of research questions, design of survey questionnaire, and execution of survey.

### A. Research Questions

In achieving the objectives of study, four research questions were formulated.

**Research question 1 (RQ1)** – What are the most used effort estimation techniques in agile software development teams?

**Research question 2 (RQ2)** – How accurate is the effort estimations done using the above techniques?

**Research question 3 (RQ3)** – Which effort predictors are used within the aforesaid

techniques for effort estimation? **Research question 4 (RQ4)** – What are the factors that have an impact on the accuracy of the effort estimations?

### *B. Survey Design*

A survey is a most effective and trustworthy form of investigation that targets at collecting data from a wider and most related population (Orel, 2020). It is mandatory to define its purpose, the unit of analysis to be used and a representative population sample related to the research problem in order to perform surveys. The survey was defined as follows:

- 1) *The purpose:* Collecting data on the state of the practice on effort estimation in ASD in Sri Lankan context.
- 2) *The analysis Unit:* Elements of the effort estimation process such as effort estimation techniques, cost drivers, size metrics.
- 3) *The target population:* Practitioners who have worked with effort estimation in agile teams
- 4) *The sampling unit:* Practitioner responsible for performing effort estimation in an organization.

This study was conducted in the form of an online questionnaire which was shared among the target responder group. The use of the e-form helped to maximize the number of respondents. The survey questionnaire encompassed with thirty-eight closed-ended questions and two open-ended questions. For the coverage all the research questions formulated, questionnaire was structured in to three sub sections: Demographic information, ASD practices, and Effort estimation practices. The aim of the obtaining the demographic information is to understand the background of the responders. ASD practices section includes questions related to the application of agile methodologies in software development. Effort estimation practices section includes questions related to the application of effort estimation techniques.

Some of questions in the survey has been combined and denoted as a single question for the ease of presentation. In the survey, Questions 1 to 12 were compulsory and designed as

categorical measurement scales. Question 13 is an open-ended question which is not compulsory. Question 6 is a multiple answer question, and all others are with a single answer. Respondents were given the chance to be anonymous with their feedback, but they could provide contact details willingly for a follow up interview.

#### *1) Demographic Questions:*

**Question 1** - Is your organization, project base, productbase or both?

**Question 2** – What is your age?

**Question 3** – What is your job title?

**Question 4** – What is your experience in agile softwaredevelopment (in years)?

**Question 5** – What is the size of your project team?

#### *2) ASD Methodology Questions*

**Question 6** – Which agile methods are used by your team?

**Question 7** – What is the length of iteration (ex: Sprint)?

#### *3) Effort Estimation Questions*

**Question 8** – What is the effort estimation technique employed in your ASD project?

**Question 9** – What is the size metric utilized in effort estimation?

**Question 10** – This is a multi-part question focusing on the accuracy of effort estimation technique employed. Here the impact of the chosen effort estimation technique to estimate accuracy and accuracy of each technique is assessed.

**Question 11** - This is a multi-part question focusing on the effect of cost drivers to the accuracy of effort estimation. According to literature, factors affecting the accuracy of the effort estimates can be categorized as communication, team expertise and social factors. Communication factors includes strength of communication among team members, linguistic diversity of team members, and involvement of the client in estimation tasks. Team expertise factors include prior experience in ASD, agile estimation, project domain, and technology stack. Social factors include team members' cultural diversity, geolocation, familiarity, and

unity.

**Question 12** – This is a multi-part question focusing on general project factors that can impact to the accuracy of effort estimation apart from above cost drivers. Factors include scope of the project, type of the software developed, size of the task breakdown, quality of requirement specification, effort estimation team constitution.

**Question 13** – This is a non-compulsory open-ended question for obtaining responders’ suggestions on increasing the accuracy of effort estimates in ASD.

### C. Survey Execution

As the initial step, a pilot survey was conducted with the help of few industrial experts. Based on the feedback received, questionnaire was modified and improved. Then in collecting responses, online questionnaire survey was shared to the responders mainly through the LinkedIn social media platform, so that eligible responders for the study could be reach more comfortably. Further some other respondents were invited through emails by contacting few reputed software development organizations. The survey questionnaire was available online from 1st of August 2020 to 30th November 2020 and there were 111 total responses.

## IV. RESULTS

### A. Demographic Questions

As per the Question 1, 47.3% of the respondents work in an organization which has both products and services base projects. Among the rest, 28.1% works in purely product base organizations while 24.6% are in purely service base organizations.

Question 2 assessed the age range of the respondents, and the results show that 56.1% of respondents were age between 25 and 30, 28.1% of respondents between 30-40, 14% of respondents were age below 25 and only 8.0% of respondents were age above 40.

Question 3 captured the respondent’s job title. Respondents were playing diverse roles associated with ASD. Among respondents 50% of respondents were developers and there were also roles such as “Team Lead”, “Tester”, “Project Manager”, “Software Architect”, “Business Analyst”, “QA Lead”, “DevOps Support Engineer”,

“SCRUM Master”, “QA Manager” and “Project Coordinator” etc. These results suggest that developers also play an important role in effort estimation ASD same as the higher-level project leadership or management roles such as project managers, architects, team leads etc.

Question 4 assessed the respondent’s experience in agile software development. The results show that 40.4% of respondents have 1 to 3 years’ experience and 37.8% of respondents have more than three years’ experience in agile software development environment. Among them 24.6% of respondents have 3 to 5 years’ experience and 12.3% of respondents have 5 to 10 years’ experience.

Question 5 assessed the project team size of respondents. As per the results half of respondents (50%) were in teams of 3 to 9 members. Further, 25.4% were working in teams of 10 and 15 members. It is evident that ASD is more popular with small size teams.

### B. ASD Methodology Questions

Question 6 captured the agile methods employed by the respondents’ project teams. As per the results, most popular agile methodology is “Scrum” (66.7%) followed by “ScrumBan” (20.2%). Table 1 shows the status of adopting ASD methodologies including hybrid approaches. Further in Question 7, length of an iteration (in weeks) practiced in respective development methodology was assessed. It was obvious that most teams have adopted an iteration two weeks. Proceedings of 14th International Research Conference of KDU. You can use this document either as a set of instructions or as a template into which you can type your own text directly. The template has adopted the main good-practices used in scientific publications, which are also compatible with those of Social Sciences and Humanities.

Table 1: Employed agile method in respondent’s teams

Agile Method	Percentage
Scrum	66.7%
ScrumBan	20.2%
Kanban	5.3%
XP	1.8%
Lean	1.8%
Scrum, XP	1.8%
XP, Kanban	0.9%

Scrum, lean, kanban	0.9%
Scrum, Kanban, FDD	0.9%

### C. Effort Estimation Questions

In achieving one of the objectives of the study, Question 8 captured the effort estimation techniques that are practiced by ASD teams. The results suggest that “Expert judgment” is the mostly used effort estimation technique (33.3%) followed by “Planning Poker” (31.6%) and “Use Case Points” (28.1%). Table 2 shows the usage of different effort estimation techniques. Moreover, this result is a significant deviation from the results of existing studies in literature (Britto, Mendes and Borstler, 2015) (Usman, Mendes and Börstler, 2015) where “Planning poker” was resulted as the mostly used effort estimation technique. Table 2 shows the status of adopting different effort estimation techniques.

Table 2. Effort estimation technique used by respondents’ agile teams

Effort Estimation Technique	Percentage
Expert Judgment	33.3%
Planning Poker	31.6%
Use Case Points	28.1%
COCOMO	4.4%
Delphi	1.8%
Disaggregation	0.9%

Question 09 captured the size metrics used upon estimating the effort by ASD teams. Results shows that ‘Story point’ is the mostly used (57.9%) size metric followed by ‘Use Case points’ which have 31.6% of usage percentage.

Question 10 which is a multipart question that captured the accuracy level of each effort estimation technique according to the opinion of the responders. Estimation accuracy is the most important feature expected from an effort estimation technique. If estimations are erroneous by a huge margin, there is no point of conducting an estimation. Around half of the responders (52.3%) agreed that the adopted estimation techniques have an effect towards the effort estimation accuracy, while 24.6% had a neutral response and 20.1% disagreed. When considering the accuracy of the estimations received by each technique, there was an

accuracy of 89.5% for “Expert Judgement” while 86.1% for “Planning Poker” and 56.3% for ‘Use case Point’ technique.

Question 11 is also a multipart question that captures the effect of cost drivers effect to the effort estimation accuracy. When considering all factors under three categories, communication between team members, client involvement in effort estimation process, team members with prior experience in ASD, effort estimation technique used, and familiarity among team members usually effect the effort estimation accuracy in positive manner. Lack of expertise on project domain and lack of technological knowledge, and lack of team unity seems to affect the effort estimation accuracy in a negative manner.

Question 12 is focused on the project related factors which can impact to the accuracy of effort estimation except above mentioned size metrics. As per the results, scope of the project, type of the software system developed were main factors affecting the accuracy. Further, following deductions could be made based on the results obtained.

- Estimating relative effort is accurate more than estimating absolute effort.
- Unclear, unstable, and miss-documented requirements decrease the accuracy of the effort estimation.
- Estimations conducted as smaller tasks provides more accuracy than large tasks.
- Estimations are more accurate when estimation is done by the same team who are also responsible for development.

After the analysis of the feedback obtained for Question 13, few of commonly received suggestions were summarized as follows.

- It is important to involve the assigned person(s) for
- the task during estimation.
- Considering of the performance of employees assigned for the task is important.

- It is important to have clear requirements and client involvement.
- It is important to create and use planning documents, such as specifications and project plans.

Further an advanced statistical analysis was conducted with the objective of finding any available relationships between the identified factors and estimation accuracy, and estimation techniques. Thus, a correlation analysis and a multiple linear regression analysis were conducted. For the correlation analysis average value of responses for the communication factors, team expertise factors, and social factors were used to compared with Expert Judgment, Planning poker, and Use Case points techniques. Result of the analysis showed that all the three types of factors have a high correlation with "Planning Poker" technique. But when considering the "Expert Judgment" and "Use Case Points" techniques only communication and team expertise factors have a high correlation and social factors do not affect hugely for effort estimation accuracy. With the integration of results of correlation analysis and the results of the linear regression analysis, a conceptual model for effort estimation was constructed illustrated as in Figure 1.

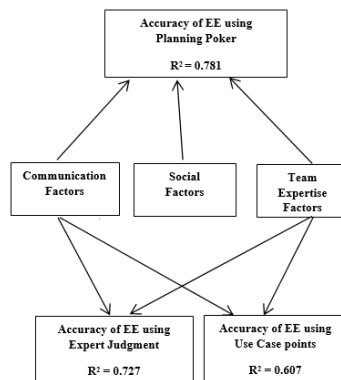


Figure 1: Proposed conceptual model for effort estimation

## V. DISCUSSION AND CONCLUSION

In response to the dynamic business environments, most of the software development organizations have now shifted to ASD from traditional plan driven development approaches. Estimations and planning in agile approaches happens progressively due to its iterative nature. Effective planning requires accurate and reliable

estimates. The objective of this research study was to investigate the status of the practice of agile effort estimation in the Sri Lankan context. In this study a survey-based research methodology was adopted. Thus, feedback to online questionnaire survey was obtained from industrial professionals with an exposure to ASD. Collected data were analyzed using several advanced statistical methods. As per the results SCRUM is most widely adopted ASD methodology while Expert Judgment is the most used and most accurate effort estimation technique followed by Planning Poker and Use Case Points. Accuracy of all above techniques highly depends on the team's communication strength and the team's expertise in ASD and additionally, social factors also affect in the Planning Poker technique. Finally, a conceptual model for agile effort estimation was proposed. Also based on the suggestions of responders, new set of factors affecting estimation accuracy could be identified. In future works we are planning to integrate the newly identified factors to this conceptual model and validate it through industrial application.

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#### ABBREVIATIONS AND SPECIFIC SYMBOLS

ASD – “Agile Software Development” FDD – “Feature Driven Development” XP – “Xtreme Programming”

EE – “Effort Estimation”

MREE – “Mean Magnitude of Relative Error” MRE – “Magnitude Relative Error”

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# Mobile Applications for Precision Agriculture Practices: A Review

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**Abstract**—In most developing countries like Sri Lanka, agriculture plays a vital role in economic and social aspects. Paddy cultivation is considered the most economically significant field of agriculture. Since farmers are the backbones of the paddy and rice industry, their satisfaction and efficient involvement directly affects the development of the paddy cultivation industry. As a result of the timely necessity of accessing information for decision-making in paddy cultivation, numerous paddy cultivation advisory services implemented in different regions can be identified worldwide. Access to continuously updated information on matters such as weather, machinery, diseases, pests and fertilizers at the right time allow farmers to make effective decisions. This review paper enhances details about software applications in paddy cultivation, developed to benefit farmers and other related stakeholders. A review of the system modules, features and technologies of providing timely information on paddy cultivation is mentioned by comparing prevailing systems. Moreover, factors that affect the prominence in using these types of systems are discussed in detail. This review shows that agriculture-based applications are highly demanded in countries like India, Sri Lanka, Myanmar and Africa. These applications have been developed to fit into their specific domain. Inefficient module functions, limited real-time services, complexity and lack of usability of prevailing systems are the main gaps identified through this review.

**Keywords:** *machine learning, mobile applications, paddy cultivation, precision agriculture, smartphone applications*

## I. INTRODUCTION

Agriculture is considered as the oldest profession learnt by humankind after hunting. With the advanced improvement in agricultural research and development process over the centuries, the field of agriculture has progressed up to the current commercially beneficial stage (Kuba & Jha, 2017). During last couple of decades agriculture in all around the world is progressively shifting from traditional practices to scientific methodologies. “Rice is life” is a very familiar slogan for developing countries where Paddy cultivation is closely linked to the cultural and socio-economic life of the entire population. In the prevailing state of Sri Lanka, the contribution of rice for the Gross Domestic Products is approximately 18%. More than 30% of labour force is dedicated for rice production industry in both direct and indirect ways. The main income of 1.8 million families in Sri Lanka is based on paddy cultivation (Adhikarinayake, 2005). However, due to several challenges which are currently existing with the paddy cultivation industry, farmers have to face many difficulties in obtaining a satisfactory harvest through the cultivation efforts. Climate variability in recent years has critically affected the usual aspects of human lives, where the agricultural sector can be considered as one of the most vulnerable (Alahakoon, 2017). In addition, insufficient knowledge, lack of interest and insufficient guidance are the main problems faced by the paddy cultivation industry. The positive outcome of these prevailing issues can be identified as the approach of prioritizing the rice industry development in Sri Lanka with the integration of modern technologies (Sylvester, 2016).

The rapid growth in information technology is contributing for the social empowerment and

innovations in developing countries from grassroots level(Rajput & Goyal, 2019). Not only in Sri Lanka, the emergence of new applications and services for paddy cultivation can be clearly recognized in worldwide(Norasma et al., 2013). These applications are trying to address the gap between farmers and the access to the agriculture-based information. Access to continuously updating information on weather, machineries, diseases, pests, fertilizers, etc. at the right time allow farmers to make effective decisions. This review paper enhances details about software applications in paddy cultivation developed for the benefit of farmers and other related stakeholders in worldwide. Review of the system modules, features, and technologies of providing timely information on paddy cultivation are mentioned through the comparison of the prevailing systems.

The rest of this paper is organized as follows. Section II of the paper discusses the methodology used in this research. Section III includes a comprehensive review on the available applications for paddy cultivation advisory purposes. Section IV discusses about the results obtained through the review. Finally, section V concludes the overall research indicating the importance of this research.

## II. Methodology

The purpose of this research is to review mobile applications related to paddy cultivation based of their functionalities and effectiveness. This research followed a systematic search strategy to find agriculture-based mobile apps available in Google and Apps stores.

Selected applications represent different regions, different technologies used, and different functionalities. Applications are critically reviewed based on these criteria.

Finally, depicted in Figure 1., research findings are summarized and discussed through this paper.

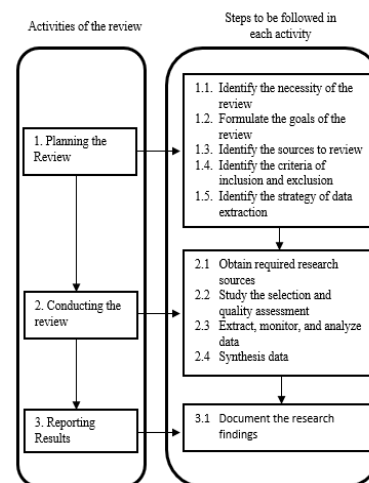


Figure 1: Research Methodology

## III. Mobile Applications Review

Selected mobile applications for this research include different types of agriculture-based systems. Paddy cultivating countries like India, Sri Lanka, Africa, and Myanmar have mainly focused in developing mobile applications to increase the effectiveness of paddy cultivation through farmers' satisfaction. Some of these applications have built exclusively for paddy cultivation while several applications include many other crops addition to paddy.

A mobile application comprises with a set of functionalities that are required to satisfy both functional and non-functional requirements. In order to provide a better experience for the users, these applications use number of latest technologies for different purposes such as front-end, back-end frame works, model building etc(Goonathilake & Kumara, 2020). This review focuses on the technologies used and different features provided by the selected applications.

### A. TANU's Paddy Expert System

This application has developed to provide information on paddy cultivation to Indian farmers. Its functionalities allow farmers to access information on cultivation practices, nutrient management, crop protection, farming and harvesting machineries. And also, this mobile app provides details about marketing and related institutes for paddy cultivation. Since its first release in 2017, more than 5000 downloads have been recorded. The current rating and

application size are 4.6 and 88.00 MB, respectively (Paddy Expert System, 2017).

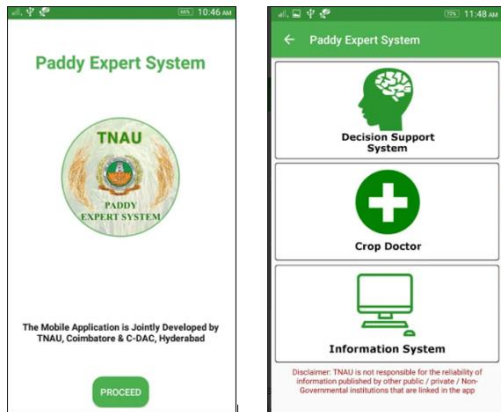


Figure 2: TANU's Paddy Expert System

### B. riceXpert

riceXpert has developed by National Rice Research Institute (NRRI) in India with the purpose of providing real time information to farmers on rice varieties, nutrients, insect pests, weeds, disease-related problems, and machineries. In addition, it includes functionalities to deliver news, announcements and FAQs related to paddy cultivation in India. The most important feature in this app is ability to make customize queries by farmers through text, image, and voice. NRRI experts can address these issues on real time basis. More than 10000 downloads have been recorded since its first release in 2016 and currently riceXpert is 13.59 MB and has a 4.4 user rating (RiceXpert, 2016).

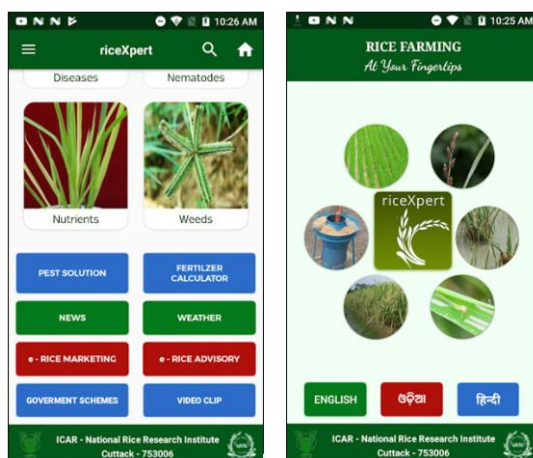


Figure 3: riceXpert

### C. Krushi Advisor

This is an Android based agriculture app available in Sinhala language that provides advisory services for crop cultivation in Sri Lanka. Addition to the farmers, this app targets several other communities including agricultural entrepreneurs and researchers. This informative system comprises with knowledge required in different crop cultivations including paddy as one of the major crops. Users can directly connect with the 1920 hotline for agriculture advisory services. As well, this system can be used in offline by downloading reference data at the installation process. It has initially released in 2018 by the Department of Agriculture Sri Lanka and it has been downloaded by more than 10000 users. Current download size of this app is 3.42 MB and it has rated by users up to 4.5 (Krushi Advisor, 2018).



Figure 4: Krushi Advisor

### D. Agro Life Sri Lanka

This application also available in Sinhala language and provides informative services to crop farmers. Features like providing knowledge on impact of climate, storage procedures, communication for agriculture related queries are included addition to the common features that are available in the above-mentioned applications. This application has been released in 2020 by KOMA Labs currently its size in 4.2 MB. It has been achieved more than 1000 downloads with 4.7 user ratings (Agro Life Sri Lanka, 2020).



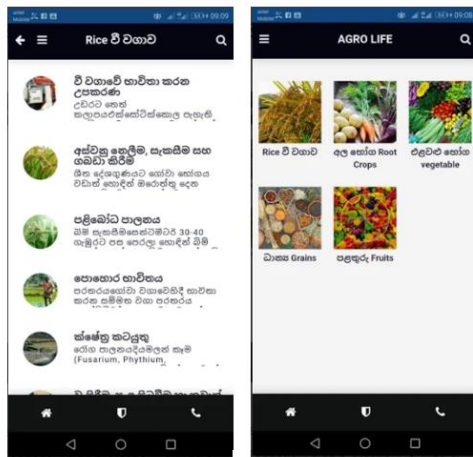


Figure 5: Agro Life Sri Lanka

### E. RiceAdvice-WeedManager

AfricaRice and Co-Capacity has developed an Android based application named as RiceAdvice that includes decision support tools to provide guidelines in field-specific management related to paddy cultivation for African farmers. The two main tools available with the application are RiceAdvice and RiceAdvice-WeedManager. Relevant guidelines are provided by taking inputs from farmers through MCQs. Currently, this application supports for both English and French. More than 1000 downloads have been recorded since the first release in 2016(RiceAdvice-WeedManager, 2018).

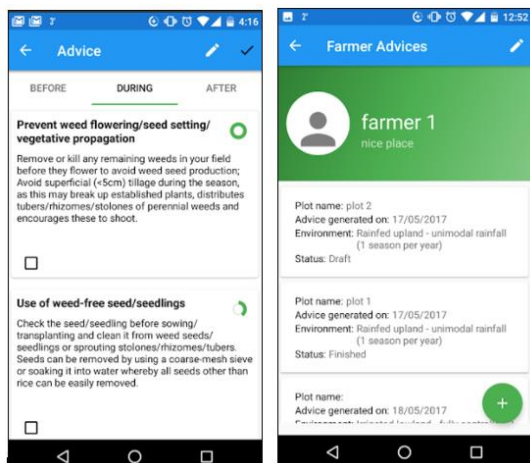


Figure 6: RiceAdvice-WeedManager

### F. Golden Paddy

Golden Paddy is a mobile application developed for paddy farmers in Myanmar. It is available in Myanmar language, and it guide farmers in paddy

cultivation to increase their yields and income. Users can access to weather forecasts and paddy market rates in real time basis. Currently it has achieved more than 10000 downloads with 4.6 user rating. It has updated to newer version since its first release in 2016 and current size of the app is 11.62 MB(Golden Paddy, 2016).



Figure 7: Golden Paddy

Paddy cultivation is one of many fields in agriculture. Even there are some differences exist among paddy cultivation practices and other crop cultivation, some processes and informational requirements between these cultivation domains are similar and linked together. Therefore, this research has focused of most beneficial and popular mobile applications that have developed for other types of crop cultivation purposes excluding paddy cultivation. **OneSoil Scouting** one of the best farming applications, that can be commonly used for planting fruits and vegetables. The feature that allows farmers to access satellite views of their farming fields to detect areas with different problematic conditions is the most significant functionality. However, this feature does not perform perfectly during severe weather conditions. Farmers can maintain notes on their farming procedure to track the growing stages of crops. Access to social media and weather forecasts also, enhances the importance of this system. **Farm Dog** is another agriculture application similar to OneSoil Scouting app(Farm Dog, 2016). This system provides recommendations based on the cultivation notes made by the farmers.

In the field of agriculture, trade can be considered as an integral part. **Agrellus-Grower** is a buying



and selling application for agricultural products (Agrellus - Grower, 2021). Farmers can buy fertilizers, chemicals, equipment for their farming activities through different sellers available within the system. **Kugler Timing** App is useful in tracking and scheduling farming tasks in cultivating corn, barley, soybeans, wheat, etc (Kugler Timing, 2018). The most remarkable feature available in Agrivi app is the ability to monitor farming expenses based on sales, income, and other cost related factors. There are systems like **Crop Nutrient Advisor** that are dedicated for nutrient management for different crops and systems like **Plantix** are functioning as crop doctors which can detect and provide recommendations for crop related diseases (Crop Nutrient Advisor, 2020; Plantix, 2015). All these applications have built with the intension of provide facilities for farmers in different ways related to cultivation. Even these types of prevailing applications do not directly useful in paddy cultivation, the technologies, features and concepts of them can be effectively used to improve the effectiveness of paddy cultivation based mobile applications.

#### IV. DISCUSSION

The results of this research on reviewing paddy cultivation and other agriculture-based mobile applications shows that there are different types

of systems have been implemented in different regions in world. Out of them, applications related to paddy cultivation are mostly available in countries such as India, Sri Lanka, Myanmar, Africa, etc. According to the summarized comparison depicted in Table 1., several features and functions can be recognised in common with all these applications while some of the features have been developed in regions-specific manner. Most of the features available in these applications are dedicated for knowledge delivery where some of the applications have been able to provide information in real time basis. User ratings of these apps which are more than 4.0 stars represent the effectiveness of their functionalities. Features like access to weather forecasts and ability to communicate with agriculture experts enhances the dynamic performances of these applications.

Mobile apps like OneSoil Scouting, Plantix, etc are also dedicated for different agricultural purposes including crop disease detection, crop nutrient advisories, agricultural trading etc. Even these types of applications are not specifically developed for the use of paddy farmers, the features, technologies, and concepts used in these systems also can be used for the advancement of prevailing paddy cultivation-based applications.

Agriculture based Application	Technologies Used	Feature						
		Crop and Machinery Details	Fertilizers	Diseases	New s	Weather Forecasts	Experts' Advisory	Other
<b>Paddy Expert System</b> <i>India</i>	Data Analytics	✓	✓	✓	✗	✓	✗	Paddy marketing
<b>riceXpert</b> <i>India</i>	Mobile Networking	✓	✓	✓	✓	✓	✓	Paddy marketing
<b>Krushu Advisor</b> <i>Sri Lanka</i>	Mobile Networking	✓	✓	✓	✓	✗	✓	-
<b>Agro Life</b> <i>Sri Lanka</i>	Data Analytics	✓	✓	✓	✗	✓	✗	Storage process
<b>RiceAdvice</b> <i>Africa</i>	Data Analytics	✓	✓	✓	✗	✗	✓	Weed Managing
<b>Golden Paddy</b> <i>Myanmar</i>	Data Analytics e-commerce	✓	✓	✓	✓	✓	✗	Paddy marketing

## V. CONCLUSION

This review paper provides insights into the existing mobile applications used for precision agricultural practices in particular paddy cultivation. From our study, we draw the following conclusions:

Firstly, we noted that mobile applications developed for facilitating precision agricultural practices particularly in the field of paddy cultivation are highly demanded in countries like India, Sri Lanka, Myanmar, Africa, etc. System features and functionalities of these applications are mostly based on their particular regional contexts.

Secondly, we recognized that the reviewed applications have limitations due to the inefficient module functions, limited real-time services, complexity, and lack of usability. Overall system complexity exists with these applications are considerably beyond the current level of digital literacy of rural farmers.

Thirdly, the applications that have been developed for Sri Lankan context, it can be seen that the user interactive features are either unavailable or poorly implemented. Absence of essential dynamic features to provide real time access to agricultural information has identified as the main reason for poor user interest and satisfaction.

For future research, since this study mainly focused on mobile applications used for precision agricultural practices in particular paddy cultivation, we suggest reviewing more applications related to other crop cultivation practices in the field of agriculture.

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# Role of Workplace Cyber Incivility and Personality Traits on Employee Knowledge Sharing Behaviour

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**Abstract** - Knowledge sharing behaviour can achieve a greater level of innovation and creativity. Employees who were victimized with computer-mediated workplace incivility may hinder knowledge with rational justifications. The purpose of this paper is to identify the role of workplace cyber incivility on knowledge sharing behaviour. Additionally, this study identifies the mediating effect of personality traits (Extraversion, Agreeableness, Conscientiousness, Neuroticism, Openness to experience) on the relationship between them. The study is predominantly designed as a quantitative study based on the positivistic paradigm. Data were obtained from an online self-administered questionnaire from permanent employees in software development organizations in Sri Lanka, and 251 responses were analysed using correlation and SEM bootstrapping. The study draws attention towards workplace cyber incivility victims, who may negatively respond to knowledge sharing behaviour, creating hostile work environments. The theory of trait activation can be used to explain the individual differences of the said relationship. The study also proposes partial mediation on the same relationship. The findings of the study have several theoretical and practical implications. It advocates the necessity to address workplace cyber incivility to ensure employee knowledge sharing behaviour.

**Keywords:** *knowledge sharing behaviour, cyber incivility, personality traits*

## I. INTRODUCTION

In this prodigiously turbulent and dynamic world, organizations are striving to achieve a competitive advantage. Organizations achieve a competitive edge by developing and using knowledge and information which in return

develop products, services, ideas, and information. Knowledge is a strategic asset (gain through continuous learning) for any organization to boost the efficiency and ability of the decision-making process (Issac, et al., 2020). Knowledge sharing behaviour (KSB) can be identified as the transmission of explicit and tacit knowledge from knowledge providers to receivers (Bock, et al., 2005; Lin & Huang, 2020). In particular, tacit knowledge is the most important knowledge to win the battle (Meulenbroek, et al., 2018). Therefore, organizations onboard employee those who are rich in knowledge sharing behaviour. However, employees do not share knowledge as expected which is puzzling (Bock, et al., 2005).

In this study, we purport that cyber incivility could be the reason to hinder knowledge sharing behaviour. Modern technology has been led the way of communication in the organization to an electronic communication system that is easy, efficient, and speedy. Besides, emails are the most preferred and commonly used mode of communication in organizations. Yet, emails can be a double-edged sword due to non-face-to-face communication (Lim & Chin, 2006); examples of such behaviours are hurting comments, gossips, irritable emails, and short or no response for emails. This can be identified as cyber uncivilized practices in organizations. When employees are disregard or mistreated it will affect their psychological wellbeing. Hence, that prevents employees from sharing knowledge with others; especially between supervisors and co-workers.

Knowledge hiding between supervisors and co-workers has diverged victim to victim based on their individual differences through their experience of cyber incivility. In this study we concentrate mostly on an ignored individual

aspect in knowledge sharing literature: we examine which personality trait plays as a mediator in cyber incivility and KSB. Most previous studies focusing on the facilitators of KSB, yet there is less research on barriers to KSB (Farrukh, et al., 2018). There is a growing concern to identify possible barriers for KSB, hence, we propose that workplace cyber incivility is one of the possible barriers for KSB. Therefore, the objectives of the study are twofold. First, we identify the impact of workplace cyber incivility on employee knowledge sharing behaviour. There is a dearth of research focusing on cyber incivility and individual-level knowledge sharing behaviour. Second, investigating the role of personality traits as a mediating factor between cyber incivility and KSB.

## II. THEORETICAL BACKGROUND

### A. Knowledge sharing behaviour

Knowledge is a most valuable intangible asset which expedites competitive advantage, change, and expansion of Information Technology (IT). There are two dimensions of knowledge (1) explicit; facts, rules, and policies that can be articulated and codified in writing or symbols which shared easily (Matzler, et al., 2008) and (2) implicit; the knowledge which is embodied in practices and routine which is difficult to share. Knowledge sharing is decisive for companies to develop knowledge, skills, attitude for creativity and innovation. Therefore, KSB can be defined as “the degree of one’s positive feelings about sharing one’s knowledge” (Bock, et al., 2005). This is a conscious behaviour (voluntary, proactive, behavioural awareness) shaped by the culture, ethics, and code of conduct of the organization (Lin & Huang, 2020).

There are a contextual, group, and individual antecedents which affect the KSB such as, technical, procedural justice, creativity, shared norms, personality, intrinsic motivation, and social capital (Shaari, et al., 2015). Nevertheless, there is less research on barriers for KSB such as workplace mistreatment and workplace incivility (Lin & Huang, 2020). Moreover, knowledge sharing behaviour is determined by an individual's personality traits (Farrukh, et al., 2018), knowledge sharing attitudes (employees may share knowledge when they perceive

pleasure and meaning for helping others, besides they reluctant to share knowledge when they perceive their knowledge is not important to others), subjective Norms (the degree to which subordinates and co-workers persuade to share knowledge through psychological contracts), and intention to share implicit/ explicit knowledge (Ahmad & Karim, 2019). Nevertheless, knowledge is considered as a source of power and fuel to obtain political mileage; employees deliberately hinder their knowledge in order to achieve individual competitive advantage (Issac, et al., 2020).

### B. Cyber incivility

Workplace incivility is identified as any rude or discourteous behaviour that drives to psychological or physical consequences for both victims and bystanders of such behaviours, creating hostile workplaces. Particularly, workplace incivility can be defined as “low-intensity deviant behaviour in a workplace with ambiguous intent to harm the target, violating the social norm of mutual respect towards both individuals and organizations” (Andersson & Pearson, 1999). There is research focusing on cyber harassment but less on cyber incivility (Lim & Teo, 2009). There is a growing concern to address cyber incivility because of the anonymity of the perpetrator. If managers overlook addressing cyber incivility, that may escalate to the next level of aggression. Cyber incivility can be defined as computer-mediated less severe detrimental behaviour that violates mutual respect and norms (Lim & Chin, 2006). Further, Lim and Teo (2009) stated that cyber incivility is electronic aggression that occurs in workplaces through email communication (Sharifirad, 2016). Researchers stated that abusive supervision and deviant behaviours can reduce KSB (Ahmad & Karim, 2019). Therefore, we have identified that cyber incivility is a predictor of knowledge-sharing behaviour. Victims may camouflage knowledge by playing dumb, evasive hiding, and justify their hiding behaviour (Irum, et al., 2019). This has led to our first hypotheses;

H1: there is a negative impact between workplace cyber incivility and KSB

### C. Personality traits

Personality demonstrates individual differences based on their behaviour, cognition, and emotions which are conceptualized through personality traits. Personality traits are the intrinsically characteristics of a person that exposed as a particular pattern of demeanours for different situations. Personality traits can be defined as “the individual characteristics and behaviours, organized in a way that reflects the unique adjustment the person makes to his or her environment” (Barrick, et al., 2001). Personality traits of Conscientiousness, Extraversion, Neuroticism, Agreeableness, and Openness to experience leads to certain kinds of attitudes and behaviours. This has led to our second hypotheses;

H2: there is a relationship between workplace cyber incivility personality traits (Extraversion, Agreeableness, Conscientiousness, Neuroticism, Openness to experience)

Extraversion includes traits such as convivial, loquacious, gregarious, assertive, active, zealous, and expressive who has a vigorous desire for the accolade, convivial apperception, status, and power. Extroverts may not be a victim of workplace cyber incivility because they have more positive social interactions. Therefore, we hypothesized that workplace cyber incivility may negatively relate to the extrovert trait.

H2A: there is a negative relationship between workplace cyber incivility and Extraversion

Agreeableness includes traits such as courteous, flexible, trusting, good-natured, cooperative, forgiving, soft-hearted, and tolerant. It is predicted that those who are high in agreeableness may less likely to be a victim of workplace cyber incivility. Therefore, we hypothesized that,

H2B: there is a negative relationship between workplace cyber incivility and Agreeableness

Conscientiousness personality type includes traits such as hardworking, meticulous, exhaustive, responsible, organized, and persevering. Further, these individuals are attention to detailed and spot the subtle deviations as uncivil. Therefore, there is a positive relationship between said variables. We hypothesized that;

H2C: there is a positive relationship between workplace cyber incivility and Conscientiousness

Neuroticism includes traits like apprehensive, dispirited, exasperated, disconcerted, emotional, worried, and insecure. Neurotic employees experience a greater deal of negative life experiences. Therefore, we hypothesized that;

H2D: there is a positive relationship between workplace cyber incivility and Neuroticism

Openness to experience includes traits like imaginative, cultured, curious, pristine, broad-minded, perspicacious, and artistically sensitive. Openness individuals are providing favourable responses for the absence of evidence for less detrimental behaviours. Therefore, we hypothesized that;

H2E: there is a negative relationship between workplace cyber incivility and Openness

A personality trait is a most studied individual-level predictor in KSB literature (Jadin, et al., 2017). Individuals with high agreeableness and conscientiousness traits are more likely to share knowledge among others (Matzler, et al., 2008). Knowledge sharing behaviour is a helpful social interaction; therefore, there is a positive relationship between Extraversion, Agreeableness, Conscientiousness, and Openness to experience and KSB. Neuroticism This has led to our third hypotheses;

H3: there is a positive relationship between personality traits (Extraversion, Agreeableness, Conscientiousness, Neuroticism, Openness to experience) and KSB

Additionally, the Theory of Trait activation elucidates the individual traits are activated to respond to the situation (Tett, et al., 2013). Succinctly, traits and situations are the two-sided of the same coin. Determinately, we propose that personality traits mediate the relationship between workplace cyber incivility and KSB. This has led to the fourth hypothesis;



H4: personality traits mediate the relationship between workplace cyber incivility and KSB.

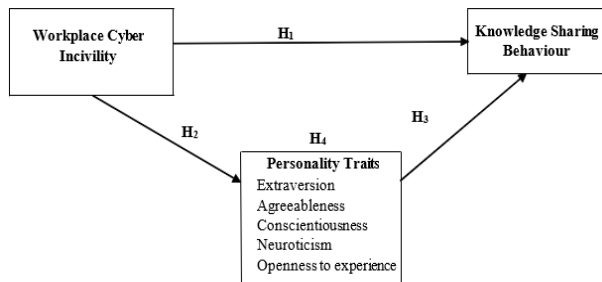


Figure 1 Conceptual Framework

### III. METHODOLOGY

Parametric assumptions of normality, linearity, multicollinearity and common method bias are met and the parametric test is fitting in this study. First, demographic data analysis is presented; the sample consisted of 62% male and 38% female employees. Besides, the sample represents a younger and educated population (below 25 represents 23%, 26 to 35 represents 31%, 36 to 40 represents 31, and more than 40s age group represents 25%) with 23% postgraduate, 59% bachelors, and 18% of professional qualifications. Ostensibly, there were fewer tenure employees due to the nature of the industry; 23% of the employees have more than 10 years of experience while the majority having 1 to 3 years of experience (43%) and 34% have 3 to 5 years of tenure in the same organization.

Table 1 indicates the descriptive output data; mean values for workplace cyber incivility, Extraversion, Agreeableness, Conscientiousness, Neuroticism, Openness to experience, and KSB are 2.90, 2.63, 3.13, 3.47, 3.40, 3.73, and 2.65 respectively. A low standard deviation indicates that the data points incline to be very proximate to the mean. However, KSB values are spread out over a substantial range.

Table 1 Means, standard deviations, correlations

Construct	Mean	SD	1	2	3	4	5	6	7
1. WCI	2.90	1.12	<b>(0.86)</b>						
2. PE	2.63	1.13	.502**	<b>(0.76)</b>					

3. PA	3.13	0.76	.042	.221**	<b>(0.54)</b>				
4. PC	3.47	0.99	-.216**	-.310**	.681**	<b>(0.98)</b>			
5. PN	3.4	0.95	-.193**	-.244**	.630**	.837**	<b>(0.82)</b>		
6. PO	3.73	0.87	-.135*	-.200**	.551**	.687**	.748**	<b>(0.82)</b>	
7. KSB	2.65	1.00	-.467**	.937**	.219**	.292**	.228**	.243**	<b>(0.70)</b>

Note: N = 251

WCI (workplace cyber incivility), PE (Extraversion), PA (Agreeableness), PC (Conscientiousness), PN (Neuroticism), PO (Openness to experience), and KSB (Knowledge Sharing Behaviour)

\*\*\*p<0.001, \*\*p< 0.01, \*p< 0.05

The square root of AVE values is in diagonal parenthesis

There is a negative relationship between workplace cyber incivility and KSB (R= - .467). Consequently, personality traits demonstrated a positive relationship with KSB. There is a weaker relationship between cyber incivility and KSB (Table 1), this has led to identifying the missing link between cyber incivility, personality traits, and KSB.

#### A. Measurement Model

Confirmatory factor analysis (CFA) was used to ensure the validity and reliability of the measurement scales. Table 1 average variance extracted (AVE) ensures convergent validity with greater than 0.5 output value. In this study, AVE ensures the convergent validity of the model which is demonstrated in figure 2. Conscientiousness had the highest discriminant validity among all the constructs. However, agreeableness and KSB did not achieve the threshold value for discriminant validity. However, we have achieved an optimum level of discriminant validity by sequentially removing items from the model. Measurement model fit indices were tested to check the fitness of the SEM model. The goodness of the fit indicates;  $\chi^2(2/df) = 3.899$ , RMSEA = 0.108, CFI = 0.862, GFI = 0.705, and TLI = 0.849 ensures the best fit with output data. The goodness of fit indices ensures that the model is well fitted with the data.

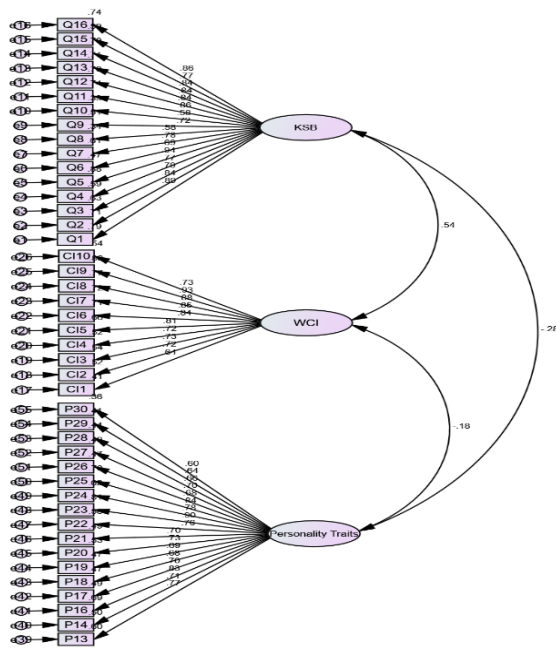


Figure 2 Confirmatory factor analysis

### B. Structural Model

We have hypothesized a negative relationship between cyber incivility and KSB (H1); according to output data ensured a negative relationship ( $\beta = -0.507$ ,  $p = 0.00$ ). It is argued that if employees experience cyber incivility behaviour by one unit, they may decrease or hinder their explicit and implicit KSB. Further, 26% of the KSB variations ( $R^2 = 0.26$ ) can be explained through the selected cyber incivility behaviours.

To test the second hypothesis (H2); we have hypothesized that there is a relationship between workplace cyber incivility personality traits (Extraversion, Agreeableness, Conscientiousness, Neuroticism, Openness to experience). Output data for workplace cyber incivility ensures a (H2A) positive relationship with workplace cyber incivility and extraversion ( $\beta = 0.502$ ,  $p = 0.000$ ) and negative relationship with (H2C) workplace cyber incivility and conscientiousness ( $\beta = -0.216$ ,  $p = 0.000$ ); (H2D) workplace cyber incivility and Neuroticism ( $\beta = -0.193$ ,  $p = 0.002$ ), (H2E) workplace cyber incivility and Openness to experience ( $\beta = -0.135$ ,  $p = 0.031$ ). Yet, there is no relationship between workplace cyber incivility and agreeableness (H2B).

To test the third hypothesis (H3); we have hypothesized that personality traits (Extraversion, Agreeableness, Conscientiousness, Neuroticism, Openness to

experience) positively relate with KSB. According to output data, extraversion ensures a positive relationship with KSB ( $\beta = 0.906$ ,  $p = 0.000$ ), rejecting all four-sub hypothesis. It is expected to increase 0.906 of KSB if we increase extraversion personality traits. Finally, we have hypothesized (H4) that personality traits (Extraversion, Agreeableness, Conscientiousness, Neuroticism, Openness to experience) mediate the relationship between workplace cyber incivility and KSB. We have used bootstrapping to test the mediation effect.

Table 2: Total Effect

Path	Direct effect	Indirect effect	Total effect
H4A: WCI → PE → KSB	0.05	0.35	0.40
H4B: WCI → PA → KSB	0.04	0.06	Rejected
H4C: WCI → PC → KSB	0.47	0.04	0.49
H4D: WCI → PN → KSB	0.48	0.03	0.51
H4E: WCI → PO → KSB	0.49	0.02	0.51

Note: N = 251

WCI (workplace cyber incivility), PE (Extraversion), PA (Agreeableness), PC (Conscientiousness), PN (Neuroticism), PO (Openness to experience), and KSB (Knowledge Sharing Behaviour)

According to table 2 output data; H<sub>4A</sub> is accepted and there is a partial mediation of 0.35 ( $\beta = 0.35$ ,  $p = 0.08$ ) and the mediation effect is significant under 95% of bootstrap confidence level. 37% of the KSB variations ( $R^2 = 0.37$ ) can be explained through the extraversion mediation. Second, H<sub>4B</sub> rejected, there is no evidence to ensure mediation effect under 5% of bootstrap significant level ( $p = 0.51$ ). Third, conscientiousness ensures a partial mediation between cyber incivility and KSB ( $\beta = 0.04$ ,  $p = 0.002$ ). further, 29% of the KSB variations ( $R^2 = 0.29$ ) can be explained through conscientiousness mediation. Fourth, H<sub>4C</sub> ensures a partial mediation of 0.03 between Neuroticism and KSB ( $\beta = 0.03$ ,  $p = 0.007$ ) with significant bootstrapping. Moreover, 27% ( $R^2 = 0.27$ ) of the KSB variations can be explained through Neuroticism and cyber incivility. Fifth, openness ensures a 0.02 ( $\beta = 0.02$ ) of partial mediation between cyber incivility and KSB and the bootstrapping significance is 0.019 ( $P = 0.019$ ). Moreover, 29% ( $R^2 = 0.29$ ) of the KSB

variations can be explained through openness mediation. Finally, we can conclude that personality traits mediate the relationship between workplace cyber incivility and KSB. Succinctly, 89% ( $R^2 = 0.88$ ) KSB variations can be explained through cyber incivility and personality traits (Figure 3).

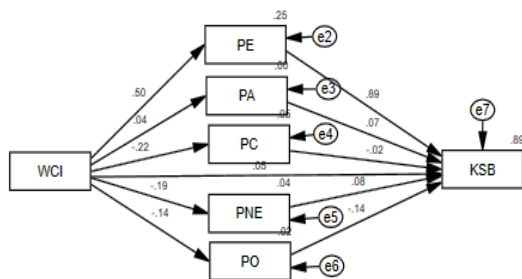


Figure 3: Results of the structural model for direct, and bootstrap indirect effect  
Note: N = 251

## V. DISCUSSION

The purpose of this study is to identify the role of workplace cyber incivility and personality traits on KSB of IT sector employees in Sri Lanka. The first objective of our study was to identify the impact of workplace cyber incivility and KSB. The findings are consistent with the previous studies. When employees perceive workplace cyber incivility; they tend to hinder KSB (Farrukh, et al., 2018; Santoso & Anggraeni, 2020). Consequently, despite different initiation to encourage knowledge-sharing behaviours, employees may not share knowledge due to their personal barriers and situational factors (Anand, et al., 2020).

The second objective of the study was to identify the mediating effect of personality traits on workplace cyber incivility and KSB. According to the theory of trait activation; individuals tend to hinder knowledge by playing dumb and justifying their such behaviours based on experienced situations. In aligning with the previous studies, if employees with extraversion personality traits are less likely to perceive workplace cyber incivility (Farrukh, et al., 2018). Yet, workplace cyber incivility negatively relates to conscientiousness, neuroticism, and openness personality trait employees. Additionally, the

literature suggests that extraversion, conscientiousness, neuroticism, and openness personality traits employees are more likely to share information (Matzler, et al., 2008). Finally, the findings of the study show the negative indirect effect of personality traits (extraversion, conscientiousness, neuroticism, and openness) between workplace cyber incivility and KSB (Sharifirad, 2016). Nevertheless, employees with traits such as positive social interactions, cooperative, hardworking, responsible, and imaginative employees are more likely to share knowledge though they perceived less-detrimental cyber behaviours (Jadin, et al., 2017; Tett, et al., 2013). We have concluded that personality traits partially mediate the said relationship.

## VI. THEORETICAL AND MANAGERIAL IMPLICATIONS

Implications of the study are twofold, stating with theoretical implications followed by implications for managers. Workplace cyber incivility is a fairly new detrimental behaviour that impedes knowledge sharing behaviour among others. This study light shed on organizational behaviour and information management literature by unveiling the relationship between cyber incivility, personality traits, KSB directly as well as indirectly. Consequently, we have made a contextual contribution to the IT sector addressing rarely studied predictors of KSB. In addition to the theoretical implications, there several managerial implications for practitioners and organizations.

Knowledge-sharing behaviour generates substantial positive consequences for organizations and employees such as competitive advantages, survival, innovations and creativity, and interpersonal relationships (Anand, et al., 2020). Therefore, it is of utmost importance to identify and address workplace cyber incivility; ignoring less detrimental behaviours may create a hostile work environment that demoralizes KSB. First, practitioners should ensure a civilized workplace; this can be done through proper orientation, training programs, and awareness sessions to use technology wisely. Second, create policy, procedures, code of conduct, and shared

norms to ensure civilized culture. Nevertheless, it is the organization's responsibility to continuously update its policies and communicate them among all the members of the organization. However, such initiations should start from the top management, when they use computer-mediated communication and knowledge management. Third, we have identified that though employees experienced workplace cyber incivility, their personality traits guide them for their behaviours. Hence, practitioners can recruit employees who are rich in personality characteristics and ethics. Last but not least ample employee engagement programs and knowledge management would help to encourage KSB among employees.

## VII. LIMITATIONS, FUTURE RESEARCH, AND CONCLUSION

Several limitations of this study need to be addressed; we have measured KSB and workplace cyber incivility based on a measurement scale which is mental constructs. Therefore, there can be the possibility of occurring common method bias, we have addressed this using different scales to measure the constructs (Podsakoff, et al., 2003). Moreover, the reason for optimum discriminant validity could be the contextual differences; these measurements were developed in a western context. There are many research avenues for future researchers. First, we have conducted our study on cross-sectional nature which lacks in-depth exploration. Therefore, these constructs can be used to identify in-depth barriers for KSB among employees. Second, longitudinal studies may help to identify employee KSB. Last but not least it is better to identify the most significant personality trait which encourages KSB and identify moderating variables such as gender, generational differences, and educational level.

In conclusion, knowledge-sharing behaviour is critical for organizational survival and competitive advantage. However, negatives feelings and experiences may hinder employee knowledge-sharing behaviours. Therefore, this study attempted to identify the negative relationship between workplace cyber incivility and KSB via the mediating role of personality traits including Extraversion, Agreeableness, Conscientiousness, Neuroticism, Openness to

experience. The findings demonstrated that perceived workplace cyber incivility practices can negatively be impacted not only for employees but also for teams and organizations; if employees reluctant to share knowledge among others. Consequently, addressing and mitigating workplace cyber incivility behaviours could be an antidote for hindrances of knowledge. We believe that this study will stimulate the discernable views of researchers and practitioners to give more attention to deliberate less-severe detrimental cyber behaviours in organizations and KSB.

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# Comparison of Machine Learning Classifiers for Sentiment Analysis in Hotel Reviews

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**Abstract**—Sentiment analysis or opinion mining refers to the process of identifying people's sentiments, opinions, attitudes and emotions behind a written text. In recent years, sentiment analysis studies have become an active research area under natural language processing. Understanding the opinion behind the user-generated text can be applied to various applications. When it comes to the hotel sector and travel planning, user reviews and comments are quite useful. Therefore, guest reviews are becoming a prominent factor, which influence people's booking decisions. In addition, knowing about these comments is important for quality control of the hotel management too, because it may be worth checking out some stats over time. The fundamental objective of this research is to compare several machine learning classifiers and find out the best classifiers to develop a sentiment analysis model for the hotel reviews, to tackle customers' sentiment. Under this research, a comparative analysis was established among Multinomial Naïve Bayes (MNB), Bernoulli Naïve Bayes (BNB), Logistic Regression (LR), Stochastic Gradient Descent Classifier (SGD), Linear Support Vector Classifier (SVC), Random Forest Classifier and Multi-layer Perceptron Classifier (MLP) classifiers. Moreover, two feature extraction techniques called Count Vectorizer and Term Frequency Inverse Document (TF-IDF) are also compared to find out the best approach to perform the feature extraction. The result from this research shows that the highest results were obtained in Logistic Regression with TF-IDF method (Accuracy 87.39%) and SGD algorithms with TF-IDF (Accuracy 87.71%), while the lowest accuracy was obtained for Bernoulli NB classifier with Count Vectorizer (Accuracy 64.67%). Every time when using Count Vectorizer as the feature extraction method, the accuracies decreased, than when the TF-IDF method was used.

**Keywords:** *sentiment analysis, machine learning classifiers, feature extraction techniques*

## I. INTRODUCTION

With the rapid development of the internet and smart mobile devices, E-Commerce and social media have already penetrated everyone's daily life. Owing to that, Users are now able to freely express their opinion about a variety of products and services, by generating reviews, comments, and reports. According to recent estimates, more than 2.5 quintillion (10<sup>18</sup>) bytes of data are generated daily, while by 2020 1.7 MB of data will be created for each person on earth per second.

The tourism industry leads a crucial role in the economical side of each country around the world. Therefore, travel planning, hotel, and restaurant websites are frequently used by tourists before making their selection. Since these websites contain the bulk of opinions from previous customers, selecting a hotel or a restaurant from thousands of opinions is an overwhelming task. As a result, nowadays people tend to rely on online reviews, to take advantage of the experiences of others. User comments have become a critical and influential source for decision-making. User comments are not just useful for other users but also the business owners who can improve the quality and innovation of their business services and devise innovative marketing strategies. When it comes to the hotel field these users' opinions or reviews are very much useful to tourists to select the best place to stay as well as hotel managers to assess the quality of the hotels.

Sentiment analysis, which is the most popular decedent application of Natural Language Processing (NLP) has been successfully used to analyses user's generated reviews. NLP gives machines the ability to read, understand, and derive meaning from human languages. When it comes to sentiment analysis, it adopts a text analysis technique of NLP to identify the attitude of the text writer. As a result, this technique is mostly used in the business field to identify customer sentiment toward products, brands, or services in online conversations and feedback to identify their opinion and feelings.

The properly constructed sentiment analysis systems can eliminate the need for surveys and change the way traditional market research is conducted. It is because, without consuming so much time, the constructed sentiment analysis system can be used to summarize and identify the sentiment of all feedback comments. Various methods can be used as model sentiment analysis, including Neural Network, Support Vector Machine, Naïve Bayes, Decision Tree, and others. Among these methods, a proper accurate method that is compatible with the data set and the given case scenario should be selected to train the sentiment classification model.

So, this research aimed at developing a Sentiment Analysis model to identify customer satisfaction over the reviews on the hotel industry and conducting a comparative study on different machine learning algorithms and feature extraction techniques. The paper is organized as follows, Related Works in Section II, Methodology and Experimental Design in section III, Results in section IV, Discussion and Conclusion in section V, Future Works in section VI and finally the References.

## II. RELATED WORKS

### A. Pre-Processing and feature extraction techniques

As the initial step in Sentiment Analysis, all the reviews in the dataset must be labelled. Labelling the text data, whether it is positive, negative, or neutral also plays a significant role in the sentiment analysis domain. For that most researchers used labelling based on intuition and labelling based on sentiment polarity. Since

labelling based on intuition differs from the user perception, labelling based on sentiment polarity has shown effective results rather than human intervention labelling ( Zvarevashe et al., 2018).

Secondly, the labelled dataset must be cleaned, for that most researchers have used the following phases. Removing emoji, numbers and remain only the text with letters, White space removal, tokenization, removal of stop words, stemming, and lemmatization (Ghosh et al.,2017; Symeonidis et al., 2018; Kasper et al., 2011).

As the last last step under the pre-processing stage, feature extraction needs to be performed. For that purpose, in one of research ((Ghosh et al.,2017), different feature's weights for a feature set were discussed, Feature Presence (if the feature appears on the text –1 if not –0), Feature Frequency (Number of times feature occurs in the document), Term Frequency Inverse Document (Evaluate how important a word is to a document). With referring to feature extraction techniques, rather than using only the frequency of the words, the usage of the TF-IDF method resulted to be more effective since it considered the importance of the word as well as its frequency (Shi and Li,2011). Another research has used a technique called CountVectorizer (Tripathy et al.,2015) for converting features into a numerical representation. There, it transforms the review into a token count matrix.TF-IDF transformation, mostly used for machine learning classifiers such as Logistic Regression, Bernoulli Naïve Bayes, and Linear SVC. For Neural Networks, the feature-learning method called word embedding was used.

### B. Machine Learning Classifiers

After conducting the pre-processing and feature extraction of the given text dataset, then the sentiment classification model should be built. In consideration of that, most of the existing studies, which have been conducted under the sentiment analysis domain, used machine learning classifiers. The most used machine classifiers were Naive Bayes, SVM, Logistic Regression, and Decision Tree. Among these classifiers, some of them used just only one from them and some of them have used two or three out of them to have a comparison of each other (Farisi et al.,2019; Yordanova et al.,2017; Bhargav et al.,2019; Nohn et al.,201; Patel et al.,2020).

As a summary, most of the researchers have used Naive Bayes, SVM (Support Vector Machine) and logistic regression, Stochastic Gradient Decendent, and Decision tree machine learning classifiers. Among them, Naive Bayes, SVM classifiers were performed as out fliers by giving more accurate prediction models. When comparing different classifier's results, in sentiment analysis other than the accuracy it also evaluates their result based on precision and recall value measurements too.

### III. METHODOLOGY AND EXPERIMENTAL DESIGN

The proposed system workflow shows in the following Figure 1. The main phases of the system workflow as follows, Collection of Hotel Reviews, Review Preprocessing, Feature Extraction, Model training with Machine Learning algorithms, Selecting the best machine learning algorithm which gives the highest accuracy to train the final sentiment analysis model.

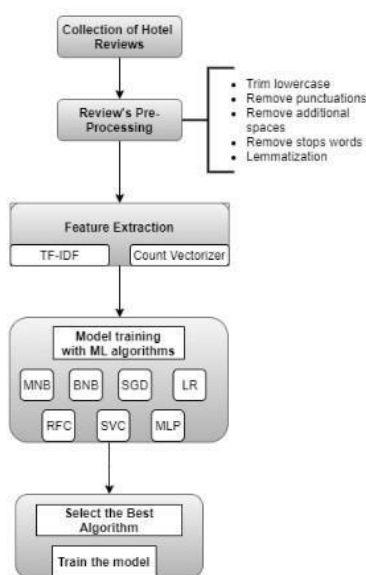


Figure 1. System Workflow

#### A. Dataset

The Data Set was collected from the Kaggle website (Sharma,2017). And it included around 40000 hotel reviews under 5 columns. Only the review and the satisfaction column were considered throughout this research. In the initial dataset there were 26521 positive reviews and 12411 negative reviews. Therefore, we had

to balance it before applying it to train the prediction model.

B. Pre-processing and Feature extraction the following Figure 2 depicts the main steps performed under the pre-processing stage. In sentiment analysis, the main intention of doing pre-processing is to remove all the unnecessary wordings and symbols from the reviews and to remain only the words that are important to identify the sentiment of a review. Therefore, under this research in the basic pre-processing section, two functions were used.

Within the first function initially, the whole review texts were converted into lowercase letters, and then the square bracket, numbers, and punctuation were removed. And that pre-processed reviews were again sent through a second function where it removed additional spaces, newline characters, and only remained the words with English letters. Basic pre-processing functions were performed using Regular Expressions. For that built-in package in python called "re" was used.

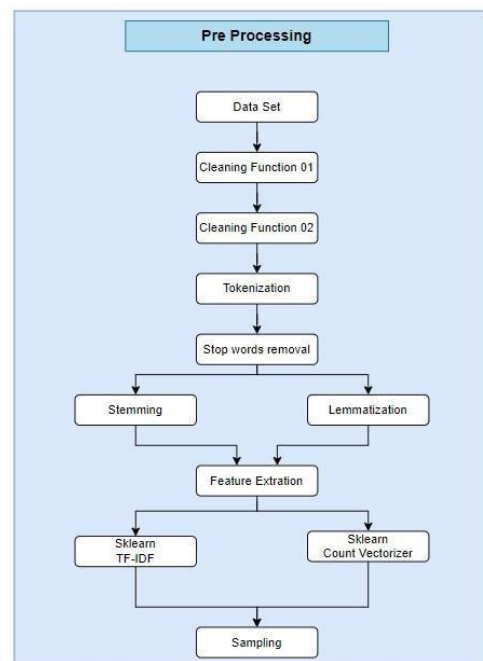


Figure 2. Pre-Processing Workflow

After doing basic pre-processing functions then to easier to filter out unnecessary tokens, the tokenization was performed. Before transforming text into vectors using nltk.word\_tokenize the text was converted into

tokens. In this case, the reviews were tokenized into words.

Thereafter the stop words were removed from the token set using `nlk.corpus.stopwords.words` method. The Stop words were removed because they do not add much information in the overall modelling procedure. When it comes to sentiment analysis by removing stops from the given text, it can focus more on words that add some value to the meaning of the text.

Afterward either stemming or lemmatization was performed to achieve the root forms of inflected words. In this study, both stemming, and lemmatization were tried out to see which method is more appropriate for the sentiment analysis. Stemming is different from lemmatization in the approach since it uses to produce root forms of words and the word produced. Lemmatization always gives the dictionary meaning word while converting into root form.

In this research, the WordNet lexicon database was used for lemmatization purposes.

Afterward, then the next step is feature extraction. The main intention of feature extraction was before giving the input to the training model it must be converted into numbers. Since machines do not understand the meaning of the text, it needed to be transformed in a way that machines can interpret it. Therefore, the reviews were transformed in the form of vectors. This helps to increase the accuracy of learned models by extracting features from the input data. This phase of the general framework reduces the dimensionality of data by removing redundant data.

To do that in this research two techniques were tried out. One is Word Frequency Indexing using Sklearn `CountVectorizer`, Word Frequency Indexing using Sklearn `Term Frequency Inverse Document`. Both `CounterVectorizer` and `TF-IDF` methods were used before training the model with different machine learning algorithms. When it comes to `CountVectorizer` it considers the count of each word in reviews. In the `TF-IDF` method, it considers the value count of words

with the importance of each word within the whole word Corpus.

### *C. Model Training with Machine Learning Algorithms*

The dataset which was used was not a balanced one therefore before training the model with machine learning algorithms, the dataset was balanced using a method called oversampling.

And with the oversampling method, generates synthetic data that tries to randomly generate a sample of the attributes from observations in the minority class. To do that we have used a common technique called SMOTE (Synthetic Minority Over-sampling Technique). And it generated a result dataset with (Positive Reviews, 21234), (Negative Reviews, 21234), which was a balanced one.

When it comes to the training process 80% of the dataset was allocated for training purposes and 20% of the data set was allocated for testing purposes. After doing the sampling then the models were trained using different machine learning algorithms.

SGD Classifier and Logistic Regression were imported from `sklearn.linear_model` library. `MultinomialNB` and `BernoulliNB` were imported from `sklearn.naive_bayes` Library. `Linear SVC` was imported from `sklearn.SVM`, `MLP Classifier` was imported from `sklearn.neural_network` and `Random Forest Classifier` was imported from `sklearn. Ensemble`. Using these different algorithms different prediction models were built. While training the model the four parameters were recorded to select the best machine learning algorithm. They were Accuracy, Precision, Recall Score, F1 Score, and finally the confusion matrix. These statistics were calculated using `sklearn.metrics` module.

Following equations show how the calculations were performed in each parameter which we have discussed earlier.

Accuracy simply means the ratio of correctly predicted observations.

$$\text{Accuracy} = \frac{\text{True Positive} + \text{True Negative}}{\text{True Positive} + \text{False Positive} + \text{False Negative} + \text{True Negative}}$$

Precision means the ratio of correctly predicted positive observations to the total predicted positive observations.

$$\text{Precision} = \frac{\text{True Positive}}{\text{True Positive} + \text{False Positive}}$$

Recall is the ratio of correctly predicted positive observations to all observations in actual positive cases.

$$\text{Recall} = \frac{\text{True Positive}}{\text{True Positive} + \text{False Negative}}$$

F1 score means the average of precision and recall. Since here we are dealing with an uneven class distribution, the F1 score also needs to consider, when selecting the best machine learning classifier.

$$\text{F1 Score} = \frac{2 * (\text{Recall} * \text{Precision})}{(\text{Recall} + \text{Precision})}$$

#### IV. RESULTS

The following Table I shows the result obtained after using different classifiers. The result shows that the accuracy was higher when using the TF-IDF method as the feature extraction technique rather than using the CountVectorizer method. It is because in TF-IDF method considered the overall document weightage of words. The meaning of it is, it takes into consideration how often the word appears in the document plus how often the word appears across all documents in the data set. But in CountVectorizer method only consider the frequency of the word count within each review. Following Figure 3 shows the matrix of CountVectorizer and Figure 4 shows the matrix of the TF-IDF method.

	also	area	around	away	back	bar	bathroom	bed	best	better	bit	block	breakfast	business	car	c
0	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
1	0	0	1	0	0	0	0	0	0	0	0	0	0	2	1	0
2	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0
3	0	2	0	0	1	0	1	1	0	0	0	0	1	0	1	0
4	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0
5	1	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0
6	0	0	0	0	1	1	1	1	2	0	1	0	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	1	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0

Figure 3. Count Vectorizer Matrix

	also	area	around	away	back	bar	bathroom	bed	best	better
0	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.175662	0.150741	0.000000	0.000000
4	0.000000	0.316641	0.000000	0.000000	0.166753	0.000000	0.000000	0.000000	0.195049	0.000000
5	0.000000	0.206784	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
6	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
7	0.000000	0.000000	0.204025	0.000000	0.000000	0.000000	0.000000	0.000000	0.218039	0.000000
8	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.441796	0.000000	0.000000
9	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Figure 4. TF-IDF Matrix

When it comes to machine learning algorithms, the highest accuracy result and correct confusion matrix were given when using the SGD classifier and Logistic Regression with the TF-IDF method. The lowest accuracy was given when using the BernoulliNB with both the CountVectorizer method and TF-IDF method.

Table 1. Result Table

	CountVectorizer	Term Frequency Inverse Document
<b>Multinomial_NB</b>	Accuracy:86.68 % Precision Score:90.82 Recall Score:89.51 F1 Score:90.16 Confusion Matrix: [[1999 480] [557 4751]]	Accuracy:85.44 % Precision Score:90.64 Recall Score:87.63 F1 Score:89.11 Confusion Matrix: [[2015 479] [655 4638]]
<b>Bernoulli_NB</b>	Accuracy:64.67 % Precision Score:75.44 Recall Score:71.36 F1 Score:73.35 Confusion Matrix: [[1251 1232] [1519 3785]]	Accuracy:74.07 % Precision Score:78.02 Recall Score:86.64 F1 Score:82.11 Confusion Matrix: 1136 1305] [ 714 4632]]
<b>Logistic Regression</b>	Accuracy:84.51 % Precision Score:89.84 Recall Score:87.06 F1 Score:88.43	Accuracy:87.39 % Precision Score:92.62 Recall Score:89.00 F1 Score:90.77



	Confusion Matrix: [[1972 521] [685 4609 ]]	Confusion Matrix: [[2140 374] [580 4693]]
<b>SGD Classifier</b>	Accuracy:85.40 % Precision Score:90.42 Recall Score:88.03 F1 Score:89.21 Confusion Matrix: [[1950 498] [639 4700]]	Accuracy:87.71 % Precision Score:92.64 Recall Score:89.40 F1 Score:90.99 Confusion Matrix: [[2177 372] [555 4683]]
<b>Linear SVC</b>	Accuracy:82.05 % Precision Score:87.99 Recall Score:85.16 F1 Score:86.56	Accuracy:85.96 % Precision Score:90.79 Recall Score:88.38 F1 Score:89.57
	Confusion Matrix: [[1889 614] [784 4500]]	Confusion Matrix: [[2001 476] [617 4693]]
<b>Random Forest Classifier</b>	Accuracy:80.44 % Precision Score:79.29 Recall Score:96.10 F1 Score:86.89 Confusion Matrix: [[1217 1318] [205 5047]]	Accuracy:83.34 % Precision Score:86.50 Recall Score:89.60 F1 Score:88.02 Confusion Matrix: [[1724 744] [553 4766 ]]
<b>MLP Classifier</b>	Accuracy:84.51 % Precision Score:88.57 Recall Score:88.71 F1 Score:88.64 Confusion Matrix: [[1832 612] [603 4740 ]]	Accuracy:85.90 % Precision Score:88.28 Recall Score:87.36 F1 Score:87.82 Confusion Matrix: [[1811 621] [677 4678]]

As per the results, the highest accuracy (87.71%) was obtained by the SGD Classifier when using the TF-IDF method for feature extraction. Not only for the accuracy, for the other three parameter also had the highest scores for the SGD classifier with the TF-IDF.

## V. DISCUSSTION AND CONCLUSION

According to the result obtained from this research, it is shown that in feature extraction, when the TF-IDF method is used, the accuracies of all classification algorithms were higher than the Count Vectorization method. Since the TF-IDF method considers the overall document weightage of the words, it gave higher accuracy for the sentiment analysis.

Among these, all classifiers Logistic Regression and SGD Classifier were outperformed rather than other classifiers. And the Bernoulli\_NB classifier was the worst classifier to be used for the sentiment analysis.

In conclusion, to enhance the accuracy of the sentiment identification model initially the reviews had to be preprocessed to remove unnecessary words, symbols and to remain only the important words. And for the feature extraction, it is good to use the TF-IDF method rather than using other methods. For sentiment analysis, the Bernoulli\_NB classifier was not good enough and the Logistic Regression and SGD Classifier performs best and gave better results.

## VI. FUTURE WORKS

In this research, several most used classifiers were tried out to find the best classifier among them. So, in the future, other classifiers also can be tried out to find the best one. Furthermore, other feature extraction methods also can be tried out to find the best approach. The proposed system works only for the English language; therefore, this can be enhanced to identify any language text's sentiment. Therefore, it could be useful for identifying the sentiment of reviews that are written in Sinhala and that could be very much useful in the Sri Lankan context. Here for convenience, we have removed the emoji at the very beginning during the pre-processing. But the emoji's also play a significant role to identify the sentiment of a text, so that feature also can be

added to identify the sentiment of the emoji as well. And in the future, it is expected to build a useful application for the hotel domain using this proposed sentiment analysis model.

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# An Experimental Study on Computer-Based Virtual Classroom Learning, and Its Impact on Student Performance Based on Sri Lankan University Students

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**Abstract** - Virtual Reality (VR)-based platforms have the potential to bridge the existing gap between educationalists and students. Computer-based simulators have the ability of Virtual Reality (VR), and it has a potential to take learning beyond the traditional online teaching-learning experience of educationalists and students together in the same room with the aid of online learning tools. VR-based educational applications were introduced to the market recently with the advancements and rapid growth of the pandemic to face 'new normal' ethics. VR-based simulators allow students to visualize or immerse the concepts taught in classroom textbooks, whether the student is at home, the library or anywhere in the world. In the global framework, many student learning reforms are initiated. However, modern VR learning delivery technologies, VR training methods, and gamification technologies are not yet addressed in Sri Lanka. Further, VR technology's influence on student performance is not profoundly studied in the Sri Lankan university context. Therefore, it is important to conduct an experimental study to find the student's mental behaviour, especially with the academic performance in the virtual paradigm. The research was developed via quantitative research techniques as a pre-post experimental study to achieve the research objectives with Quantitative data collection methods. Further, descriptive statistical analysis approach based on paired t-test analysis method was used and data analysis was done via IBM SPSS statistical tool. The main variables identified as Knowledge of Structures, Feedback, Mental Models and the conceptual framework were designed based on literature for the t-test. As pre-test, students were given a questionnaire to fill before the

simulator training treatment. The questionnaire was designed based on available literature, while there were three-hypotheses based on the variables. The chosen VR learning platform was 'Unimersiv' ancient Rome visit for the students, and that lesson gives a great knowledge on ancient history. After the simulator learning, the same set of students was given the post-test questionnaire to fill. Significant correlation analysis proved that there is a positive and direct effect of each independent variable mentioned above.

**Keywords:** *virtual reality, learning, simulators, experimental study*

## I. INTRODUCTION

Transfer of information or knowledge has been a priority for civilizations since the beginning. From ancient history to today education is the basement for society, and People are constantly looking for ways to make knowledge transfer more easily, more quickly, and more effectively (Alexander, Westhoven and Conradi, 2016). Universities have always first innovated cutting edge of new technologies and tools, driving or directing students on development and preparing the next generation of developers, scientists and entrepreneurs. Virtual and augmented reality technologies are at the frontier of development right now (Connable et al., 2019).; the market is forecast to reach \$13.9 billion in 2017 (IDC), and change is happening at a frenetic pace. Virtual Reality (VR) has the potential to transform the way we learn and teach, from providing in-depth knowledge and helping us understand complex subjects to facilitating language immersion and virtual trips (Fletcher, 2009).. It's already widely used in global schools for younger children, but we're

seeing its use more and more in higher education for a variety of reasons, including its ability to enhance learning and help with student recruitment.

In 2021, VR technology using in higher education is not a new or unknown practice. Most of the tutors in universities, business schools and colleges who are already taking full advantage of the VR technology in teaching with illustrating practical and theoretical aspects (Osman, 2018). Virtual Reality (VR) based platforms have the potential to bridge the existing gap between educationalists and students. Computer based simulators have the ability of Virtual reality (VR) has potential to take learning beyond the traditional online learning experience of educationalists and students together in the same room with the aid of online learning tools. VR based educational applications were introduced to the market recently with the advancements and rapid growth of the pandemic to face the 'new normal' ethics. VR based simulators allow students to visualize or immersive the concepts taught in classroom textbooks, whether the student is at the home library or anywhere in the world. In the global framework, many student learning reforms are initiated. However, modern VR learning delivery technologies, VR training methods, gamification technologies are not yet addressed in Sri Lanka.

#### A. Research Problem

A key advantage of exploitation VR in education is that students learn through experience. VR permits to bring 2D objects to real life and makes visualization via a reality, enabling students to experience the theories practically. Practical consequences are vast, as VR technology opens new traditions to absorb skills that are difficult to teach.

As per the literature, in the beginning, VR is used in higher education to train students' soft skills. Virtual Speech is being used by universities around the world to improve communication skills essential for employment after graduation. These mentioned skills require representative practice, which is terrible to achieve constantly with the traditional or online teaching methods (Shinn and Habedank, 1992). In the global framework, many student learning reforms are initiated. However, modern VR learning delivery

technologies, VR training methods, gamification technologies are not yet addressed in Sri Lanka. Further, VR technology's influence on student performance is not profoundly studied in the Sri Lankan university context. Therefore, it is important to conduct an experimental study to find the student's mental behavioural especially with the academic performance in the virtual paradigm.

#### B. Objective

To identify the impact of the simulator-based VR learning on the key factors of academic performance (Knowledge of Structures, Feedback ability & Mental Models) of the Sri Lanka university students.

## II. METHODOLOGY

The research was developed via quantitative research techniques as a pre-post experimental study to achieve the research objectives with Quantitative data collection methods. Further descriptive statistical analysis approach based on paired t-test analysis method used and the data analysis done via the IBM SPSS statistical tool. The main variables identified as Knowledge of Structures, Student Feedback, Mental Models, and the conceptual framework designed based on literature for the t-test.

#### A. Independent Variables

- 1) Knowledge of Structures.
- 2) Student Feedback.
- 3) Mental Models.

#### B. Dependent Variable

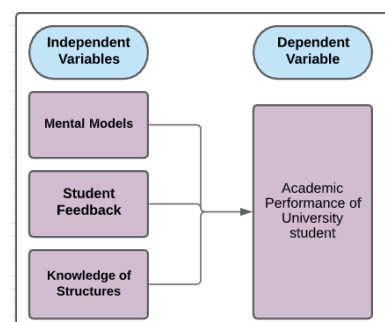


Figure 1. Conceptual Framework

Source: Authors

#### C. Hypothesis

Formulated hypotheses based on independent variables are as follows:

**Hypothesis One.** Hypothesis one is as follows:

- 1) H1a: There is a difference in mean values (impact in individual performance) of pre and post VR learning platform tests on their knowledge of Structures.
- 2) H1o: There is no difference in mean values (impact in individual performance) of pre and post VR learning platform tests on their Knowledge of Structures.

**Hypothesis Two.** Hypothesis two is as follows:

- 3) H2a: There is a difference in mean values (impact in individual performance) of pre and post VR learning platform tests on the Student Feedback.
- 4) H2o: There is a difference in mean values (impact in individual performance) of pre and post VR learning platform tests on the Student Feedback.

**Hypothesis Three.** Hypothesis three is as follows:

- 5) H3a: There is a difference in mean values (impact in individual performance) of pre and post VR learning platform tests on the Mental Models.
- 6) H3o: There is no difference in mean values (impact in individual performance) of pre and post VR learning platform tests on the Mental Models.

#### D. Population

The study was focused on the state of the academic performance of the students after exposure to the modern virtual learning platform. It was highly arguable to select an effective sample population that result in justifiable and generalizable findings to the Sri Lanka university system. Therefore, the researcher selected the government university students in the 2nd year due to the importance of the academic performance was understand by them in the 2nd year of student life as well as its influence over the entire degree program. The size of the population of Sri Lanka government university was approximately 39400(Sri Lanka University Statistics, 2020) during the time of the study.

#### E. Sample

The G power 3.1.9.2 program was used to calculate the sample size from the given population. The effect size (d) was set to 0.89 based on past studies on meditation conducted by researchers (Lee and Kang, 2020), the sample size of 385 Based on a priori power analysis by G\*Power, Using the parameters of Confidence Level in 95% Confidence Interval 5% Population consider as the number of adults in Sri Lanka, the minimal total sample size was 96 for one group pre and post paired t-test.

### III. RESULTS AND ANALYSIS

#### A. Descriptive Analysis of Gender and Age Factors of the Individuals.

The research was conducted with 96 university students in 6 universities in Sri Lanka. The participants were all under the age of 25 at the time of conducting the research.

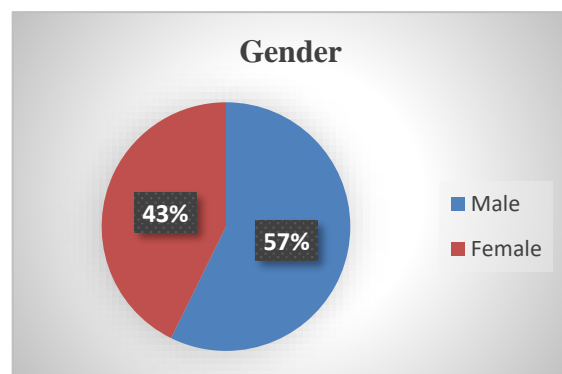


Figure 2. Gender  
Source: Advanced Excel - Authors

Results on Questions Categories into main 3 sections. Survey results on question 'A' category to describe the variable of Individual skills/Competence. This category describes the self-estimation level of the skills of each participant which is related to Knowledge of Structures. They have gone through the traditional learning method in pre-test and VR



based learning platform in the post-test and answered the questions in section A which is related Structure of different knowledge levels they experienced with VR platform and traditional methods.

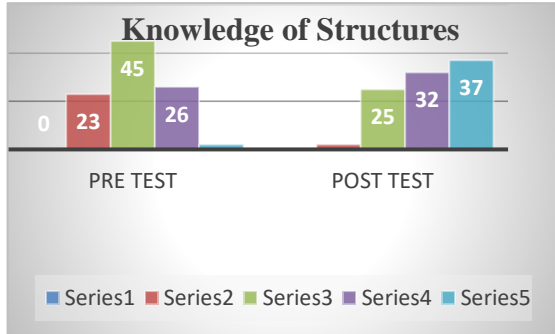


Figure 2. Knowledge of Structures  
Source: Advanced Excel – Authors

'B' category to describe the variable of Student feedback relevant to the individual performance by the series of questions after the pre and post-test which related to individual readiness to mentality to learn new things and feedbacks related to the performance estimated by themselves.

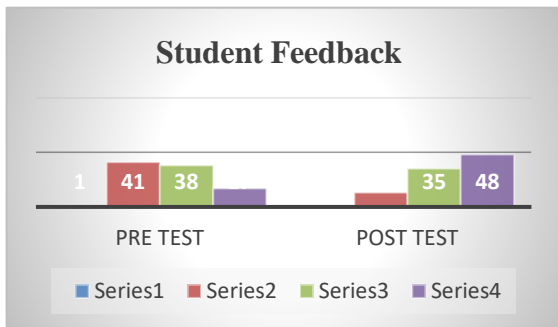


Figure 3. Student Feedback  
Source: Advanced Excel – Authors

Results on Question 'C' Category is mainly designed to describe the variable of Mental models for complete the learning tasks accomplishment. By analysing the survey results, there should be a clear understanding of the individuals' Mental models rather than the physical state and their readiness to complete the given learning task accomplishment.

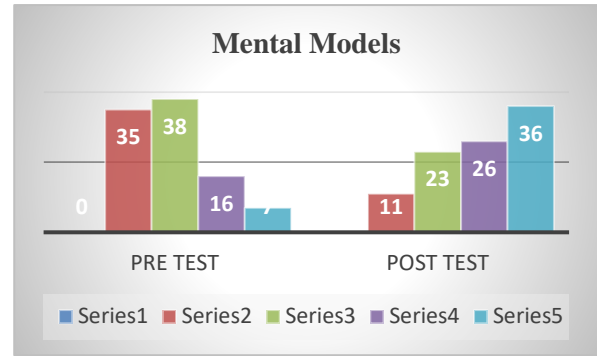


Figure 4. Mental Models

Source: Advanced Excel – Authors

#### IV. DATA ANALYSIS AND DISCUSSION

##### A. Correlations Test Results Between Variables

Table 1. Correlations Test Results Between Variables.

		Knowledge of Structures	Student Feedback	Mental Models
(a)		(b)	(c)	(d)
Mental Models	Pearson Correlation	1	.643**	.862**
	Sig. (2-tailed)		.000	.000
	N	96	96	96
Student Feedback	Pearson Correlation	.643**	1	.592**
	Sig. (2-tailed)	.000		.000
	N	96	96	96
Knowledge of Structures	Pearson Correlation	.862**	.592**	1
	Sig. (2-tailed)	.000	.000	
	N	96	96	96

\*\* . Correlation is significant at the 0.01 level (2-tailed).

Source: SPSS – Authors

The results show that correlation is significant at the 0.01 level. Correlations test results between

variables show a greater than .5 for each compared variable.

This correlation is significantly performed to justify the validity and reliability of selected three variable factors. The result indicates that there is a significant level of correlation between all variables. Correlations test result between, Mental Models, Student Feedback and Knowledge of Structures variables are 0.862, 0.643 and 0.592 respectively, which indicated a strong relationship between the level of integration and other variables. The highest value of Pearson Correlation, which is indicated as 0.862 in Mental Models that has a strong relationship with the dependent variable of academic performance of students.

1) *Impact on Mental Models over the academic performance of students.*

Pre-post Test Paired Samples Statistics of Mental Models over the academic performance.

Table 2. Pre-post Test Paired Samples Statistics.

		Mean	N	Std. Deviation	Std. Error Mean
(a)		(b)	(c)	(d)	(e)
Pair 1	Pre-Test - Mental Models	15.84	96	1.951	.350
	Post Test - Mental Models	20.26	96	3.715	.667

Source: SPSS – Authors

The observed difference between pre and post-test is 0.317. The standard error gives the accuracy of a sample mean by measuring the sample-to-sample variability of the sample means.

Table 3. T-test Analysis Results on the Impact Mental Models over the State of academic performance.

		Paired Differences				t	df	Sig. (2-tailed)	
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower				Upper
(a)		(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
Pair 1	Pre-Test - Mental Models	-4.419	3.922	.704	-5.858	-2.981	-6.273	30	.000

Source: SPSS - Authors

Pre-test results of individuals without VR simulators and post-test after exposure to VR simulators indicate in the table above. According to the paired T-test that indicates that Hypothesis H1a is supported with  $p < 0.05$  level. T-value = - 6.273. That is, there was a significant interaction between mental models individuals after exposure to VR simulators. At the Significance level at the  $P < .05$  these results show the Null hypothesis gets rejected since  $t = - 6.273$  and  $p < 0.05$  and there is an impact on VR Environment training.

2) *Impact on Student Feedback on the academic performance of students.*

Pre-post Test Paired Samples Statistics of Impact of the Student Feedback over the academic performance.

Table 4. Pre-post Test Paired Samples Statistics.

		Mean	N	Std. Deviation	Std. Error Mean
(a)		(b)	(c)	(d)	(e)
Pair 1	Pre-Test - Student Feedback	16.26	96	2.816	.506
	Post Test - Student Feedback	20.87	96	3.452	.620

The observed difference between pre and post-test is 0.114. The standard error gives the accuracy of a sample mean by measuring the sample-to-sample variability of the sample means. Paired Sample T-test Analysis Results on Impact of the Student Feedback over the academic performance.

Table 5. Analysis Results on the - Student Feedback over the State of academic performance.

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error	95% Confidence Interval of the Difference				
				Lower	Upper			
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
Paired Sample 1 - Student Feedback Pre Test - Post Test	4.613	4.688	.842	6.333	2.8938	5.47	30	.000

Source: SPSS - Authors

According to the results of the paired T-test that indicate that Hypothesis 1 is supported with  $p < 0.05$  level. T-value = - 5.478 That is, there was a significant interaction of improving Student Feedback after exposing to the VR based learning platform.

3) *Impact on Knowledge of Structures over the academic performance of students.*

Pre-post-test Paired Samples Statistics of Knowledge of Structures over the academic performance.

Table 6. Pre-post Test Paired Samples Statistics.

	Mean	N	Std. Deviation	Std. Error Mean
(a)	(b)	(c)	(d)	(e)
Pre Test - Knowledge of Structures	16.55	96	2.514	.452
Post Test - Knowledge of Structures	21.10	96	3.902	.701

Source: SPSS - Authors

	Mean	N	Std. Deviation	Std. Error Mean
(a)	(b)	(c)	(d)	(e)
Pre Test - Knowledge of Structures	16.55	96	2.514	.452
Post Test - Knowledge of Structures	21.10	96	3.902	.701

The observed difference of pre and post-test is 0.25 Standard error gives the accuracy of a sample mean by measuring the sample-to-sample variability of the sample means. T-test Analysis Results on the Knowledge of Structures over the academic performance.

Table 7. Analysis Results on the Knowledge of Structures over the State of academic performance.

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error	95% Confidence Interval of the Difference				
				Lower	Upper			
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
Paired Sample 1 - Knowledge of Structures Pre Test - Post Test	4.548	4.718	.847	6.279	2.818	5.368	30	.000

Source: SPSS - Authors

Null hypothesis was rejected and the H3a is significantly proved as the difference in mean values of pre and post VR Environment test on their Knowledge of Structures in the t value of - 5.368.

The research goal is to conduct an experimental study about computer-based virtual classroom learning methods and their impact on the study performance of selected university students in Sri Lanka. Study about existing university facilities in Sri Lanka and get an idea about the

impact and ideas to improve VR-based new classroom concepts in Sri Lankan universities in the future. This study supposes practical to evaluate the overall impact and power of digital VR systems related to the university system. The future benefits to the educational industry and facility that estimates to achieve within Sri Lanka were emphasized with the above statistical figures in the Pre and post-test experimental details. The improvements of the current Sri Lankan university educational systems as an entity or educational department could be gain attributed to several renovations and combined with new VR-based digital makeovers with renovations based on the independent and dependant variables of research Mental Models, Student Feedback Knowledge of Structures. There was a comprehensive value indicate in the post-experimental test parallel to the Mental Models over the State of academic performance - 6.273, Impact on Student Feedback over the academic performance of students -5.478 and Impact on Knowledge of Structures over the academic performance of students 5.368. The most impacted variable identified as the mental model t-test value -6.273 where VR based learning platform gives visual, auditable, immersion study experience comparing to traditional learning method impact on the human brain.

## V. CONCLUSION

According to the quantitative results, the researcher identified that all selected factors have a significant correlation with each other. The significant correlation analysis proved that there is a positive and direct effect of each independent variable have a positive impact on the dependent variable of academic performance. All Null Therefore, the findings of this research proved the academic performance of Sri Lanka university students can be improved by exposing them to modern learning platforms using VR simulators to provide knowledge. Most significantly, this study output provides a baseline for indication to prove that VR is a more appropriate and modern technology for effective teaching on par with traditional teaching practicing in Sri Lanka. The most impacted variable identified as the mental state model t-test value -6.273 where VR-based learning platform gives visual, auditable, immersion study

experience comparing to traditional learning method impact on the human brain. Most significantly, this study results provide a baseline for evidence to prove that virtual reality is a more suitable and modern technology for effective learning in with traditional training programmes practising in Sri Lanka. Based on the survey result findings implementing VR based environment for university students has the potential to gain high-quality educational experience, team-spirited ability to enhance the leadership and soft skills need in the industries with high mental demand, performance to obtain a higher state of student performance. Comparing to traditional classroom learning programmes, students can involve in interactive live scenarios with a virtual study environment to build and increase their performance rather than an unrealistic traditional environment.

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# Implementation of Smart Pet Care Applications in an IoT Based Environment

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**Abstract** - The idea of Information Technology and machines has become a rising demand, leading to the concept of interconnection between humans and machines. This concept has adopted a negative impact on human lives and their well-being. Because of this negativity, people tend to adopt pets to get emotional support. Pets require extra care and it is not easy as it used to be with today's busy lifestyle. As a result, one of the significant challenges has been figuring out how to grow pets in a simple manner. The best solution for this kind of problem is to use new innovative technologies. For this matter, an IoT-based solution should be included. The question that led to this research was, "How to implement a Smart Pet care Application within a proper IoT based Environment?". Implementation of a smart pet care application that satisfies every requirement of petting would ensure greater comfort and peace of mind for pet owners. This paper discusses the characteristics and technologies of the latest smart Pet Care applications and proposes solutions that satisfy the current requirements of pet owners. Before implementing this smart pet care application, a study was performed to identify features and facilities of existing pet care applications using related research papers. This research explores the impact of the IoT concept on the potential of smart Pet Care applications across modern technologies to facilitate human contact with pets. The outcome is an IoT-based mobile application that satisfies users' requirements by analyzing data.

**Keywords:** *pet care, Internet of Things (IoT), smart pet care system, monitoring systems*

## I. INTRODUCTION

In this rapidly developing world, societies cultures and economics are becoming complicated day by day. As a result, every human being is dealing with some sort of problem in life.

As their demands increase, innovative citizens come up with solutions that solve these problems. Ninety-nine percent of these solutions are based on information technology, in which data is taken as input and processed into information, resulting in meaningful and useful outputs. These IT concepts have the ability to make the connection between humans and machines. Any innovation has the potential to make mankind's work easier, but it can also have a negative influence. In this situation, the connection between humans and technology has resulted in a distraction from the real world. It also leads to a strong attachment to their emotional needs. An experiment was carried out to uncover relevant strategies to aid with this problem, and one of the outcomes revealed that owning a pet is one of them.

Keeping a pet has been practised worldwide and taking good care of them is already part of our human culture. Every year, approximately 600,000 pets are adopted. Having a pet might provide emotional comfort, but it can also be a difficult experience. Many pet owners struggle with several major issues that can arise when adopting and caring for a pet. The best solution for this kind of technological problem is to use new innovative technologies. In this matter, IoT-based solution is one of the major solutions.

IoT means not only one technology, but all the systems used to create a wireless infrastructure that manages the data obtained from a lot of sensors. Therefore, in the 21st century, we should refer to IoT as a modern Internet notion. To make the IoT services more appealing to users, sensors are needed. However, the way to process the data collected from sensors is becoming essential. Therefore, the concerns about how we should capture sensor data and process the data compelled us to learn about the latest network and data processing architecture: cloud computing and big data.

With the ideas and innovations discussed earlier in our heads, we have begun to dream of new services quickly incorporated into our real lives. We are now going to reach a lot of people living with their dogs. And as lifestyle shifts, the number of single households is rising. And most single households, when they are away from home, require a way to deal with their dogs. While we find personal pet care facilities surrounding us, they take more resources and time for faith. Here we can see the potential for personal comfort that IoT services can offer. We need to think about verifying pet status with the owner's mobile and how to provide proper pet facilities to take care of pets and pet owners smartly.

## II. LITERATURE REVIEW

Utilizing the pet implementation of the capability of location-awareness and helping pet owners easily teach their pets about behavior and feeding management, several works have discussed the enhancement. The analysis displayed the great progress of the pet monitor device interested in the Internet of Things (IoT) ideas and satisfied the criteria of pet owners who were seeking jobs without any issues. That goal was to enable pet owners to automate simple things like monitoring and feed controls. Finally, they suggested that a SOAP-based web service mechanism is an ideal choice for managing various devices and devices in a home environment. Different sensors are used to monitor different pet activities, for example, an IR sensor to check if there is food available on the plate. An RFID tag used in the pet collar allows the pet to communicate its identity. The Arduino serves as a gateway for sending the collected data to cloud storage, where it may be retrieved and viewed via a cell phone number or other electronic devices. Because the entire network was wireless, no data loss was possible. Finally, the research suggested adding RTC to the feeder (Subaashri et al., 2017).

This research has suggested a new pet care system. Remote feeding, remote automatic defecation, CCTV service, and a smartphone app that could offer control information for the above services were the basic services of the proposed smart pet care system. The system can feed the pets while the owners are away, follow their whereabouts and status, and operate the defecation pad using the owners' smartphones.

In terms of IoT technology, the suggested system stands out since it uses sensors and wireless connectivity. As a result, the suggested system is not limited in terms of space or time if a wireless connection is available (Kim, 2016).

The cat is a clean animal free of najis but keeping one at home takes effort and attention. As a result, utilizing a webcam and a stepper motor coupled to a Raspberry Pi as the main controller, this study constructed a monitoring system for an automated cat feeder. With the webcam and ancon functions, the camera captured images (pictures or movies) stored on the Raspberry Pi. The stepper motor will switch the supply valve using a General-Purpose Input Output (GPIO) pin and a program on the Raspberry Pi. The Raspberry Pi is then connected to the internet and a cloud network, allowing remote device monitoring via a web browser or smartphone app. The overall function of the machine, either immediate or planned, as well as tracking images or videos around the food in the form of feeding the cat. Finally, it is proposed to upgrade the monitoring system used to feed cats using a high-resolution camera. In addition, the use of a large stepper motor makes the revolution more powerful and faster when feeding the cat (Anggraini et al., 2020).

Cyber-physical systems are a modern generation which, by several new methods, blends machine and physical capabilities and can communicate with individuals. This thesis explored the ability of technology for computing, connectivity, and regulation to strengthen human relationships with pets. Many experiments have sought to have a normal and informative approach to requesting facilities that they point out. Attractive technologies for the future are also present in the emerging pattern in combining pet control and CPS technology. This thesis introduces an intelligent method of pet care based on Internet definition. They suggested a mobility-aware algorithm to allow digital home technologies for pets, including an intelligent pet door and a pet feeder. Its documented deployment has demonstrated that conventional goods can transcend the limitations of the method and satisfy pets' needs (Own, 2012).

This research investigated the potential of the computer, connectivity, and control systems through the Internet of Things technology to facilitate human contact with pets. It could have a modern operating process, the underlying

vision behind the Internet of Things. The research presented the substantial change in the pet care infrastructure involved in the modern Internet of Things process and answered the requirements of owners who are out without a hitch for work. The proposed framework, including the smart pet door and pet food dish, is also based on smart home technologies. As a next move, they will attempt to bring into their setup the other pet grooming tools, including litter boxes, pet monitors, etc. This will satisfy the owners' varied desires as well as concerns of wellness, surveillance, and entertainment. Anything for dogs is protected (Own et al., 2013).

The VetCompass Australia service gathers clinical evidence from veterinary practices in real-time and collects it for questioning by researchers. It provides Australian academics with long-term, cost-effective access to authoritative data from hundreds of veterinarians around Australia and new prospects for international collaboration with comparable initiatives in the United Kingdom and elsewhere. There are three phases in VetCompass Australia. Next to the rollout of the VetCompass program to gather medicinal veterinary data from Australia. Secondly, coding platform creation and enrichment (data presentation). They were eventually developing a world-first, natural language processing (NLP) application real-time monitoring interface. Advances in the processing and exchange of information from various practices would enable veterinary practitioners to provide pet animals with dramatically improved standards of treatment, enhancing their quality of life (McGreevy et al., 2017).

In veterinary medicine, veterinarians believe there is a strong demand for mobile devices, and this technology would enable them to exercise more efficiently. In this report, a veterinarians' online survey took a sample and investigated whether they felt that using mobile devices would boost their use. The findings revealed that among veterinarians, mobile devices are popular and widespread. Veterinary software and other electronic technologies have been encouraged to increase the quality and delivery of clinical veterinary medicine by providing veterinarians with a greater understanding of mobile technology. While this study was able to assess mobile technologies' current use and attitudes, further research needs to be conducted to

determine which factors prevent full use of mobile technology. Finally, the biggest shortcoming they found was that veterinarians were aware of the options available and found more widely used technologies to improve the field (Andrews et al., 2015).

The Pet Care Framework, which is based on the Android program, was introduced in this post. The goal of this framework was to have a non-exhaustive way based on a smartphone application to care for your pet. The paper explains this system's architecture methods and practical elements. The system was developed by pet experts. This paper proposes designing a mobile application based on an Android system to provide a user-friendly way for people to pet and make money. However, in future experiments, they hope to add a new feature such as pet breed recognition and improve the application using other advanced methods to improve the project and use the tool to manipulate the application (Saswadkar, 2018).

As pet ownership increases every year so does the demand for higher quality pet grooming products. This has encouraged the growth of this sector of the Internet of Things (IoT) technology. Using IoT technologies, pet owners can monitor the activities and position of their pet, remotely monitor the welfare of their pet, or even interact with their pet. In the everyday lives of pet owners, all these smart pet care items play an important role. This study's major purpose is to activate an integrated system that includes the three basic elements that pet owners should be worried about whether they are busy or not. The pet food bowl, drink dispenser, and litter box are all included. With Arduino Uno boards and Wi-Fi modules, these three subsystems are connected to the local network. In addition, the information gathered by each sensor is processed and displayed on a smartphone app. Through a single interface, pet owners may access all information on their pet's food and water consumption, as well as the timing, duration, and frequency of excrement. In addition, the application also has a control feature enabled for pet owners to provide food anytime, anywhere. A general statistical diagram with the mentioned values is presented in the application and is updated from time to time (Chen and Elshakankiri, 2020).

Mobile innovations have a huge effect on our lives globally, helping end-users enable new forms of healthcare services with advanced

technology and rule-based expert systems. In particular, the availability of the more user-friendly Android OS-based interface and economical smartphones offer new possibilities for continuous monitoring of pets' health status, such as healthy dogs/cats, toxic ingestion, and ingestion. In health management and clinical practice, the recommended technologies also help to provide users with similar services addressed here are wide and important. The pet smartphone app should be used to stop pet disease attacks. We may contact the pet expert in case of an emergency by making an appointment online with this app. This app helps locate the closest hospital for dogs. This study addresses pet health issues based on mobile phones (Kumar et al., 2017).

In Filipino, pet ownership has become an interesting addition to life. With advancements in the Internet of Things (IoT) development, doing well with pets can be done remotely. Pets can be monitored through a mobile application using microcontrollers and sensors designed to connect to the internet. The researchers designed a remotely activated smart pet door, defecation cushion, food, and water dispenser in the developed system. This project also has the potential for commercial viability, especially in the urban lifestyle, compared to other ways to care for and monitor pets through pet facilities. The developed mobile application provides the virtual presence of pet owners by collecting information about the feeding schedule of pets, music activation with voice activation of pet parents, room temperature measurement and camera surveillance via a webcam. The mobile app has been successfully tested and proven effective in delivering what has been promised (Luayon et al., 2019).

Pet monitoring in smart cities is a challenging issue. The classic approach to identifying animal tracking methods, such as airbags, GPS, and RFID, has the disadvantage of providing full monitoring and tracking of pets. Such devices have many limitations and are very expensive. The massive improvement of the Internet of Things (IoT) in smart cities can be used to provide human control and interaction with pets using the Internet and its technologies. This paper presents an approach to video tracking pets to identify and categorize the object of interest using in-depth learning skills (Hammam et al., 2018).

It is almost difficult to provide full-time attention to the pet due to the demanding work life with most pet owners and not being able to share the caring assignment with others. This paper seeks to build an intelligent and collaborative method to resolve the distance between the pet and the pet owner to address the previously described dilemma. This study is based on the IoT idea using the Linux operating system and the Raspberry Pi board as a development tool. The suggested device provides the pet owner with a mobile program that can connect with the pet over the Internet in real-time. The user will use the vision module of the machine as a feed module to provide a view of their pet and monitor the servo motors of the handheld computer on the pet for feeding as an output module. They hope that this technology can be improved and used by pet owners for real-time contact with their remote pets in the future, where they can physically be in the same place (Shih et al., 2016).

### III. METHODOLOGY

The title of this research paper is "Implementation of Smart Pet Care Applications in an IoT based Environment" and the question that led to this study was "How to implement Smart Pet Care Applications within a proper IoT based Environment?" This research paper aims to analyze the features and usages of the technology of the current smart Pet Care applications. This study was performed using secondary data. A systematic approach was performed to gather data from published research studies on the Smart Pet Care Applications.

The following steps were used in the process of paper selection. At first, the related research was found according to keywords. Then both manual and automatic searches were performed to find the most suitable research. In the searching process, special attention was given to research found from ResearchGate, IEEE and ACM digital library. The next step was to eliminate duplicate research. Then read all the papers' abstracts and keywords. The study that was not linked to my research topic was then removed using the exclusion criteria. Finally, inclusion criteria were followed to select recent papers that can be applied to the study area.

As the next step, research papers were analyzed and summarized the findings from those papers in the tabular format. It is an easier method to represent the findings from the literature review. In this context, it helped to identify the Impact of the IoT concept on smart Pet Care applications over time, it thus allowed to suggest new possibilities for implementation of Smart pet care applications.

#### IV. ANALYSIS

Based on the literature review of research papers, these are some characteristics and technologies of the latest smart Pet Care applications that apply to help pet owners give well-being to their pets.

Table 1: Analyzing existing features.

Research Title	Research outcomes
Automatic Pet Monitoring and Feeding System Using IoT (Subaashri et al., 2017)	<ul style="list-style-type: none"> <li>RFID tag (Pet collar)</li> <li>IR sensor (Checking for food availability)</li> <li>Arduino(gateway)</li> <li>Mobile application</li> <li>Suggestion- RTC to the feeder</li> </ul>
Smart Pet Care System using Internet of Things (Kim, 2016)	<ul style="list-style-type: none"> <li>CCTV service</li> <li>Remote feeder</li> <li>Remote automatic defection</li> <li>Mobile application</li> </ul>
Mobile-based monitoring system for an automatic cat feeder using Raspberry Pi (Anggraini et al., 2020)	<ul style="list-style-type: none"> <li>Webcam &amp; stepper motor (Remote feeder) Raspberry pi(gateway)</li> <li>Mobile &amp; web-based application</li> <li>Suggestion- high-resolution camera &amp; large stepper motor</li> </ul>
For the Pet Care Appliance of Location Aware Infrastructure on Cyber Physical System (Own, 2012)	<ul style="list-style-type: none"> <li>CPS (Cyber Physical System) technology Smart pet door</li> <li>Smart pet feeder</li> <li>Numerous networking devices</li> <li>Mobile application</li> <li>Suggestion-litter boxes &amp; pet cam</li> </ul>

The study and application of the IoT in Pet systems (Own et al., 2013)	<ul style="list-style-type: none"> <li>Smart pet door</li> <li>Smart pet food bowl</li> <li>Suggestion-pet grooming devices</li> </ul>
Pet Care System Based on Android Application (Saswadkar, 2018)	<ul style="list-style-type: none"> <li>Mobile application</li> <li>Real-time dashboard</li> <li>Suggestion-pet breed</li> <li>recognition</li> </ul>
Implementation of an IoT based Pet Care System (Chen and Elshakankiri, 2020)	<ul style="list-style-type: none"> <li>Arduino Uno board</li> <li>Wi-Fi modules</li> <li>Mobile application</li> <li>Health/activity monitors</li> <li>Pet monitors and interactive camaras</li> </ul>
Health experts for pet monitor system with IOT (Kumar et al., 2017)	<ul style="list-style-type: none"> <li>Mobile application</li> <li>Real-time dashboard</li> <li>GPS tracking</li> <li>History and trends overview</li> </ul>
A smart pet care IOT mobile application (Luayon et al., 2019)	<ul style="list-style-type: none"> <li>Mobile application</li> <li>Camera surveillance</li> <li>via a webcam</li> <li>Room temperature measurement</li> </ul>
A Pet Animal Tracking System in Internet of Things using Deep Neural Networks (Hammam et al., 2018)	<ul style="list-style-type: none"> <li>Air tag</li> <li>GPS &amp; RFID</li> <li>Deep learning capabilities (detect and classify the object of interest)</li> </ul>
Internet of Things for human - Pet interaction (Shih et al., 2016)	<ul style="list-style-type: none"> <li>Linux OS and Raspberry Pi board (development platform)</li> <li>Mobile application</li> <li>Servo motors of the portable device on the pet for feeding</li> </ul>
VetCompass Australia: A National Big Data Collection System for Veterinary Science (McGreevy et al., 2017)	<ul style="list-style-type: none"> <li>Real-time clinical data</li> <li>Mobile application natural language processing (NLP) technology</li> </ul>
Mobile Technology in Veterinary Clinical Medicine (Andrews et al., 2015)	<ul style="list-style-type: none"> <li>Veterinary mobile application</li> <li>Clinical veterinary medicine</li> <li>Improve the quality and delivery of veterinary clinical medicine</li> </ul>



## V. CONCLUSION AND FUTURE WORKS

When analyzing this research, it can evaluate patterns within the content. We can see that the existing research papers have touched all most all the technologies. Especially most of the research mainly focused on IoT-based devices for Smart Pet Care applications. We can see there are many kinds of IoT devices used for many different purposes. And almost all the research focused on a mobile application because that is the most effective and easiest way to handle human interaction with pets.

Several research projects have tried to address the need for services in a typical and practical manner. Exciting features brought out the new concept of merging pet care with various technologies. The findings show the most significant breakthrough in technology in the pet care system, but they also meet the needs of pet owners. It is simple to meet the many needs of owners using modern technologies like IoT, and the well-being, monitoring, and enjoyment of pets are all protected.

This review aims to provide future recommendations that will help develop the IoT-based mobile application for improving the interaction between pet owners and pets. The expected mobile application will help pet owners care for pets so that pets get better care and save people time and effort. With the help of this solution, the overall aim is to focus on various issues related to pets and find suitable solutions for pet problems.

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# Optimum Waste Collection System with Smart Mobile Application

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**Abstract** - Irregular disposal and collection of wastage is a huge problem in cities. Due to rapid population growth and manipulation of urbanization, huge garbage emissions and environmental pollution may occur. It is effective and important to manage waste collection to get rid of the issues related to inefficient process of collections, irregular removal of garbage trash bins, overflowing bins and to prevent health issues. Another major challenge for daily life is the current pandemic situation that we have been facing with COVID-19. Therefore, during this pandemic, it is very important to carry out the garbage disposal and collection process in a well-safe and efficient manner at the right time, to minimize contact with outsiders and it will be immensely useful in preventing and controlling the spread of this epidemic. Without proper waste disposal, a home is vulnerable to the spread of disease. This research work plans to develop an optimum waste collection application for truck drivers and citizens. The system will facilitate truck drivers to find the shortest path for the only fullest bin by using route optimization. Arduino and ultrasonic sensors have been used to create the smart bins by facilitating relevant sensor data and Google map API for tracking the location in the proposed application. Mainly Firebase for backend resources to the device, including data storage, user authentication, static hosting has been used, while Flutter has been used as the mobile application development platform. As per the studies and analysis of the related technologies and platforms, the Flutter is used to develop cross-platform applications for Android, iOS, Linux, Mac, Windows operating systems. The proposed work provides an accurate, convenient, user-friendly Android mobile application as the final research output.

**Keywords:** *route optimization, urbanization, firebase, Google map API*

## I. INTRODUCTION

Manage waste collection services play a major role in the efficient use of public services with the rapid population growth and the manipulation of urbanization. Especially, due to the current pandemic of Covid 19, it is important to have a proper and well-managed garbage disposal and waste collection process to ensure the safety and good health of everyday life. Then the proper management and planning for wastage collection is a priority key factor for "Smart City". Waste management is a central feature of every society. (Singh & R.Saxena, 2018) (M.S.Kadam & S.S.Sarawade, 2016) It has evolved along with societal development and growth.. Nowadays smart waste processes have an important role in evolving waste management. Internet of things (IoT) technology and emerging modern computing platforms offer new opportunities to automate waste management. (Amir & Rola Pola Anto, 2018). Existing waste dumping sites are full beyond capacity and under unsanitary conditions. The prominently Environmental pollution may be owing to the Municipal Solid wastes. (Augustyn, et al., 2019) (McAllister, 2015) The world generates 2.01 billion tonnes of municipal solid waste annually, with at least 33 percent of that extremely conservatively; not managed in an environmentally safe manner. Worldwide, waste generated per person per day averages 0.74 kilograms but ranges widely, from 0.11 to 4.54 kilograms. It is perceived that usually the waste space gains too much assigned due to irregular removal of garbage occupancy in the dustbin. The aim of this work is to use the modern computing domain to enhance the quality, performance, and interactivity of urban services, and hence provide an efficient and proper waste management system that will overcome the shortcomings of the present waste collection procedure additionally decrease cost and create better utilization of resources. Here it is presented a cloud-based system that will find the best route for collecting waste. This smart and expert system can take dynamic decisions and control special situations such as a collection

route is blocked, waste level and the number of required trucks exceed capacity, etc. Most developed countries passed through a period when they were developing environmentally. Today, however, most of these countries have effectively addressed much of the health and environmental pollution issues associated with wastes generation. The total solid waste generated in Sri Lanka (Reinhart, 2020) is assumed to be around 6,400 tons/day but daily waste collection by Local Authorities is estimated at 3500 tons.

Western Province	58.5%
Eastern Province	8.5%
Central Province	8%
Southern Province	7%
NW Province	6%
Northern Province	3.3%
Sabaragamuwa Province	3.2%
Uva Province	3%
NC Province	2.5%

Figure 1. Percentage of Solid Waste collected by Local Authorities Sri Lanka

As a result, there is a serious threat to the excessive accumulation of solid waste in the urban environment. Owing to the urban-rural divide, a similar scenario is now occurring in rural areas as well. Today, coping with waste is a big challenge. Furthermore, when it has done the research and gathered information about the current waste collection procedure in Sri Lanka and as well as global resources regarding the waste collection process it can be concluded as follows.

- In Sri Lanka it has usually 5 days waste collection procedure
- Only the well-Developed countries used fully automated method for waste collection
- Truck drivers are still unable to drive through narrow streets and rural villages.
- Throwing garbage to the roads
- Health issues. (ex: Dengue, Kolaria)
- Traditional waste management (TWM) procedure wasting cost & fuel

## II. LITERATURE REVIEW

Waste management and waste collection can be defined as one of the popular research problems that have been developing with various

conceptual modern computing and engineering techniques and IoT-based models. The following studies were conducted on the waste management and waste collection procedural studying areas of the different main categories of existing waste collection process with various applications and the techniques in globally and as well as Sri Lankan context. Authorities describe the Waste Management activities. Each stakeholder seems to have their own responsibilities. The municipality must take very good care that waste can be recycled, and households must be careful to separate recyclable materials from household waste. Metropolitan strong waste, normally known as trash or waste, is non unsafe disposed of materials created by family units, organizations, plants, cultivating, and sewage. This is comprised of waste, organics, and recyclable materials, and its administration is constrained by the region. Civil strong waste is normally gathered, exasperated, and sent for handling to either a Landfill or Municipal Recycling Centre. (Busch, 2016).

EU Waste System Directive sets down waste necessities Maintenance and reusing. Part States must actualize squander the board arrangements in consistence with the rule, where the reusing objective for all waste materials from families is half. Indeed, this implies that by 2020 Finland should reuse 50% of its metropolitan waste. The order presents the 'polluter pays rule' and the 'broadened duty of makers.' It consolidates arrangements on dangerous waste constantly oils (old Directives on unsafe waste a lot of oils annulled with impact from 12 December 2010) and incorporates two new reusing and recuperation focuses to be accomplished by 2020: half groundwork for the reuse and reusing of certain waste materials from families and other comparable sources; and 70% planning of waste materials from families. Part States are needed by the Directive to execute squander the executive's plans and waste decrease programs.



Figure 2. Waste Management hierarchy

Source: <https://ec.europa.eu/environment/waste/framework/>

The Trash assortment and control was a major worry that should be examined. In “Review of: Smart Bins for Garbage Monitoring and Collection Using IoT System by the Prof. S. P. Pander speaks to the proposed Garbage assortment and the board framework for private or business territories utilizing the Internet of Things. In this paper, (Pande, 2019) brilliant canister is based on Arduino 328board, a microcontroller-based stage that interfaces with GSM modem and Ultrasonic sensor. This program tracks the trash canisters and informs by means of a page concerning the measure of trash gathered in the trash receptacles. This page additionally sends the trash assortment vehicles with all the information. This IoT Garbage checking framework venture is a creative framework that will help keep the towns clean.

G. Arunkumar and G. Bhanu Priya, have done research work on “SMART GARBAGE COLLECTING BIN FOR MUNICIPAL SOLID WASTE.” for the International Journal of Modern Trends in Engineering and Science. And the authors had researched for minimization of end-to-end delay in the implementation of smart waste management. The automatic waste management system is the latest trend in this research work and is one of the best combinations to use in this (Arunkumar & G. Bhanu Priya, 2016).

O. Osibanjo and I. C. Nnorom presented an E article and proposed a Smart City waste management system (SWM) that allowed for IoT applications. Originally, the Smart Waste Management (SWM) program was developed in smart cities. E SWM system provides on-time garbage collection that ultimately minimizes the total cost of the garbage collection process. e proposed work shows that the IoT waste management system empowers cleaning

operators to detect cleaning problems in real-time. This system thus helps to improve overall productivity and cleanliness. (Osibanjo & I. C. Nnorom,, 2007)

Internet of things (IoT) is an emerging technology that offers promising solutions for the modernization of traditional systems. It makes successful agreements resulting in the crystallization of smart cities, smart houses, smart manufacturing, and the smart world. This article has introduced a smart waste management architecture for smart cities and an effective routing strategy with the least architectural delay considered.

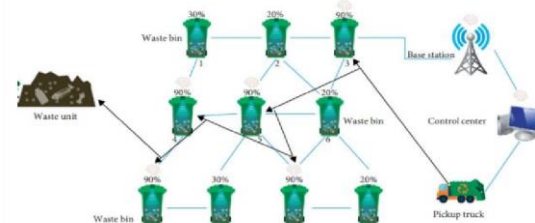


Figure 3. IoT-Enabled Smart Waste Bin Management System and Efficient Route Selection

C. Chow, W.-M. W. So, and T.-Y. Cheung has worked on another new waste collection bin to help facilitate education in plastic recycling. Aside from landfills and incineration, plastic recycling has been an alternative method for solid waste management. Recycling quality is, however, affected when all plastics are discarded into a single recycling bin which increases the recycling industry's cross-contamination and operational costs. With the following the design process of the engineering, a new eight-compartment plastic waste collection bin is designed to facilitate plastic recycling and source sorting, which also provides educators with insight into solving environmental problems. The quantities of collected plastic waste correspond well to the dimensions of the building (Chow & W.-M. W. So, 2018) ICT and PC organizing have arrived at pretty much every part of present-day life and affect human existence even in the most far off territories of agricultural nations. (Wilson & C. Velis, 2006) (Usón & G. Ferreira, 2013). The fast development in ICT has prompted an expansion in PC ability and yet to a decline in the lifetime of the products because of which developing amounts of waste electrical and electronic hardware (e-squander) are created every year. For most agricultural nations, particularly in Africa, the creation of ICTs relies more upon second-hand or renovated EEs, the



vast majority of which are imported without corroborative usefulness testing. A. K. Jha, S. K. Singh, G. P. Singh, and P. K. Gupta, have suggested ideas in this research way (Jha & S. K. Singh, 2011), critical volumes of e-squander are being treated in these nations. The difficulties confronting agricultural nations in e-squander the board include: the absence of sufficient waste administration frameworks, the absence of enactment explicitly managing e-squander, the nonattendance of any End-of-Life (EoL) item reclaim framework, or the presentation of expanded maker obligation.

When it has moved to related works and researched based on the position of waste management within Sri Lankan context-based (Foundation, 2017) the research works and facts in Status of Waste Management in Sri Lanka," Environment Foundation (Guarantee) Limited; given the ongoing catastrophe at Meethotamulla and the misguided choice to dump trash in Muthurajawela, an asylum of wetlands under the Fauna and Flora Ordinance, it is valuable to discover the set of experiences to squander the board in Sri Lanka. With the Western Province representing roughly 60% of waste creation, Sri Lanka produces 7000 MT of strong waste each day. Everybody produces a normal of 10.4 kg of waste a day. Just 50% of the waste produced is gathered, as per the Waste Management Authority, and the Central Environmental Authority. Appraisal of the existence cycle, arrangement, reusing, and decrease of every single waste sort, and appropriate landfilling is necessary.

Duties regarding gathering and discarding waste are assigned to the nearby specialists of the particular Divisional Secretariat, either a metropolitan chamber (according to Municipal Council Ordinance - 1947), a metropolitan board (Urban Councils Ordinance-1939), or a locale committee (Pradeshiya Sabha Act - 1987). Squander the board and removal arrangements are made as per the 1981 National Environmental Act No.47 and Public Nuisance Ordinance. Government organizations have been attempting to sort out the nation's best waste administration methodology throughout the previous 20 years, or somewhere in the vicinity. Albeit a few strategies and activities advanced clean landfills, different measures were directed into energy programs against squandering. CEA started a 10-year squander the executives' framework called the "Pilisar Project" in 2008 with the objective of "Squander Free Sri Lanka by 2018." Unfortunately, the absence of a cognizant

endurable methodology has added to unintelligible and fruitless procedures.

This examines the overall highlights of casual reusing, featuring both positive and negative perspectives experience shows that the foundation of new conventional waste reusing frameworks without considering previously existing casual frameworks can be profoundly counterproductive. The best option is to consolidate the casual area into squander the executives arranging, drawing on their conventions and skill and simultaneously trying to improve the manageability and living and working states of those concerned. The preferred option is to integrate the informal sector into waste management planning, building on their practices and experience, while working to improve efficiency and the living and working conditions of those involved. Issues associated with integrating informal recycling into the formal waste management sector are discussed in this research works respectively. (Pariatamb & Masaru Tanaka, 2017) (Basnayake & Chettiyappan Visvanathan, 2014)

Plastic, polythene, metal, and glass reusing endeavours should be energized and financed at various scales, and the distance between squander makers and recyclers should be topped by setting off more assortment communities and making the cycle more freely available. As discussed, and worked on his research by (Cialani & R. Mortazavi, 2020). Squander is an asset and effective activities in the waste business should be made, and it should be set up as an organization that produces pay instead of an industry of no incentive for the company.

Specialists need to utilize logical specialists to decide the best waste administration model in Sri Lanka, regardless of whether it be waste-to-energy, cremation, or a mix of the two. Landfills at present should be thought of, as there will be an amount of expendable waste delivered even after burning and from other waste to energy tasks. In the event that such waste fizzles for brief energy activities, the landfill would need to be held as a choice. As a common society, we have an obligation to urge individuals to move towards more feasible and asset productive types of use. (Dahlén & A. Lagerkvist, n.d.)

Table 1. Different Ranges of Daily MSW Collection[tonnes/day]

	Number of Local Authorities
Up to 1	111
1-2	48
2-5	76
5-10	26
10-20	23
20-50	19
50-100	5
100-150	2
>150	1
Total Number of Local Authorities	111

Table 2. National Color Codes for Waste Separation Containers

Color	Description
Green	Organic Waste
Blue	Paper wastes
Red	Glass, Bottles
Brown	Metals, Coconut Shells
Orange	Plastics/Polythene

### III. METHODOLOGY

Smart waste management and optimization are some of the upcoming topics in today's research works. Out of all optimization and waste collection systems and procedures slightly challenging this research area in the general public and urban council authorities because, even though the same citizen or same city, it has to manage several varieties of trash and garbage and it may have different garbage disposal routines or habits. Not only that but also day by day the amount of waste disposal may increase with the high population growth and industrialization.

After selecting a topic for the research, initial information about related works for this

research that have collected already were gathered by the literature review as well as have done interviews with the urban council authorities and as well as the randomly selected citizens in the general public who are involved with this waste management and waste disposal domain. Since there aren't the same research works that have been done, related proposed systems in waste collection and apparel market analysis studies research have been reviewed. When reading various journal papers and conference papers there were so many approaches and techniques that have been developed to enhance the efficiency and design IoT based systematic approaches. The analysis was done mainly to identify the current systems available with the advantages and drawbacks of such systems and get the ideas & preferences of individuals within the society is related to waste collection procedures.

- Data gathering and collect from the smart bins.
- Fill level of bin-ultrasonic sensor
- And then it sends data to the cloud using GSM module
- Shortest path-shortest path algorithm
- Nearest bin & bin locations-Google map API platform



Figure 4. Methodology of the overall solution

Citizens can put waste in the smart bin. Then smart bin measures fill level using an ultrasonic sensor. Those details send to the AWS through the GSM module. Then AWS sends that relevant data to the database. According to that detail's citizen map is working. Then it viewed the Filled bin-red color and unfilled bin-green color. Furthermore, if filled between 70%-100% showed in red color and otherwise shown in green color in the app. After logging into the app citizen can find the nearest bin and truck driver's location. And the app has separate logging for the truck driver, and the truck driver can be logged into using the phone number and relevant OTP,

and then it shows the next nearest bin, and then the truck driver can collect the nearest filled bin. In addition to that main process, citizens are capable of add complaints using app and it sends to the database.

#### IV. PROPOSED SOLUTION

In order to obtain an optimum waste collection system to fulfill the efficiency and optimization this research work will propose an application that In this proposed system there are multiple dustbins located through the exact locations in the particular city, these dustbins are provided with low-cost sensor that helps in tracking the level of the trash bins and a unique ID will be provided for every dustbin in the city so that it is easy to identify which garbage bin is fill. When the amount reaches the edge limit, the device will transmit the amount by the unique ID provided. This information can be accessed by the concern authorities from their place with the help of internet and instant action can be made to clean the dustbins. The main objective of our project enables a two-way communication between the infrastructures deployed within the city and the operators/administrators. A centralized system for real-time monitoring is our goal to fulfil. During this method both the municipal and citizens have the benefit from an optimized system which results in major cost savings and fewer urban pollution. The final proposed solution can be summarized as illustrated in Figure 5.

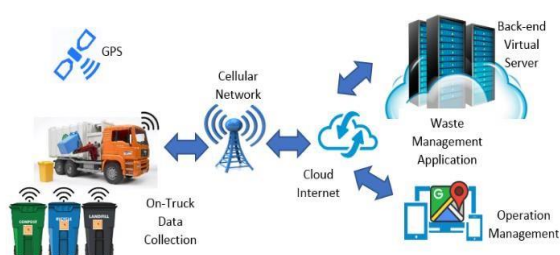


Figure 5. Smart Waste Management System Schematic of Proposed Solutin

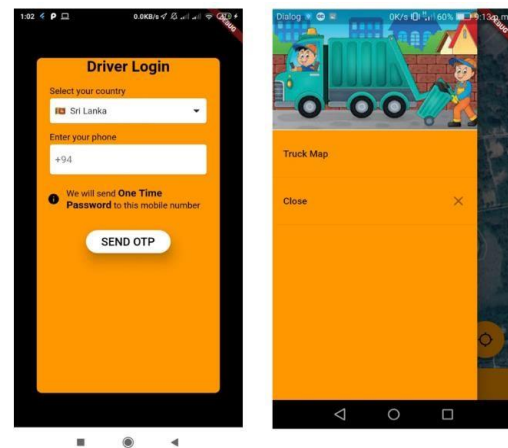


Figure 6. Driver Login Page User Interfaces

This system also has a mobile application. It supports both citizens and truck drivers. A citizen can find the nearest bin and truck driver locations. A truck driver can find the nearest next filled bin and collect it. Because of this app, the truck driver can skip the unfilled bin. Driver login there is a drawer to enter for the truck driver login page and it sends an OTP for verification while the Drive login. Any unauthorized person may not be allowed to log through the driver login except the authorized truck drivers. And then after successful login, it can be viewed the bin locations in one interface and then in another interface, it can be viewed the nearest filled bins with the citizen's locations before starting the collection process. On the screen, it shows the unfilled bins in green colour icons and can be easily identified the filled bins in red colour icons. Then the driver can load the map and by clicking the Start Ride button the driver is allowed to start the ride to fulfill the waste collection process. Then according to this map with the corresponding filled bins, the drivers may lead to an efficient waste collection process. And then the citizens also can experience the smart waste collection procedure with this proposed solution. The User interfaces of this explained process can be represented as in Figure 6.

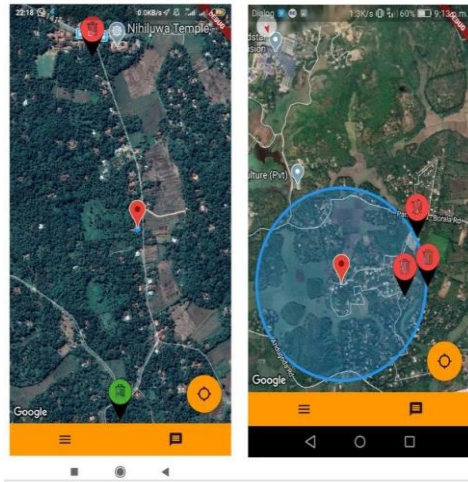


Figure 7. Bin Locations and Map View User Interfaces

## V. DESIGN & IMPLEMENTATION

Under the design, mainly it must do the selecting the appropriate tools and platform in order to build up the software design architecture for the mobile app implementation. Design and Development will explain how the technological strategies and tools were decided to create this application and the process that has followed to construct the proposed system. This system implementation and design mainly consist of two phases. They are gathering and sending data from the waste bins and finding the optimal route for the waste collection process.

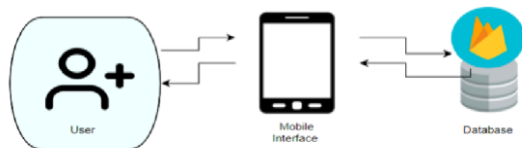


Figure 8. High-level System Design Architecture of the Application

The first phase mainly focuses on collecting data from waste bins using sensors and sending them to the server. Both the weight and filling level of trash bins is sensed using two sensors that are fixed with the trash bin to gather data. To detect the filling level ultrasonic sensors are used. It operates with the propagation of sound waves. Distance to object is determined via a sound transit time. And it is not detected by color, transparency, or glossiness of a surface which is very much advantageous for sensing waste filling level. Other than that, the LED display

shows if the container is full to alert the users. All these data gathered are sent for the processing which is done using a Microcontroller and GPRS (General Packet Radio Service). The data collected from sensors requires filtering and sorting. These raw data will be formatted into structured data. A central server receives the data and stores all the necessary information for current and future use.

Then the second main phase is Finding Optimal Route for Waste Collection. In this stage, we find the optimal route for waste collection. If the truck can collect all the waste from any place with the shortest possible path, it can save fuel, money, and time. Moreover, we analyze the usage pattern of different localities to collect maximum waste and allow waste bins more time to fill up. In this phase, I use the Google Maps API platform to find the nearest bin. A truck driver can easily find the nearest filled bin skip the nearest unfilled bins. According to the app, it shows unfilled bin in green color and filled bin in red color. This system must be a mobile-based framework for the problem domain. There are several languages to produce mobile devices, as well as platforms. As the project objectives and the system architecture of the outcome initially have studied the latest appropriate technological domains and then finalized to use in the application implementation as below.

### A. Flutter

Flutter is very innovative but perhaps a promising platform that had already attracted the attention of big companies that have already released their apps. Since components are implemented in Flutter itself, however, there is no layer of communication between the view and the code. So, buttons, text, media elements, and context are all drawn by the graphics engine of Flutter. Widgets are essential elements of the user interface used to construct the application's user interface and build stunning, highly customized user interfaces.

### B. Arduino

Arduino is an open-source electronic prototyping platform focused on easy-to-use software and hardware. Arduino is a prototyping board based on a microcontroller that can be used in the development of digital devices that can read inputs such as a finger on a button, touch a screen, light a sensor, etc. and convert it into output such as flipping on an LED, turning a



motor, playing songs via a speaker, etc. Arduino board consists of a USB plug for communicating with your machine and a bunch of link sockets that can be connected to external devices such as motors, LEDs, etc. There are many factors that made this possible, such as rapid growth in information technology, lower electronic product, and device costs and widespread internet connectivity.

### *C. Ultrasonic Sensor*

The Ultrasonic Sensor (Distance-adjustable or Zone-setting Convergent Reflective Sensor) sends ultrasonic waves from an emitter to a sensing target, and then receives a detector for the reflected waves. The Sensor uses the resulting information to assess an object's location, or to measure the object's distance. This Sensor Form decides the Distance from the Sensor to an object based on the time taken from the transmission of the ultrasonic waves before they are received with the sound intensity. Unlike photoelectric sensors, Ultrasonic Sensors can detect an object without having its colors affected it.

### *D. Firebase*

Firebase is a powerful platform for your Web and Mobile App. Firebase will supply backend resources to your device, including data storage, user authentication, static hosting, and more. You can easily create mobile and web apps with Firebase that scale from one user to a million. What noteworthy is that people were using Envolv to transfer data on applications that were more than just talking messages. Developers were using Envolv to synchronize real-time application data such as a game state through their users.

### *E. Google Map API*

Google Maps is an application and technology provided by Google for the web-based mapping service. The Google Maps API gives you the ability to create personalized maps that can be used to create modern applications based on Google Maps. The maps are loaded using an API key in all Maps API applications. The API key is free, but Google will track the use of the Maps API for your application and, if it reaches the use cap, it will need to buy an additional quota. With those, all the above technologies adopted have described the various tools that were used along with the programming languages, platforms,

frameworks, and development environments throughout the design and implementation process. In addition, this explored how those technologies committed themselves to growth and the uniqueness of the application.

## **VI. FINDINGS & ANALYSIS**

This explains how the data were gathered to create this program and the process of the table below shows the main findings and existing problems found while analyzing and data gathering process, and the solutions offered by the newly implemented Optimum Waste Collection system to resolve those problems. The data were gathered from previous works and the interviews conducted with truck drivers in the municipal council and citizens in selected areas for this proposed project. Mainly it has been concerned to find the existing procedures of waste collection systems and the drawbacks or problems encountered in the waste management process in the Sri Lankan context. A survey on the regular waste collection process and citizens' perspectives in the general public was held as the initial finding of this research problem moreover and to measure the factors which may affect the existing waste collection process and the drawbacks of the current methods. This Google form questionnaire-based survey was collected 65 responses. It consisted of 10 different question tips regarding traditional waste management procedures, environmental pollution level, issues that occurred on citizens' side as well as the problems faced by truck drivers and trash bin collectors to identify for the respondents. As well as the main summary of this questionnaire has concerned two major analyses under separate questions to determine what the satisfaction or overall acceptance of the citizens and garbage collectors during the existing waste collection process is. And to determine and analyze the most prominent and prioritized issues to be addressed via this research work and proposed solution. According to responses, respondents were related to several areas in the country, both urban areas & rural villages, every category of age group. When considering about total average of existing situation and issues facing with the traditional waste collection system by the general public generally it could conclude as below. With 63.3% of the percentage as the highest scored citizens who are not satisfied with the current waste collection procedures in particular areas, only 10% of respondents are in totally satisfied with



current waste collection procedures in their areas.

What is your opinion on the waste collection procedure currently available in your area?

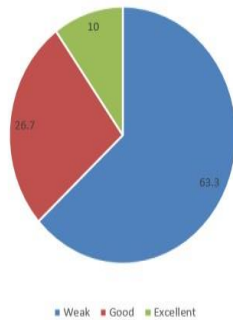


Figure 9. Pie chart I of Questionnaire Survey Results

And we have analyzed that environmental pollution can be defined as another major adverse effect of improper waste collection. So, then it may occur health diseases and can be threatening to the day-to-day healthy life of the citizens. So, this finding with the responses has clearly represented how those problems affect the general public, and then it is required to pay attention in order to address these existing problems with the traditional waste management process. The highest score with 66.4% have agreed about this issue and they are expecting a proper solution for this at least some considerable extent.

Do you face environmental pollution or health issues due to not arriving at waste collection on time properly?

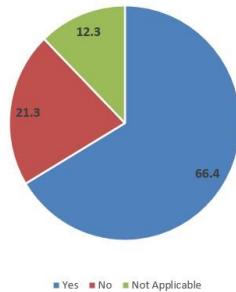


Figure 10. Pie chart II of Questionnaire Survey Results

Finally, out of all those survey results and analyses, it is concluded to determine and address the current burning issues in the waste collection system and propose a smart optimum solution as the final system. The below table reflects the main findings and existing problems found while analyzing and data gathering process, and the solutions offered by the newly implemented Smart Waste Collection system to resolve those problems specifically.

Table 3. Overall Analysis of the proposed Solution

Findings/ Problem Encountered	Analysed Solution
Traditional waste management (TWM) procedure wasting cost & fuel	Collect only filled bins, no need to go for unfilled bins
Health Issues	Stop Bins overflowing
Increased level of environment pollution	Control the bin overflowing and collect waste timely
Time wasting (Traffic Jam)	Manage bin collecting routes
Improper & inefficient collection	Collect only the filled bins which have reached the filling level

## VII. CONCLUSION AND FUTURE WORKS

The present status of the solid waste management practices in Sri Lanka is required to concern with more on time and well managed regular collection process. One of the difficult operational problems that municipal and local authorities are facing is the collection of municipal solid waste. In recent years, the exponential population growth, high density of urban areas, diverse culture, changing food habits, and lifestyles have seen an unresolved problem in terms of Municipal Solid Waste Management. Consequently, the municipalities have been facing many other issues related to the collection, management of solid waste. The present study is a comprehensive review of research work on the present waste management status identifying the associated challenges and deriving potential solutions for the optimum waste collection application in the Sri Lankan context. The proposed work demonstrates that the waste management system in the Mobile application empowers the collection operators to detect waste bin filling level issues in real-time. We have used smart bins in which waste-detecting sensors are fixed. These sensors can send signals to the nearest sensor referenced to the base urban council. Therefore, this system helps in increasing overall productivity and efficiency. The proposed system contains all the important stages from the collection of waste in

the filled bins, load to the truck and using the optimum shortest route for transportation and does the collection process will not occur any traffic jam, unnecessary delay. and recycling it in the recycling unit. As future works main aspect of this proposed work can be defined as recycling of the waste and proper storage and maintenance in the storage units too. To create a highly accurate and efficient Smart Waste Collection System with the Mobile App development this paper has been reviewed the existing technologies and related works done within other several related research areas. Even though there are so many various waste management and waste collection systematic approaches and as well as waste management and related research have been done already, there isn't an existing system with a mobile application to address these current issues have been facing in the Waste Collection process on overall Traditional Waste Collection strategy, especially in Sri Lanka. As a further enhancement, the Google map API advanced feature activation can be added with more efficient use of the app and enhance the additional important hardware parts for future development. To gain a conclusion on such a research study area the information on the effectiveness of a systematic solution may have been gathered by reviewing related works and existing systems and then its evaluation summary gave the points to be considered in developing such a real-world application in future with the digital era and to survive with the future challenges such as pandemic situations and current new normal.

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## Mobile-Based Animal Vaccination System for Sri Lanka

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**Abstract** - Traditionally, animal vaccination is done by a veterinary doctor and the issue of vaccination record book/card is maintained by the pet owner. However, there are many issues in the traditional system, such as damaging the record book, forgetting to vaccinate their pets, and the veterinary doctor requiring to update manually. Although lots of pet care apps are available, hardly any pet vaccination app is found in other countries. Even in Sri Lanka, there is no digitalized method in the pet vaccination process. The mobile-based animal vaccination system covers the whole process of animal vaccination, and it can be used as a digital vaccine card. The system provides vaccine stock management, pet owner registration, pet profile maintenance, reminder alerting, and appointment management, event notifying, and reporting. Further, emergency and insurance claiming facilities available in the system have not been previously implemented for animals. Pet profile transferring is also possible in the system. The mobile-based animal vaccination system is developed using the ionic framework, and Geofencing is used to locate pet food and pet product shops. The system enhances the animal vaccination process in Sri Lanka, and the automated process will be a great benefit for pet lovers as well as veterinary professionals.

**Keywords:** *animal vaccination, vet clinic, IT in health*

### I. INTRODUCTION

Traditionally animal vaccination is done by a veterinary doctor and issue vaccination record book. Pet Owners have to maintain the vaccination book (similar to the baby card) to prove that the animal has been vaccinated when an emergency occurs. The record book could be damaged or lost and hard to carry always during

a visit to the veterinary doctor or veterinary clinic with the pet(s). Due to busy schedules, pet owners may forget to vaccinate their pets in the stated period. Similarly, there are many issues faced by pet owners and veterinary doctors during the vaccinating process. The veterinary doctor requires to carry out some documents related to animal vaccination. Veterinary doctors also require to update vaccine details and manage vaccine stocks manually and if the vaccination record book is lost, no other way to trace the history of the treatment, vaccine details, and pet's health.

There are lots of pet care apps in other countries. However, there is no digitalized method in the pet vaccination process in Sri Lanka or other countries. The mobile-based animal vaccination system can use as a digital vaccine card. The system come up with vaccine stock management, pet owner registration, pet profile maintenance, reminder alerting, and appointment management, event notifying, and reporting. Further, an emergency clicks and insurance claiming facilities available in the system have not been implemented before for animals. Pet profile transferring is also possible through the system.

Most of the pet care apps are focused only on pet owners but the mobile-based animal vaccination system enhances the quality of the animal vaccination process and provide better service to the pet owners, veterinary doctors, and veterinary hospitals or clinics.

The main aim of this project is to digitalize the process of animal vaccination. So, it will help to reduce diseases caused by animals and all the paper-based cards and forms from the process.

### II. RELATED WORK

There are some vaccine apps to prevent diseases from animals (Andrew D. Gibson, 2015). But here we are focusing on the health of an animal.

Mission rabies app is implemented in Ranchi, India as a method of mass vaccination (Gibson, 2015). Over 20000 people die from rabies each year in India and according to their survey over 70% of people are affected by rabies from an infected dog. This bespoke smartphone app "Mission Rabies" was developed to facilitate data entry and team management too. here they are mainly targeting stray dogs and infected dogs. Thus, other domesticated animals are do not cover through this. Vaccinated dogs were marked with non-toxic paint along the top and back of the head to allow for identification of past vaccination surveys and prevent repeat vaccination.

Research on the vaccination of dogs in Sri Lanka was conducted by Professor Indira Silva (Silva, 2016). In the study, it was discovered infections, diseases, and types of vaccinations use for dogs in Sri Lanka. Further, she recommended dog vaccination, and the dog is considered the main target for rabies elimination in the research.

Method and system for providing animal histories and tracking inventory drug usage is a research which is done for providing up to date health histories of animals to identifying the animal and a data entry device coupled to a computer for recording the Indica elements (Bortolotti, et al., 2013). This system display health records, location, the net amount of drug taken for animal treatment from the inventory. The veterinary doctor also uses a computer for data insertion. It is not practical when the doctor is visiting the animal.

Multi-user system authoring, storing, using, and verifying animal information is a research which is done by Barrs Lewis, Tom Mayer, John Shorrock. A secure centralized repository for storing animal characteristic information, owner information, health information provided by a multiplicity of different user classes (Lewis, et al., 2003). A unique animal identification code used and stored in the database. The code serves as a primary key for an animal's electronic records and allows a records table easily associated with a particular animal. This is one of the best ways for legal issues because it has an authoring process. But this solution doesn't address mobility.

Some Sri Lankan researchers adopted existing technologies to create an electronic platform for rabies surveillance (De Silva, et al., 2017). Information entered by trained clinical staff and patient data is deployed in real-time. An automated short message service (SMS) alerts inform patients for vaccination follow-up, appointments and informs public health inspectors about an incident of animal bites. But intense to improve the completeness of surveillance and treatment, greater public engagement is needed and the cost for training and support staff is high in this project.

Web and mobile-based surveillance systems for humans and animals are conducted in the Kilosa district of Tanzania. The major objective of this project is to investigate an approach and practices to improve the communication of rabies surveillance information at different levels (Kipanyula, et al., 2016). The researcher has especially focused to establish the significance of applying a human sensor web system to strengthen the rabies surveillance system. They found that domesticated dogs are considered as the main transmission agent of rabies from animal to humans. Although this method has been implemented and little success has been recorded due to poor coverage, usually less than 25% during vaccine campaigns resulting from budgeting constraints, poor infrastructure, and poor response from dog owners in a rural setting where does dogs are considered valueless animals.

A survey of rabies antibodies in confined, hunting & roaming dogs in Nigeria is a research which is done by Daniel Oluwayalu. In this study, the researcher mentioned that vaccination is the most cost-effective method to eliminate rabies and the importance of keeping dog vaccine histories and demographic data (Oluwayalu, 2015).

E-surveillance in animal health is a system that is implemented by using mobile tools (Madder, et al., 2013). Short Message Service (SMS) is using for disease reporting. After the development of smartphones and tools has expanded, the probabilities of data collection have expanded. According to the research domestic animals are also very important for preventing diseases like rabies from the world.

Therefore, there should be a personal vaccination system and vaccination has proven to be a boon



for animal health as well as human health. Most of the researches is focused on mass vaccination. Thus, it will raise demand for a personal animal vaccination system for the guardian as well as for the veterinary doctor.

### III. RESEARCH METHODS

Nearly eight (8) similar types of systems were studied during the literature review to identify the user requirements and the implemented features. Interviews are used to collect requirements from the sample. Sample (N=350) consists of veterinary doctors, veterinary clinic staff, and pet owners. In addition, observation of the work environment supports to implementation most practical solution. It helps to understand the process and bottlenecks of the current process easily.

The system is developed using an ionic framework. Ionic is the open-source hybrid mobile app development framework. Most people carry a smartphone these days for their daily activities. Hence, the mobile-based solution is very much feasible in implementation.

The mobile-based animal vaccination system provides three (3) views to the Pet Owner, Veterinary Doctor, and Veterinary Hospital/Clinic as illustrates in below Figure 1.

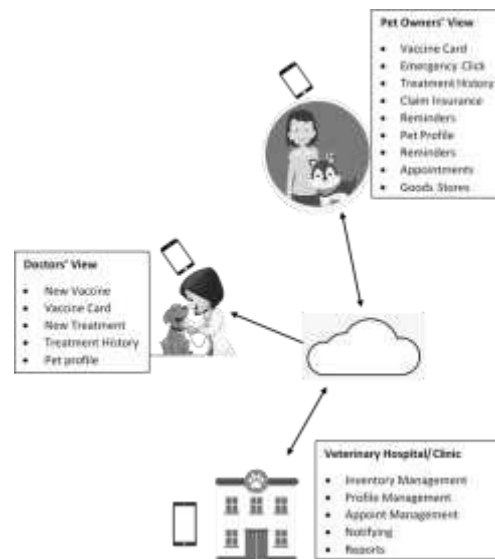


Figure 1. Overview of Mobile-based Animal Vaccination System.

### IV. RESEARCH METHODS

Below table 1 indicates the inputs, processes, and output of the system.

Table 1. Input, Processes, and Output of the Animal Vaccination System

Input	Processes	Output
<ul style="list-style-type: none"> <li>Accept the user's registration with their pets</li> <li>Inventory stock inputs</li> <li>Health record inputs</li> </ul>	<ul style="list-style-type: none"> <li>Store user details, pet details, health records in real time.</li> <li>Enable users to request for their appointments.</li> <li>Pushing reminders and notifications.</li> <li>Inventory Management.</li> </ul>	<ul style="list-style-type: none"> <li>Display past records</li> <li>Display reminders and notification</li> <li>Display profiles</li> <li>Display reports</li> </ul>



Figure 2. Admin login



Figure 3. Pet Owner Dashboard

The pet owners able to make reminders and alerts. Emergency Click facility helps pet owners to call for a pet ambulance when an emergency occurs. Pet owners can transfer pet profile, vaccine, and treatment history to another person when selling or for any other reason.

Pet insurance is now available in Sri Lanka and pet owners can directly contact an insurance agent and claim for losses easily through the app with the novel feature of insurance claiming. Further, pet owners can find nearby animal food shops and pet product shops located. This feature developed is developed using Geo-fencing and it notifies shops around a 10m radius through a notification.

In veterinary doctors' view, the veterinary doctor can enter the vaccine details and treatment details, update the pet's health condition, and also view past records related to the pet's health and treatment/vaccinations.

Veterinary hospitals/clinics can maintain stock management, profile, and appointment management through the app. Veterinary hospital/clinic view provides to send notifications to their clients/pet owners about special events/notices. The system provides different types of reports related to daily operations and stock management.

The main user interfaces as follows:

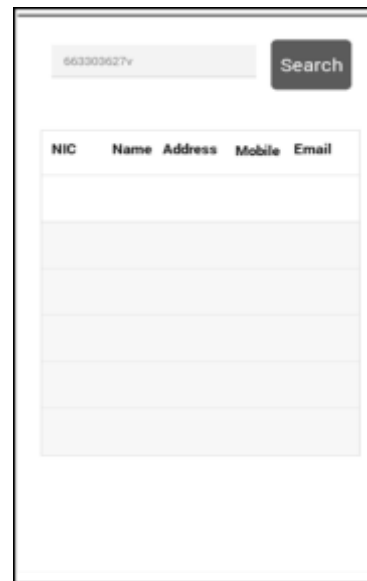


Figure 4. Pet Owner profile search

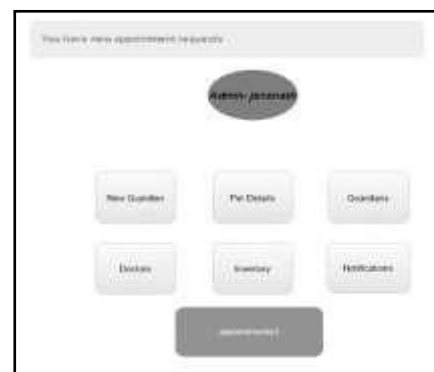


Figure 5. AdminDashboard

## V. CONCLUSIONS

Traditionally animal vaccination in Sri Lanka is done by a veterinary doctor and issue vaccination record book. The Pet owner has to maintain that book (similar to the baby card) to prove that the animal has been vaccinated in case of an emergency. The record book could be damaged or lost and hard to carry always during visit the doctor with the pet(s). Due to the busy schedules of pet owners/guardians, they might forget to vaccinate their pets in the stated period. Similarly, during the vaccinating process, the veterinary doctor requires to carry some documents related to the vaccination. Veterinary doctors require to update vaccine details and manage vaccine stocks manually. Likewise, there are many issues in the current animal vaccination system.

At present, everyone carries a smartphone for their day-today activities. Hence, it is feasible to implement a mobilebased solution for animal vaccination to enhance the process. Digitalization of the veterinary process will be a great benefit for pet lovers as well as veterinary professionals. Because they can keep track of their animals without any hesitation. The online payment function will be implemented later as it will be useful to pet owners.

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# Mobile-Based Feedback System for Undergraduates, Academic and Administrative Staff of Higher Education Institutes in Sri Lanka

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**Abstract** - Student feedback is one of the good practices in Quality Assurance (QA) in Higher Education. At present, most of the Higher Education Institutes (HEIs) collect feedback for different purposes, such as lecturer evaluation by students and course evaluation by lecturers. A paper-based questionnaire is a method mostly used to collect feedback, which has many issues as it is costly, inefficient, erroneous and ineffective. Unlike other similar types of systems, the mobile-based feedback system maintains anonymity, collects results, generates reports and provides output. Further, the system is an eco-friendly and user-friendly platform for users and is available twenty-four hours and all round the year. The system is developed using Android studio, Android SDK, and NetBeans. The server-side language is Java and the database is based on cloud technology.

**Keywords:** *student feedback, quality assurance, higher education*

## I. INTRODUCTION

Student Feedback is one of the good practices of Quality Assurance in Higher Education. At present, most of the Higher Education Institutes (HEIs) collect feedback for different purposes lecturer evaluation by students, course evaluation by lecturers, institute quality, etc. A paper-based questionnaire is a method used to collect feedback mostly. The method has many issues: costly, inefficient, erroneous, and ineffective.

The number of undergraduates is kept on increasing and limited staff to collect student feedback from all faculties. The response rate is low and takes a long time to issue feedback outcomes are the main issues of the current

system. Thus, there is an urgent need for an automated feedback management system for any HEIs.

The objectives of the system are to enhance the efficiency of the feedback process, to provide better decision-making capability for the management of the HEIs to improve the quality in the institute while reducing printing cost and storage space.

## II. LITERATURE REVIEW

Several similar types of systems during the literature review have been identified during the literature review.

There is a web-based feedback collecting system that provides an automatic generation of feedback from students and there are view panels to view outcomes of the feedback (Rahman, et al., n.d.). This research's main objective is to create a unique and useful "online student feedback system" with exceptional quality and services that differentiate it from another system. It provides feedback to students to evaluate teachers as per categories like always, poor, usually, very often, sometimes. Student can provide their perception about a teacher by this feedback system. This system will provide a result report to students given feedback. In his system, users are broadly classified into four categories, those are Admin, student, faculty.

There was a Student Feedback System delivered via the student staff interface as an online system that acting as a Service Provider. (PRAKASH, et al., n.d.) This system web-based feedback system provides student feedback about teachers,



feedback result of each teacher (staff), generate automatically feedback result reports and provide feedback result view panel to the principal. In the proposed system is generally used by four kinds of users. Those are students, staff, and head of department, principal.

There was another online student feedback system collecting feedback from the students and provides the automatic generation of feedback (ABHINAV, 2018). The student can give feedback in the online system by answering a set of multiple-choice questions. It has three kinds of users Student, Teacher, Administrator.

The main aim of the Online Feedback System for Educational Institutions to better evaluation of faculty performance using semantic web technology was to provide students' feedback online Students give feedback online using a standard designed form (Sivasankari, et al., 2016). The proposed system security was included, the result of which the feedback is only visible to authenticated users and generating useful feedback reports according to given feedback. There were five kinds of users. Those are student, admin, faculty, Head of department, and principal.

The student-Faculty Evaluation System was a LAN-Based student faculty evaluation system for Lady of Fatima University" which is all about how the students will evaluate their professor by using the computer (Enriquez, 2011). It will give the school and the student an easy way of evaluating the faculty members maximizing the school facilities. All the information given by the students will be treated with the utmost confidentiality. Automatically generate the feedback result reports. There were five kinds of users in this system: student, faculty, guidance, HR, and Dean. The scope of this system is intended for in-depth evaluation and analysis of the existing manual procedure of student evaluation.

There were two online feedback collection systems, one system is intended to collect the feedback from users of the Information Technology and Communication (ITC) wing of the National Institute of Technology, Calicut (SREEJITH, 2004). The second part of the project is to develop an online feedback collection

system for collecting feedback about the faculty from the students. This system has three user levels. The user means the student/faculty who has the access to the services provided by ITC.

The purpose of the Mobile-based Student Feedback system was very useful to maintain feedback reports by the administrator and provides to give feedback for the teaching of a lecturer by the student in a mobile-based system online (P, 2019). Evaluates the answer given by the students based on the feedback which will be given by a number 1 to 5. Provides an overall report of the feedback helping the students to give suggestions about where a faculty is lagging. This mobile system has generally three modules, those are admin, student, and management.

Zonka Feedback offers feedback forms and customer satisfaction surveys in various formats (Anon., n.d.). The solution can be utilized by hotels and other hospitality businesses, spas and salons, retail chains, banks, health care or any other consumer-oriented business. The feedback forms are fully customizable to match the branding of the company and employ rating scales, pre-defined templates, and a form builder. Zonka was available to collect feedback using Tables, Websites, Email, and SMS. Zonka software analysis the feedback result with graphs. And provide feedback notifications to users. The drawback is that Zonka has limited to certain questions, therefore users must pay to add more questions to the survey. Oftentimes making it inaccessible for individual entrepreneurs and small businesses.

Survey Monkey is online survey software that helps to create and run professional online surveys. It has several templates. (Anon., n.d.) Survey Monkey is limited to some questions, if the user needs more questions to add to the survey, then the user has to pay for it. The survey can be administered/sent to users via several ways – e-mail, web link, Facebook, embed link on the web page, link via Twitter, and website pop-ups. The big drawback is that SurveyMonkey is very expensive, oftentimes making it inaccessible for individual entrepreneurs and small businesses.

When review these related works, can find some limitations. Some systems have only limited functionalities, and some related works were not fully completed systems.

The summary of the literature review is shown in below table 1.

Table 1. Summary of Literature Review

Similar System	Key findings
Online student feedback system (Rahman, et al., n.d.).	<ul style="list-style-type: none"> <li>• Registration</li> <li>• Can insert, delete and update student</li> <li>• Student feedback about lecturer</li> <li>• Generate reports and can view reports by relevant people</li> </ul>
Student staff feedback system (PRAKASH, et al., n.d.)	<ul style="list-style-type: none"> <li>• Registration</li> <li>• Can insert, delete and update questions of the feedback</li> <li>• Student feedback about lecturer</li> <li>• Generate reports and can view reports by relevant people</li> </ul>
Online Feedback System for Educational Institutions for Better Evaluation of Faculty's Performance Using Semantic Web (SW) Technology (ABHINAV, 2018)	<ul style="list-style-type: none"> <li>• Registration</li> <li>• Can insert, delete and update questions, users</li> <li>• Student feedback about subjects</li> <li>• Generate reports and can view reports by relevant people</li> </ul>
Mobile Based Student Feedback System (Sivasankari, et al., 2016). The proposed	<ul style="list-style-type: none"> <li>• Student feedback about staff members</li> <li>• Generate reports</li> <li>• Can view reports by relevant people</li> </ul>
Student online feedback system (Enriquez, 2011).	<ul style="list-style-type: none"> <li>• Registration</li> <li>• Can insert, delete students and teachers</li> <li>• Student feedback about lecturers</li> <li>• Generate reports</li> </ul>
Zonka feedback software (Anon., n.d.).	<ul style="list-style-type: none"> <li>• Zonka software analysis the feedback result with graphs.</li> <li>• Provide feedback notifications to users.</li> <li>• Zonka has limited to certain questions</li> </ul>
Survey Monkey (Anon., n.d.)	<ul style="list-style-type: none"> <li>• Survey Monkey has limited to certain questions</li> <li>• Analysis happens in real time</li> </ul>

	and analysis the feedback result with graphs.
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### III. RESEARCH METHODS

At present, the Internal Quality Assurance Units (IQAU) of the HEIs are collecting feedback for different matters such as teacher evaluation by students, course evaluation by lecturers, student feedback on institute quality. The sample (N=400) of the study consists of undergraduates, academic and administrative staff of the HEIs as they are the main stakeholders of the Feedback Process. The primary data was collected through semi-structured interviews face to face interviews and questionnaires from the selected sample. Secondary data was collected based on the existing feedback forms in different matters.

Similar systems or research help to understand the domain of the system and implement user requirements in the same manner with less variance (Publish, 2009). The requirements for the mobile-based feedback system are collected during the literature review by observing similar types of systems and fact-finding techniques.

This system is technically feasible as most of the students, academic staff, and administrative staff has a smartphone. The system is developed using android studio, Android SDK, and NetBeans. The server-side language is Java and database based on cloud technology. The mobile-based feedback system was developed using the waterfall methodology as requirements are clearly defined.

Iterative waterfall methodology is used during the development of the system as some functions may change later based on the user requirements. Therefore, future modifications can do accordingly.

### IV. RESULTS AND DISCUSSION

#### A. System Design

The mobile-based feedback application provides the login interface to each user. Students can log in with a unique id, other users can log in with a username and password. After the completion of the student login, they can provide feedback according to each feedback category.

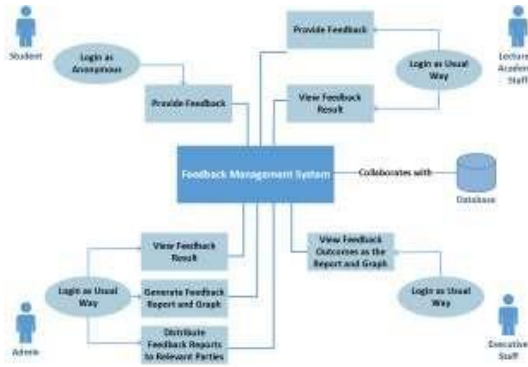


Figure 1. System Overview Diagram of Feedback System

Also, after the completion of the academic staff login, they can provide feedback according to their feedback categories and view their feedback result. In the standalone system, the administrator can view feedback results of all feedback categories, generate reports and graphs according to the result and distribute the reports to relevant people in the institute. The administrative staff people can log and view each feedback result reports to review.

**B. System Development**

In addition, the mobile-based feedback system generates different types of reports, graphs, and notifications. The following figures indicate some user interfaces of the mobile-based feedback system.



Figure 2. Login Screen



Figure 3. Student Login Page



Figure 4. Academic Staff Home Page



Figure 5. Batch Rating Form



Figure 6. Course Evaluation Form



Figure 9. Lecturer Evaluation Form



Figure 7. Student Login Page



Fig. 10. Library Evaluation Form



Figure 8. Student Home Page

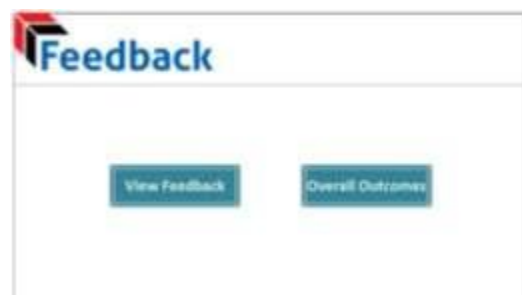


Figure 11. Admin Home Page

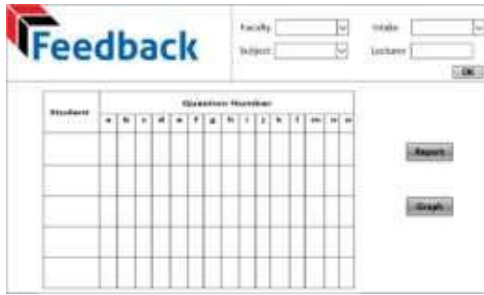


Figure 12. View Feedback and Generate Report

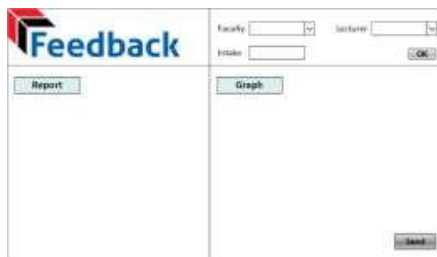


Figure 13. Distribute Result Reports



Figure 14. Administrative Staff Home Page

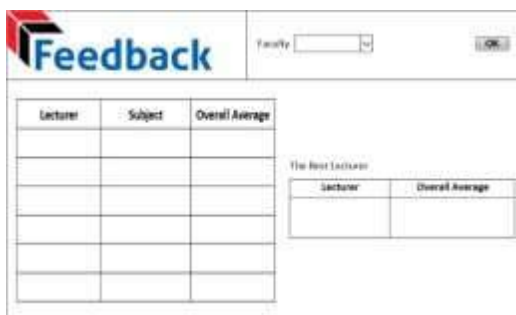


Figure 15. View Feedback Result Reports

The mobile-based feedback system is designed in order to reduce the limitations of the manual feedback system in the institute.

Through the mobile-based feedback system, undergraduates, academic and administrative staff can provide their feedback according to the respective category easily. Especially, undergraduates can provide feedback through the unique id which provides anonymity. Through the system, the IQAU can analyze the outcome easily and generate appropriate reports and graphs. Further, the relevant administrative staff can review those outcome reports and make decisions accordingly.

## V. CONCLUSION

Most of the HEIs spent considerable amount of money on the manual feedback process annually to duplicate required feedback forms. This limitation eliminated by mobile based feedback system.

The application attractive enough to collect and store feedback forms from any number of users. (Refnwrite, 2017). The mobile-based feedback system provides an eco- friendly, user-friendly platform for the relevant stakeholders to provide feedback on lecturer evaluation, course evaluation, and feedback on institute quality with 24/7/365. This app is also provided a facility to analyze the data and present the outcome efficiently and effectively. Further, the feedback app enhances the quality of the IQAU and campus as well (Samuels, 2018).

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# Automated Software Bug Management System for Small-Scale Organization

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**Abstract** -During software running, even errors due to system complexity and inadequate testing may occur. Troubleshooting plays an important role in software development and evaluation steps. Due to rapid changing technology, the whole system should adapt according to the situation, including matters such as well-skilful persons, technology and data. The bug management process has several steps, and controlling those steps is a huge challenge. Behind the situation, the small-scale Software companies need resources other than local organizations. This research focuses on identifying local small-scale organization behaviours, since they have fewer financial problems and less technological literacy of operating some licensed automation tools used in the software bug management industry. The research raises how automation techniques solve financial challenges faced by small-scale organizations. A research methodology approach which analyses previous studies and collected data is observed, and that information is validated according to the small-scale organization requirement. Finally, a proposed a system to overcome the situation is introduced, which is a web-based application that hosts the cloud. The proposed system implementation provides a facility for real-time communication between SQA, developers, and other team members via comments on each reported bug, while it assigns bugs to all the job roles represented by the agile software development life cycle, to reach historical bug records. Facility to embed the technical evidence as a report to the bug for a better understanding of the developer is also introduced. This facility generates reports for tracking each developer and tester's performance of that particular local organization. The proposed system uses an open-source development framework.

**Keywords:** *bugs, automation, management, financial, developer, literacy, small-scale*

## I. INTRODUCTION

During every stage of a given software development process; the corresponding software system generates miscellaneous types of defects. Then before developing a bug management application requires a deep understanding of software bug characteristics. But this process's initial step is estimating the bug. An efficient bug management process is critical for the success of software projects. Bug case to decrease the software reliability, quality, security, and vital area. Identifying and tracking these defects efficiently has a measurable impact on software reliability. (Strate and Laplante, 2013),(Jalbert and Weimer, 2008). The bug management process is a very difficult task, and it has prior work to do. For example, by automating bug triaging, detecting duplicate bugs, and understanding the rationale for re-opening bugs. The process of managing bugs involved several human resources such as developers, testers, reporters, project managers, product owners. (Ohira *et al.*, 2012)., Some of the bugs that developers encounter while working are having to keep separate records and update them These often have to be done manually. It takes extra time because there is a separate process to manage a bug and it consists of several steps.(Mujtaba, Mahmood and Nasir, 2011).Bug management can become even more challenging when the development projects are large. Moreover, bad fixes may cause the injection of new defects in the software. Even small-scale organizations faced related same situations within the industry. (Mujtaba, Mahmood and Nasir, 2011)

The research objective is to identify if a small-scale organization have sufficient budget to handle previous process and problems while encountering the defect managing. Because most of the time small-scale organizations used open-source tools to manage bugs. Bugzilla and

the ITracker are leading open-source tools in the industry. But JIRA has licensed software used to manage bugs. Bugzilla is depending on platforms, and it has a lower ability to customize. It is dependent on the SQL database. Then highly required opensource tool without those limitations. Another objective is to identify if they face any problems without having a customizable application. (Serrano and Ciordia, 2005),(Grottke and Trivedi, 2007). The goal of this research is to introduce a new system to overcome such a situation. The proposed system should be purchased for a low price. It is platform-independent and highly customizable.

## II. RELATED WORK

### A. Automated duplicate detection for bug tracking

Bug tracking is one of the stages in the software bug management process, that process can identify duplicate bugs. And manual bug identification was a time-consuming process of the current software development industries, it adds a higher extra cost for the development process. That system used surface features, textual semantics, and graph clustering to the prediction for the duplicate bug report. The author used 29,000 datasets from using the Mozilla project. This system should be able to develop costs by filtering 8% of duplicate bug reports. the textual analysis they used an algorithm to calculate the similarity of the document. (Jalbert and Weimer, 2008) Software bug management systems store valuable data for testing hypotheses concerning maintenance, building statistical prediction models, and investigating developer effectiveness. For the latter, issue tracking systems can be mined to explore developers' emotions, sentiments, and politeness. But detection in software artifacts is still in its early stage due to the lack of manually validated data and tools.

### B. Emotional Side of Software Developers in Jira

The working environment is always not satisfactory. Software developers also face this situation. (Ortu et al., 2016) provided a label of emotions present on issue comments. This paper authors manually labelled 2,000 issue comments and 4,000 sentences written by developers with emotions such as love, joy, surprise, anger, sadness, and fear. An efficient bug management

process is critical for the success of software projects.

C. *Impact of bug management patterns on bug fixing* The author of this paper has been mentioned it has prior work focus on improving automating bug triaging, detecting duplicate bugs, and understanding the rationale for re-opening bugs. This paper introduced four patterns and the different relations between the people involved in the process: reporter, developer, tester of a bug. Their case study is based on Eclipse Platform and Java Development Tool (JDT) projects. Presenters of this paper were demonstrated that these patterns have an impact on the efficiency of the bug management process. Their conclusion was to improve their efficiency through better communication about bugs before assigning them. (Ohira et al., 2012)

D. *Bugzilla, ITracker, and other bug trackers* Bugzilla and ITracker are the existing open-source software of the bug management industry used. Bugzilla was facilitating to input new bugs or search for, track, or edit existing ones. It had two methods to track bugs when you submit the bug to that system your mandatory input product, component, version keywords, severity, attachments, and dependencies fields are related to fixing the bug. Another way is system-generated reports. Bugzilla is a web-based application. ITracker is an issue-tracking system designed by Jason Carroll in 2002. It was supported multiple projects with independent users. Its features resemble Bugzilla's. When comparing those two systems main difference is ITracker is platform-independent and database-independent. (Serrano and Ciordia, 2005).

E. *Bug Characteristic of Open-Source Software* Manually priorities to bugs were resource-consuming. Researchers were mentioned single feature is used which leads to information loss because bugs have a lot of features including "severity", "component", "status", "assigned to", "summary" etc. But this paper introduced the solution as an improved model based on problem title, severity, and component for bug prioritization. They used term frequency and inverse document frequency to convert textual features to numeric features. They used a special algorithm to overcome the complexity of such feature-generated data. The algorithms are non-negative matrix factorization, principal component analysis. In this research on average

maximum accuracy is achieved by SVM with Non-negative Matrix Factorization (NMF) and X-mean clustering. (Iqbal et al., 2020). When developing effective tools for bug management want a deep understanding of the software bug characteristics. This research paper was based on open-source projects running by the Linux kernel, Mozilla, and Apache. They collected a sampling of 2,060 real-world bugs. The manual study is separated into three dimensions like root causes, impacts, and components. suggesting more support to help developers diagnose and fix security bugs, especially semantic security bugs. (Tan et al., 2014).

#### *F. How to Chat Technology Enables Social Translucence in Bug Report Activities*

Software bug management is a daily work routine in software engineering. The paper may focus on the use of chat technology in software engineering by analysing the coordination between client and vendor in a large government software project in Brazil (Gov-IT). author of this paper was used two methods collected data for their work live and online interviews. They used chat technology to coordinate their cooperative work by enabling the participants to monitor the availability of developers and the urgency of detecting bugs synchronously. According to their conclusion, understand the contextual nature surrounding bugs faster than using the bug tracking system. (Tenório, Pinto and Bjørn, 2018).

#### *G. Machine Learning Techniques for Software Defect Detection*

Machine Learning approaches are a trend of problem-solving. Machine learning is a vast area used in the software development industry. Machine learning techniques are proven to be useful in terms of software bug prediction. The paper is used to analysed to public data set of software modules and provides comparative performance analysis of different machine learning techniques. Software companies are spread the world widely. Then when developing the software, the quality problem is a leading issue for the software industry. The industry is suffering and closing for this issue. In this circumstance, it is important to call and remove its root cause. Recently industry economic loss will increase. (Aleem, Capretz, and Ahmed, 2015)

#### *H. Challenges of Software Quality Assurance and Testing*

Hossain trying to show some vital challenges of software quality assurance and testing which have been facing by software industries. This research covered both local and international organizations. that paper introduces the different categories of challenges along with responsible stakeholders. And they search and experiment the testing tools are available testing elements are available testing process has improved but still software has some testing challenges. The conclusion of the author is switching the systematic approach to solve the problem. (Hossain, 2018)

### **III. METHODOLOGY**

In this research, a most typical strategy is to collect data from various sources for study and refer to past analysis and analyses of previous research publications and sort some key information. According to this research used questionnaires for gathered information. This research gathered information from existing problems within small-scale IT organizations. This research identified information by giving questionnaires to all designation such as Quality Assurance (QA), Developer, BA, etc. Use of small IT base existing companies. The statistical sample was included "Enuri information system (Pvt)", "Alpha information system (Pvt)" etc. After gathering 300 sample data, analysis of them to identify research problems. It identified the main key problems that breach from each role. Identifiers were mapped with the related work. This research recognizes mapping issues raised by earlier researchers; company issues will be tailored to the needs of the organization to continue the process.

### **IV. ANALYSIS**

After analysis of previous problems, it was a clear need for the new system to overcome such problems. The small-scale organization had to struggle to reduce the budget and compatible the complex functions. The proposed system is specially developed by a selected small-scale organization. The proposed system maintains easy icons and user-friendly interfaces to identify the functions. It was designed to facilitate

Prioritization of the Bug, reviewed the progression of the developers, analyze the developer’s quality by tracking the number of bugs, generate a monthly bug managing report, provide a facility to communicate between testers, developers, and other team members via comments on each reported bug, provide facility to reviewed bug history records. predict each developer’s performance, provide the facility to embed the technical evidence (automation test technology-based report (testNG) report) as a report to the bug for a better understanding of the developer.

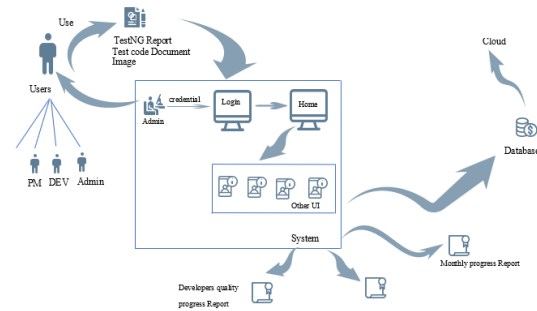


Figure 2. Conceptual design of the system  
Source: Author(s)2021

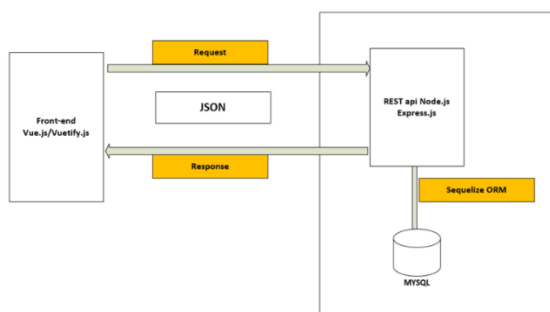


Figure 1. Communication process between front end and back-end  
Source: Author(s)2021

The previous diagram explains how to communicate the system between the front-end and back-end using JSON. JSON is a lightweight format for storing and transporting data. JSON has an attribute “self-describing data” and “easy to understand data”. JSON is the most suitable technology for transport data that generate Vue.js and Vuetify.js

## V. DESIGN

According to the overall system architecture, four types of user roles could be created by system administrator. And the system inputs are testNG reports, test code documents, test code images. Initially, the admin logs in to the system, and after he/she will create the user role as a software tester, developer, project manager, product owner. Then each user role will enter their credentials and log in to the system. It will provide the ability to function the system. The system output is system-generated reports. The system-generated reports are developer progress, bug progress, monthly progress report.

This system is a web-based system, and it was hosted by the cloud. This proposed system has 5 modules as Bug, Report, User, label, project. Each module has divided into sub-modules. Every Module manages a unique task. In the Bug module, the User can create bugs, view bug history, edit bugs. But only the Software Quality assurance engineer has permission to end bugs. Only permitted Project module for the project manager, chief operating officer, Product owner. This module provides the facility to create a new project and see current project details, edit the previously assigned project details. And Label module provides the facility to create a new label for newly created bugs or it can be edit previously once. User modules provide all the administration processes. This module provides a facility to create user roles and assign user permission. Only system admin can create user roles. The report module provides system generate reports.



## VI. IMPLEMENTATION

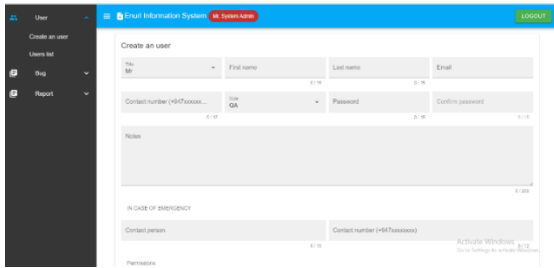


Figure 3. Web admin interface of the system  
Source: Author(s)2021

This project is an online web-based system. And this system will be doing to overcome previous research problems. The system may have only one login page. Because only the system admin creates the user roles and after created the user role, that user can be logged into the system using the credential. But the proposed system restricts some user permission from those who are not relevant to each job role. For example, only Software Quality Assurance (SQA) has permission to delete the bugs inside the system. SQA assigns the bug to the system, it will generate a separate bug id for each unique bug. And had permission to edit the previously assigned bugs for every job role that is traded. Only project managers can assign the project to the proposed system. The system implements using node.js, vue.js, and express.js technologies. JSON is the transmitted media of data from front end to back-end JavaScript, in the back-end development technology.

The system will display the status of the bug such as in queue, in due, hold, completed, QA pass. The proposed system generates a monthly bug progress report. This report will include a count of the fixing bugs in each project, the number of bugs that fail to fix, total bugs assign to the system. The system data will be host in the cloud database. That takes as a data backup. When considering the system's non-functional requirement, security act a major role. To increase the security of the system, only admin and SQA have been permitted to remove assigning bugs to each developer. The proposed system data was stored by the "MySQL" database. The system was implemented to submit the bug as image, screenshot, and embedded technical report such as (testNG report) using the Eclipse framework.

The proposed system can manage several types of bugs such as system performance bugs, functional bugs, non-functional bugs, Security, Compatibility, Usability bugs. When SQA assigns bugs mentioning the severity of the bug, then the proposed system filters bugs according to their severity. Based on the severity of bugs can be divided into critical, high-severity, medium-severity, and low severity. While assigning bugs, SQA uses a process of prioritization to separate each bug. Based on priority, it can be divided into urgent, high-priority, medium-priority, low-priority. The proposed system provides a facility to manage bugs of this type. This proposed bug managing system can be used by any local small-scale software development organization. Because most of all the software development companies follow the same life cycle. They are the main stakeholders of this product. The proposed system is most appropriate for project teams who have fully automated test suites for their testing process because proposed system provide embedded facility to attach automated test report as technical evidence. Each stakeholder can connect without any conflict after hosting it in the cloud, the organization can manage system-generated reports via cloud providers.

After implementation of the proposed system, it can be generated different types of system generated reports, that report evaluates the whole system. The report includes total bug count input to the system, solved bug count, exist, bug count, an average of solved bug count, and measure Developer's performance count of bugs they solve within a period. And measure the Software quality engineer's performance also. The report shows the final summary of the month and Year. Then it is used to calculate the efficiency and effectiveness of the employees and the organization. System-generated reports generate Quarterly, monthly, or weekly. If anyone needs to customize the report then the system provides that facility also. Finally in the evaluation part system run a fully functional testing round to ensure the system functions run without any blockers.

## VII. LIMITATION

The function of the system is always efficient when it has an automated test code of its application. There is no module for tracking real-time bugs.

While configuring some software it may generate compatibility issues, and always struggling those issues.

When used the SQL database, it is spending extra time to configure and write some quarry.

### VIII. FUTURE WORKS

Bug reporting steps are an uncoordinated distributed process. Therefore, many duplicate reports are being generated. to address this issue, there is a need for an automated duplicate report detection approach. In the fracture, researchers will plan to create software to track this problem and to extend this study by investigating more bug reports from different software systems. Researchers also would like to search to improve the accuracy of duplicates.

In facture enhancement, this approach could explore make fully automated, that means when bug tracking section module is added. The other enhancement is the wish to connect the eclipse framework to that system to upload the automated test report.

Researchers will enhance that bug report security using classification and machine learning algorithms. There are different types of supervised learning and un supervise learning algorithms are available.

The system will enhance connecting social media platforms, then employees could improve accountability of communication activities related to bug management without large effort.

### IX. CONCLUSION

The Software Development industry is constantly looking for new ways to implement services and always decrease time consumption and cost of managing problems, while at the same time they are struggling with some incidents. There is a clear need for an automation bug management process that combines previous separate activities. The number of bugs or defects can cause significant financial losses for both software developers and customers. There may be a high probability when small-scale organizations haven't a sufficient budget to handle that situation. The proposed system has been provided to the open-source platform-independent application of highly customizable. That application provides a less complex function, and it has a user-friendly interface. It is portable. The proposed system facilitates the

common communication platform. It has been providing a facility to import technical reports as evidence of a bug.

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#### ABBREVIATIONS AND SPECIFIC SYMBOLS

[testNG] automation test technology-based report

[SQA] Software quality assurance

[NMF] Non-negative Matrix Factorization

[PCA] Principal Component Analysis

[MYSQL] Relational database management system

[QA] Quality assurance

[COVID-19] Coronavirus disease

[Gov-IT] Government Information technology

[JDT] Java development tool

[Bugzilla] software quality assurance application

[ITracker] Open-source bug management software

[JIRA] Software Management application

[JSON] Stands for JavaScript object notation.

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# Student Activity Detecting and Reporting System for Online Learning Platforms

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**Abstract** - After the onset of the COVID-19 epidemic, people had to bring their work home. The working from home concept is not good for everyone, yet is suitable for some industries. The lack of positive outcomes of online lectures in the field of education is due to the lack of interaction between lecturers and students, amongst students themselves, misbehaviour of students, and misuse of microphones and cameras by students. Therefore, there is an urgent need to develop an online learning system that focuses on the positivity of learning outcomes. Existing systems are developed focusing on business perspectives. At present, there is a requirement to develop an application to overcome the said problems. Requirements for the application development were captured from previous research done by the researcher. The system focuses on tracking student behaviours using web cameras and by monitoring computer tasks. Protecting the privacy and security of users and enhancing learning accuracy by improving lecturer-student interaction during the class is the main objective of the system. Attendance marking is also generated during the main process. While making space to develop multi-platforms and using modern technologies, the most important target of the researcher is to keep students attached during online lectures as an online learning system, and the research concludes with the definitions of technologies and features that enhance the existing online learning platforms.

**Keywords:** *distance learning systems, student-lecturer interaction, video conferencing, virtual classrooms, activity detection through webcam, activity detection through computer task monitoring*

## I. INTRODUCTION

With the onset of the COVID-19 epidemic, many countries had to restrict their socio-physical

behaviour to minimize the spread of the virus. At the same time, they had to restrict their procedures to every sector of the working world to prevent the spread of the virus as a national interest. Not only the people but also the work of the government had to face the national interest. Therefore, as a more efficient solution, many work areas have had to translate their work environment into an online platform. Some areas have benefited greatly from working with the work from home concept, while others have had many problems and difficulties in fulfilling their responsibilities as well as in the way they did in the past. Among the critically affected areas, education is a big topic to consider and discuss to minimize the adverse effects and improve the effects as well as to find the best solutions for the past and the future. Teachers, lecturers, and students will face many difficulties in transforming physical education into an online platform. The physical classroom experience is very important when considering students' learning outcomes. Every aspect of teaching, in-class behaviour, attention, behaviour of the teacher, face-to-face communication, teacher/lecturer-student interaction, and student-student interaction experience greatly affects a good learning outcome when considering the best practices in physical classrooms. But when it comes to transforming education from physical classrooms into online distance learning methods, it is very difficult to meet the needs which had used by teachers/lecturers and students in physical classrooms.

Considering the platforms used to conduct online classes, they are not entirely optimized for holding a meeting for online education. Zoom, Cisco WebEx, Microsoft Teams, Google Meeting are some of the applications used to conduct online classes. These systems have been

developed for conducting meetings and video conferencing. These systems developed orienting participants, meeting conductors, administrators as users, and other security features have been developed largely focusing on business purposes. They perform better when managing the activities of an organization which may often focus on business purposes. However, teachers/lecturers, and students should focus on the importance of learning outcomes and use these system platforms, which leads it to a successful point.

The main problems that teachers/lecturers and students face while using online learning platforms are time management difficulties, lack of motivation, lack of lecturer/teacher-student interaction, difficulties in finding assignments, difficulties in identifying misbehaviors, minimum active attendance, lack of student-student interaction, minimal accuracy of attendance taking mechanism are decreasing the advantages of self-learning freedom which is the best advantage that a student can have from this distance online learning platforms. Distance learning platforms inspire the students to do self-learning and encourage to identify self-learning techniques. These reasons which are mentioned here are based on previous research done by the researcher. To avoid being happening these difficulties and problems when conducting online classes, existing systems need to be optimized, or a new unique system must be developed. From the requirements, the researcher has proposed a methodology to avoid the problems that exist when conducting online classes (virtual classrooms or video conferencing). The paper discusses how the requirements analysis is done and the flow of the development process with relevant phases. 'ActiveMeet' is an application with a set of features that enable you to conduct lectures (online classrooms) with the freedom to take advantage of online learning methods using advanced computer technologies.

## II. RLATED WORKS

Studying existing applications related to the system and research on topics of findings, are needed to find the best ways to implement the system with the necessary components. There are several popular applications that are being used today with different types of features. The

developers of those applications are doing research to provide the best experience for users while conducting online classrooms. Distance learning education inspires the students to do self-studies and a good nondisruptive own environments to do studies.

Distance education is a good way to conduct online learning activities when physical attendance is not required. Instead of physical classrooms, online classrooms allow students to learn individually in their study paths. CQUniversity conducted a survey on the satisfaction of using distance learning methods to conduct an undergraduate degree course in engineering and found that using the zoom platform to conduct online classrooms results in better student satisfaction. Students with a clear background with additional teaching mechanisms can also enjoy tutorial lessons. Not only for individual goals but also as a group of students who are satisfied with conducting sessions across the magnifying platform as a distance learning method. The use and features of magnification increase students' satisfaction with their learning outcomes, thereby reducing their ability to work as instructors (lecturers/teachers). (Taylor, Mcclanachan and Mumtahina, 2017)

Not only is COVID-19 currently causing epidemics, but many counsellors use online methods to conduct counselling programs. There are three main parts to conducting counselling programs through online platforms. The effectiveness productivity across platforms including WebEx greatly influences students' positive results when considering student groups. There are six best practices that help students to be active in sessions, some of which the researcher mentioned are technically connected to enhance positive outcomes based on research objectives, allowing students to feel the session as a community. Content that provides counsellors goals and aspirations provides a timely feedback mechanism. WebEx is a great way for students to actively engage, allowing users to share their voices and video. The third part also allows users to use multimedia services, such as YouTube videos and presentations through meetings. (Keengwe and Bull, 2016)



Primarily for this study, the required observations of students' patterns in attendance and involvement were determined with the use of Blackboard LMS. According to the findings of this study, their active participation has a positive impact on student achievements & in terms of their final grades. Being a part of developing & encouraging virtual classroom concepts, the researcher was astonished as the study proved that how student engagement affects bringing online lecturing sessions to success. Student-lecturer interaction, attendance frequency & active participation have a major influence on students' online learning process & on their path to achieve the educational goals by coming up with flying colours. As explained in the research, with the virtual learning facility & having 24x7 access to the educational materials & course content students tend to obtain higher grades & passes with minimum participation in the online classes. However, the study further describes how the assessment of students is directly related to their active interaction with the online learning programs. The conclusion of the finding is that the spirit of being present is the key to the success of learners in a distance learning space. (Rapposelli, 2014)

The publication questions that how effective it is to continue education as specifically for teaching English as a foreign language for a selected sample of medical students with the use of Zoom technology which is known as a popular distance learning tool. The researcher points out as obvious as it is the English language is a universal medium of communication & way of expressing thoughts & feelings on an international platform which can be identified as a tremendous contribution to the world of communication. When it comes to teaching such language, it should be a more interactive, motivating & engaging method of education in order to gain its maximum output. So that according to the findings of the study, teachers have been able to convert the education system to a rich interactive manner with the use of Zoom technology which is one of the new software-based conference room solutions. With the available various special features, learners always can actively collaborate with the sessions. As an interactive method of distance learning study reveals that the educators & the

students find the new method of teaching as an effective way of communication. As summed up in the study this innovative approach of distance learning is improving learning outcomes with more interactions in-between students & teachers. (Guzacheva, 2020)

The study is on the effectiveness of online learning. It is based on a direct comparison between virtual learning opportunities & the traditional in-class educational system. Previously observed insights within many educators & students, express that they are more in-live with this emerging distance learning space by considering expenses when it comes to being physically present in an institution. Findings have proved that many students appreciate these online learning methods as more effective since they are actively participating in the programs and the intended learning outcomes can be gained eventually. Though it has null & positive reporting, the researcher has demonstrated & determined the distance learning system is a success as another path that is optional for the learners. While concluding many findings and challenges being discoursed in reference to the subject. Discussion on the effectiveness of the distance learning format is ultimately dependable on the presence & lively contribution towards the lecturing or learning process from those who are signed up to the virtual learning platform. That is the reason why the publication has emphasized the fact that distanced education is moderately at least as effective as the traditional system. (Nguyen, 2015)

The research is mainly focused on how students are adapting to the concept of online education which is caused by Covid-19 pandemic. The further researcher discussed the barriers which are students collectively facing when it comes to participation in online lectures, such as coverage issues, power failures, mental tension, etc. Reported facts in the study are brought to a summation against the elements which are gathered by actual surveys. Especially the survey on the 'Duration of a class preferred by students' showcases the students' commitment & desirability towards online education. The study is also concerned about the psychological atmosphere when participating in distance learning programs with students' emotional

strikes. Most importantly with social distancing, students are badly missing their social life which seems to be a stimulation for the active engagement towards the online lectures. The study reveals when students attending to the online lecturing sessions, they feel connected & live with the learning process. The frustration of learning in a virtual environment might lead to losing their interest in attending classes. Hence the research consists of a study on the feelings & moods of learners when it comes to active participation. (Palamattath, 2020)

### III. DESIGN & IMPLEMENTATION

In the process of implementing the system, the researcher gathered the requirements of previous research based on a survey and analysis. From the findings of the research, there are several potential problems with using existing systems and applications used by instructors and students to conduct online classes. Problems that arise during lectures for a good outcome, come from students' inattention and inability to keep students' attention from lecturer / teacher lectures. And low student-to-student interaction, there is no mechanism to prevent student misconduct during lectures, and poor attendance when it is mandatory to attend to assess student progress. Students' positive learning outcomes are reduced difficulties in conducting online classes rather than physical classes. Therefore, the system needed to implement it should be designed to avoid these existing problems. As an education-oriented system, the system should be designed and implemented according to a student-lecturer-oriented approach. Therefore, for a positive learning outcome, it should be planned and implemented as the requirements have been gathered by analysing the survey information conducted by the researcher in the previous study. Online distance learning methods are very useful when considering some of the advantages that are not available when conducting physical classrooms. Advantages of conducting online classrooms are,

- No disturb like in classrooms.
- Each student can concentrate the teacher or lecturer very clearly – because everyone participates the lecture by turning off their mics and cameras. Therefore, any disturbances from

others do not affect to the concentrate of the student.

- Students and teachers have more time for readying for the lectures and lessons - no time wasting for transportation, no time wasting for readying, no need to make special attention for meals, mind is free without other considerations.
- Can take clear notes – lecturer is clear in talking because students are only hearing what lecturer speaks.
- Inspiring to self-learning – each student must participate the lectures individually from their home, therefore everything except group works force the students to do individually.
- Teachers can use more interactive methods when teaching
  - presentations, screen sharing, white board, games related to subject modules, clear example suggestions like simulation videos.
- Very effective and interactive method for visually and hearing-impaired students – partially it is very helpful to visually and hearing-impaired students because the laptop is the source, they get their lectures. They can volume up, use headphones, zoom presentations, brightness up if any difficulties occur. They can adjust the source at their own requirements for a better result.
- Recording facility of lectures – Each meeting application gives a feature to record meetings. In physical classrooms there is no opportunity to rewind lectures if any students missed it or did not able to understand. But online classrooms with the usage of such applications let students to take this opportunity.

The difficulties should be avoided, and maximum benefits can be obtained from the systems by taking advantage of online distance learning lecturers/ teachers and students. Therefore, the researcher introduces a system that helps to monitor and analyse students' behaviours and activities during online lectures. The researcher can identify the active and non-active needs of the researcher as follows. The system also has the functions of an online meeting application. But the additional functions mentioned here are only those related to the student behaviour tracking system.

## Functional Requirements

Table 1 Classification of functional requirements under user requirements

User	Functional requirements
Lecturer	<ul style="list-style-type: none"> <li>•Create an account.</li> <li>•Login</li> <li>•Scheduling meetings</li> <li>•Inviting meetings</li> <li>•Getting notifications of student's activities (sleep detection, not attending with lectures)</li> <li>•Getting notifications of computer activities (extra activities which are not related to lectures)</li> <li>•Getting notifications of in-class computer-based assessments &amp; activities</li> <li>•Receiving detailed attendance reports</li> </ul>
Students	<ul style="list-style-type: none"> <li>•Attending meetings</li> <li>•Receiving detailed report of active participation to lectures</li> </ul>

## Non-Functional requirements

- UI design – the targeted users are students and lecturers. They can use the application very easily. The system carries complex processes inside, but the interfaces must be user- friendly and simple to use.
- Performance – real time activity tracking and notifying is a core part of the application. To do that processes the system must work in a good performance condition.
- Reliability – students can take the advantage whenever something found to miss lectures. It is very important that the outputs which is generated by the system to lecturer or host are reliable.
- Efficiency – this system is designed for mainly enhancing the learning outcome of online lectures. Therefore, it is a must to work efficiently for good results.
- Security – tracking activities through camera is critically affect to the privacy of students or attendee. Therefore, the security of the system must be in a good level to perform the processes.
- Accuracy – not reliability lies on the trustworthy of the results from the system, but the system

should function at a higher level of accuracy for reliable results.

The proposed system was developed for use in windows and the web. Therefore, it is decided to be designed to be implemented according to service-oriented architecture. When spreading the system services throughout a big potential of users. Multiplatform support, multi-OS support and multidevice support can be guaranteed with SOWP. Zoom, WebEx, Microsoft Groups and Google Meeting have the same features included when considering the user interface and system features. The features which should be proposed to include within the system are,

- Monitoring and notifying about students who are sleeping or not sitting in front of the computer which means not attending to lectures actively.
- Monitoring and notifying about students who use non- related computer software to ongoing lecture. (computer games, watching movies etc.)
- Generating attendance sheets by analysing the time of student's active involvement to lectures.
- Tracking in-class assignments which are based on computer software. (By task monitoring on computer)

The system design can be shown as follows which is designed respect to the analysed requirements and features.

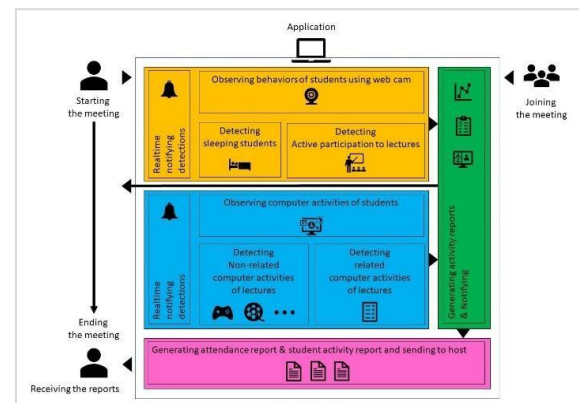


Figure 1 System Design Author (s) 2021

As a meeting application that is aimed to run on Windows operating system, it includes 4 major development modules. These include monitoring student activity via webcam, monitoring student activity via computer task monitoring, generating, and reporting activity reports, generating attendance reports, and sending to the host.

### A. Student activity tracking through the webcam

This is being used to track the misbehaviours, detect sleeping, detect whether the student is sitting in front of the computer to confirm the students whether they are attending to lectures or not. Turning off mics and cameras are very helpful when conducting online meetings. No background disturbances, zero interruptions of individual attention and it let the student to completely focus only to lecture at their eyesight. It helps to conduct the lecture without the disturbance of any activity of students and the noisy background of physical classrooms. This part is implemented using AI which helps to track facial behaviours including movements of the face(liveness), drowsiness, and sleeping. The whole part is developed using python programming language including OpenCV for facial recognition data inputs. This part is included in the windows application. Therefore, it can be able to work without any support from the server. Tracking something through a webcam is very critical when considering the privacy of the users. In this system, the tracking parts are done in the on-device-processing mechanism which tracks and processes on the device without a server connection, and the output result only be transferred through the network.

The sleep detection and movements(liveness) are tracked using points of face which is processed using a large dataset of facial data. The points are spotted as follows. (Bahadur, 2017)

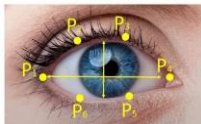


Figure 3 Points on eye (Bahadur) 2017

*B. Student activity tracking through computer task monitoring*

This is used to monitor students' computer related activities. This module can be used to identify a student who has already participated but does not connected to the lecture and is doing something else using a computer. This helps when any student does something that is not related to the subject module or to the lectures such as watching movies or playing

The sleepiness is detected through an algorithm as follows.

video games etc. The module records any kind of application that has been opened in the participant's computer. The lecturer can track when doing a in-class assignment using any computer software. As an example, if the assignment should be done using Cisco packet tracer, then the host or the lecturer can allow Cisco packet tracer to run without monitoring in the background of the computer of students. Sometimes students do not try to do in-class assignments if they are optional to perform, but it will affect the student's learning outcomes and subject module. In physical classes, the lecturer can test during class assignments. But when doing online classes, it will be missed.

EAR is the aspect ratio of the eye, which is then observed to be alive using the factors indicated with the value changes of x and y. If the EAR value is less than 0.25, the system will notify you that it is asleep. It is captured live when the student tries to cheat the software by using photos or something that looks like students but does not real.

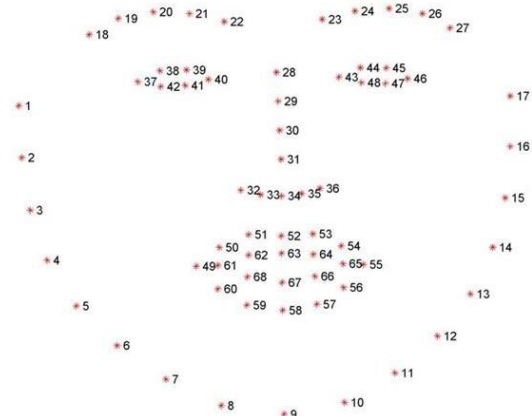


Figure 4 Points on face (Bahadur) 2017

$$EAR = \frac{\|p_2 - p_6\| + \|p_3 - p_5\|}{2\|p_1 - p_4\|}$$

Figure 5 EAR calculating formula (Bahadur) 2017





windows are the most essential platform for holding meetings. Windows applications allows the developer to enable many features offline, such as the most essential device configuration feature for tracking activity through the webcam, rather than the Web application. At the front end, the Windows application has an AI component that helps identify and monitor students' activity behaviour via a webcam. When discussing system design, it is discussed under the heading of monitoring student activities through webcam.

#### WebRTC

The controllers communicate with the WebRTC API, which helps to hold meetings by sharing video and screen and it is very easy to integrate with Java. WebRTC is a communications service that can only be shared with Frontend.

#### Backend Layer

Backend is the core server of the entire system providing mirror controls, services, repositories, and database services. Developed using Java and XML, the backend is implemented using controllers, advisors that help communicate the relationship between services and the store. Supports communication between DTOs (Data Exchange Objects) and Institutional Funds, Services and Controllers. This is the layer responsible for managing meeting schedules, generating reports, sending links, user signing and signing in, and holding meetings.

#### Database

Where the user details, user credentials, meeting schedules, real-time notification data and real-time report generating data are handled. The backend includes the database system which is implemented using MySQL.

### IV. DISCUSSION & CONCLUSION

The system is exactly same as Zoom software, a meeting application like Cisco WebEx, Microsoft Team or Google Meeting. But those applications have not been customized to consider the intervention for educational purposes. Due to the low interaction of students and lecturers and often the lack of inspiration, lack of background such as physical classrooms, learning methods in online distance learning systems are not in good condition. When considering the social behavior of

students between a physical classroom and an online classroom, online classrooms increase the distance of social behavior of students. Among students' friends can wake their friends if fall asleep during lectures in physical classrooms. But this system allows other students to care about their friends through the system features. And interactions like liking, smiling, laughing, clapping which can be also found in Microsoft teams, Zoom are also integrated with the system. And time management is a very important part in this subject field. Because the effective attention time of a student in a continuous lecture always limited to number of minutes. Keeping the students by force will be a very bad reason to negative outcomes and feedbacks to lectures. Therefore, taking short breaks, playing educational games and discussing something else which may not relate to the subject but for refresh the students by time to time is a good ethical habit that can be maintain by a lecturer. And this system is more flexible because the two types of monitoring mechanisms (behavior and computer tasks monitoring) is not mandatory to perform during the lecture time. If the lecturer does not need one of them, he/she can conduct the lecture meeting without using these features. Going back to the physical classroom in a situation like the COVID-19 epidemic is difficult and risky and must be controlled. But there are a few additional benefits, and online classrooms can be updated to connect students to lectures to train them to take real advantage of online distance learning systems. The proposed method avoids many problems for lecturers/ teachers by avoiding time management difficulties, lack of motivation, lack of lecturer/teacher-student interaction, difficulties in finding assignments, difficulties in identifying misbehaviour, lack of correct attendance marking mechanism. Lack of student-student interaction in terms of active participation, prevention of self-learning freedom. This system allows the lecturer to get a clear idea of who the lecturer is, who is not in front of the computer, who misuses the computer during lecture time, and how the lecturer lectures by looking at the advance attendance report, changing the lecture style and other satisfying mechanisms. The system layout offers advantages such as adapting the system to multiple platforms with future work as Android and iOS applications. Using system-oriented architecture allows the developer to develop and add additional features without modifying to other layers of the system. When it comes to security. The Windows application is the most appropriate and advanced method used by lecturers to monitor

students' activities without compromising their privacy.

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# Network Infrastructure Monitoring Tool for Small and Medium Scale Enterprises

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**Abstract**— Modern SMEs utilize some form of computer network to accommodate both internal employees and external customers. Hence, managing the network infrastructure is crucial for SMEs. Network infrastructure monitoring is utterly important for network management, to attend to any critical situation as preventive measures for corrections. Eventually, a hassle-free network is introduced, assuring 24x7 availability. As a result, some form of a network infrastructure monitoring tool (NIMT) is an essential element for SMEs, despite the fact that commercially available high-end NIMTs are not affordable in any situation. On the other hand, many SMEs do not consider incorporating an NIMT with priority, since they can still survive with the primary business process, although there are significant interruptions of the network infrastructure. Nevertheless, the involvement of ICT experts is essential on either a full-time or part-time basis to operate high-end NIMT, due to the complexity to deploy and maintain it. As a result, “How to introduce comprehensive, user-friendly, affordable and maintainable NIMT for SMEs?” is the research question. In our methodology, the literature is evaluated for understanding the unique requirements of network management, and the available NIMTs are analysed under eight specific functionalities. Subsequently the design is finalized, focusing on the requirements of SMEs and the system development is based on python, whereas the operating system is Linux. More importantly, the user interface is based on PHP, while the database is on MariaDB. This all-in-one NIMT solution can be used by anyone for essential network analysis. Moreover, SMEs shall benefit from this solution in an effective manner, with neither extra software license cost nor the involvement of ICT experts.

**Keywords:** *utilising network, network monitoring, all-in-one*

## I. INTRODUCTION

In the present day industry, the network management is crucial, and this include provisioning, maintaining, administrating and operation of the network infrastructure. The network management ensures resources in the network are available for users in an efficient and effective manner improving the quality of service. As the name implies, the NIMTs monitor network traffic and workstation/server performance. Moreover, those are not an all-in-one solution, so the user has to get add-on platforms, such as OS, DBMS software, web server software, hardware, etc., to effectively implement the platform for NIMTs, and it discourages users to adopt the NIMTs at the SMEs. Further, there is an extra cost with such add-on platforms, and it is further discouraged. Nevertheless, those add-on platforms must be deployed in a dedicated physical infrastructure (desktop or server) for installation and configuration on software-based NIMTs. Moreover, it is essential to have a knowledgeable person to install, configure and maintain such a system in a company, otherwise it is essential to recruit someone considering the long-run requirement. Due to those essential extra expenses, the use of NIMT is not motivated, and this has been identified as the background for the research problem of “How to introduce comprehensive, user-friendly, affordable and maintainable NIMT for SMEs?”

With the growing demand to adopt IT into the business everywhere, workstations, laptops, and servers are used by many organizations. Eventually, businesses highly rely on those devices, and the availability of them to access those devices is essential for smooth operations. However, the slowness and breakdowns situations of network infrastructure are

interrupted on the smooth operation of the business process of SMEs. Therefore preventive and corrective maintenance and resource management are highly important. For network infrastructure maintenance and resource management, monitoring network infrastructure in real-time is the best way to maintain infrastructure uptime at the required level. Eventually, this indirectly influences positively on productivity and profit of the SME. The proposed NIMT is not only a software solution to monitor the network infrastructure but it comprises the relevant hardware infrastructure as an all-in-one solution. The following objectives are achieved in the project as the solution for the research problem.

- i. To provide an all-in-one solution catering to the basic requirement for network infrastructure monitoring.
- ii. To improve the efficiency and effectiveness of the network infrastructure in SMEs.
- iii. To assure the utilization of the available hardware.
- iv. To reduce the cost of network infrastructure management for SMEs.
- v. To develop an affordable network infrastructure monitoring solution for SMEs.
- vi. To improve the business process of the SMEs indirectly.

## II. BACKGROUND

The background of the solution focuses on evaluating the purpose of the network monitoring tool, and the sources for the literature are from peer-reviewed journals. Nevertheless, the available similar products in the market are also evaluated next as per Table 1 for a clear understanding of the requirement to have an affordable device to cater to the requirements of SMEs.

### A. Literature Review

Managing network infrastructure is a critical process of modern IT-related enterprises (Ferraiolo, Kuhn, and Hu, 2008; Liu, 2021; Jovanovic, Markovic, Popovic, and Jovanovic, 2010; Verma, 2002), and this includes provisioning, administrating, operating, and maintaining of the network. Further, network infrastructure management ensures resources in the network are available to users in an efficient manner and consumed efficiently by users (Ferraiolo, Kuhn, and Hu, 2008). Eventually,

proper management of network resource increase quality of service.

Network provisioning involves providing equipment, services, or software to employees or ICT professionals (Ferraiolo, Kuhn, and Hu, 2008). Once the authenticated user requests for different services/resources, then authorization is taken place to grant relevant privileges, so the access control is managed effectively by considering the assigned privileges through the automated process to control the operations towards specific resource requirement(s).

Network administrating carries out a wide range of operational tasks that ensure smooth and efficient performance of an enterprise network (Verma, 2002), and policy-based initiatives are encouraged for network management to simplify the complexity of dealing with multiple users. The absence of a minimum level of network administration is always problematic for the smooth operation of the network environment for anyone other than operating smaller networks.

Network operation focusing on the hassle-free best functionality of the network (Svoboda, Ghafir, and Prenosil, 2015), and monitoring the network, pre-emptively identifying and solving the issues are main tasks. Among them, monitoring the network is a significant component for network operation for having proactive measures for remedial actions, otherwise, it is not guaranteed to comply with 24x7 service requirements.

Network maintenance mainly includes corrective and preventive maintenance to adopt the evolvement of the technologies adequately (Liu, 2021), so updates and bug fixes to device software, and reviews of security policies are important to incorporate within the scope of the corrective maintenance. Even intermediate devices such as L2-switches, L3-switches, and routers should be upgraded in a timely manner to assure the smooth functioning of the network.

### B. Evaluation of Tools

Among the available similar tools, few tools are considered based on purposive sampling to evaluate as in Table 1 focusing the specific requirements of the SMEs, and relevant product specifications are used for this analysis over the 8 different factors listed below.

1) *Hardware Utilization Monitoring*: hardware utilization is utterly important to observe over 24x7 otherwise the availability of the servers/services can be interrupted. Addressing such a situation all the following tools have been provided some way of communication with network administrator/team via email, text, a dashboard in the industry.

2) *Network Utilization Monitoring(NUM)*: NUM is also important for the medium and large-scale industries where complex networking infrastructures are available. However, SMEs are not comprised of such networking infrastructures. As a result, the comprehensive NUM is not essential for SMEs by considering the requirement, despite there is average use of NUM in some situations.

3) *Internal Session Detail Monitoring(ISDM)*: The number of connections that each computer maintains with some other computer can be captured through this feature with the details of the sessions. It is useful for recognizing the suspicious computer which is having an unpredictable connection with either internal or external device(s) because it can be due to internal/external threats. This feature is available by default only with the first option, and it is not affordable for SMEs.

4) *Alerting and Reporting*: This is the primary option for any monitoring tool having prompt notification in the pre-defined critical situation via email, text, mobile app, and dashboard, etc. In SMEs, at least the minimum level of these features should be incorporated to assure prompt responses due to any situation.

5) *Device Discovering*: The availability of the nodes of the networks are captured via SNMP or client application focusing the traffic towards the well-known ports such as HTTP, SSH, SMTP, DNS, ICMP, etc. However, it is not comprised as a basic feature for some cases, whereas it is possible to incorporate it through additional services.

6) *Additional License Software Required*: The basic version is not adequate in many cases to deploy the monitoring tools due to the requirement of the supplementary operating systems or application software. With that, it is further difficult to afford for SMEs.

7) *Price*: The NIMT is usually expensive along with the available features. Although it is not considered with priority by SMEs due to the non-

value addition for their business process SMEs should consider adopting some form of NIMT by considering uninterrupted networking facilities to streamline business processes.

8) *Hardware*: Almost all of the NIMTs are software-based implementation and it is required to adopt hardware to deploy NIMT which is not practical in SMEs because there is no strong technical workforce in most of the cases.

Table 1: Evolution of Available Tools

Option of the tool	Solar Winds Network Performance Monitor	Paessler PRTG Network Monitor	Manage Engine OpManager	Zabbix	Nagios XI
Hardware Utilization Monitoring	Yes	Yes	Yes	Yes	Yes
Network Utilization Monitoring	Yes	Yes	Yes	Yes	Yes
Internal Session Detail Monitoring	Yes	No	No	No	No
Alerting and Reporting	Yes	Yes	Yes	Yes	Yes
Device Discovering	Yes	Yes	Yes	No	Yes



Additional License Software Required	Yes	Yes	Yes	No	No
Price (USD)	2,675	1600	16,495	0	1,995
Hardware	No	No	No	No	No

### III. METHODOLOGY AND EXPERIMENT DESIGN

#### A. Methodology

In this research, relevant literature is considered under the requirement gathering, and the present-day related tools are evaluated for catering to the requirement of the SMEs. As a result, the main factors to monitor for evaluating the exact requirement to develop NIMT are identified as details of an enterprise network infrastructure, hardware system requirements, and software requirements.

Then, the design is introduced as a block diagram incorporating the required elements as the initial phase, and that is revised accordingly throughout the development phase. The coding is mainly based on Python and there is comprehensive testing based on identified test cases before the deployment. The physical implementation of the NIMT is assured to use at the SMEs.

The overall objective of this methodology is to introduce cost-effective monitoring tool which targets the requirement of the SMEs, and it focuses mainly to introduce an all-in-one solution for the convenient monitoring process.

#### B. Experiment Design

To represent experiment design, the Figure 1 illustrates how the experiment steps are carried out step by step as described in the methodology. The each step represents its purpose and involvement during the experiment.

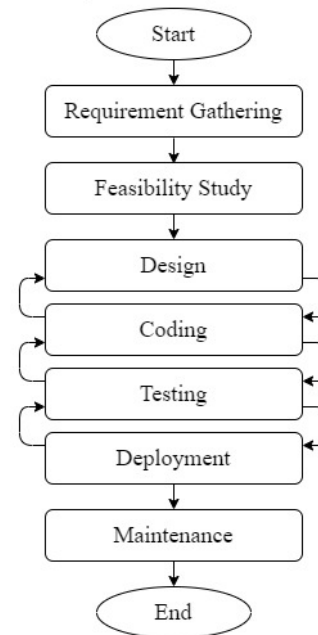


Figure 1: Flowchart of the Experiment

### IV. IMPLEMENTATION AND TESTING

#### A. Implementaion

The implementation is focused on five different elements for the solution as shown in Figure 2, and those are client application, server application, hardware device, web interface, and database. The client and server applications are developed with Python, and the web console is developed by using PHP. The database is introduced using MariaDB, and the deployment server is the Apache server.

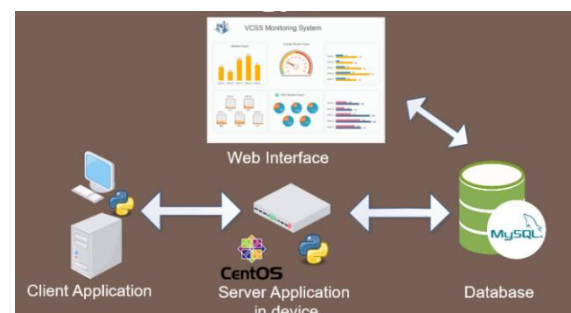


Figure 2: Solution Architecture

To introduce a prototype of the rack-mountable device, Fujitsu laptop motherboard with the processor, cooling system, RAM, and SATA hard disk are used in order to maintain low power consumption and size of one rack unit. Further, the CentOS operating system in CLI is selected due to the free license and minimum utilization of system hardware to install developed server applications. Finally, the solution development is

based on an iterative method that moves step by step in a linear fashion.

### B. Testing

A demonstration is carried out in the actual working environment to make sure the practicality of the solution based on identified test cases. The results are obtained from the demonstration exhibits focusing on the adequate requirements of the monitoring system. The evaluation of the system is based on identified requirements to demonstrate its level of performance and ratings. As a result, a comprehensive tool is introduced adhering to the requirements.

## V. RESULTS AND DISCUSSION

The Blade monitoring system is an all-in-one device and it has the capability to monitor Windows and Linux hosts. Moreover, the users can start monitoring the network infrastructure by simply connecting the device to the network and configuring the IP of the device and the network range. Further, it is possible to customize the available configurations assuring better security.

### A. The outcome of the Blade NIMT

In the Blade NIMT, authentication and authorization have been implemented as basic functionalities to access the devices. Once the environment is ready, the privileged user is allowed to generate the report and alerts as shown in the following figures for example. On the other hand, a normal user can only view the reports and alerts belonging to an individual as per the assigned authorization.

Among the different approaches to evaluate the present utilization of network as per different diagnostic measures, few of them are illustrated below for sharing some understanding. In Figure 3, the highest utilization of the RAM, the hard disk and the processor of three different devices in the network is illustrated for required involvement. This interface is available for both the administrator and normal user roles.



Figure 3: Dashboard

In Figure 4, the RAM utilization and the processor utilization are retrieved for any device in the network for management purpose, and it is possible to apply filters based on date, time period and MAC.

RAM Utilization Reports				
Date	Master Time	RAM Utilization	master_host	Client MAC
2019-04-03	14:45:00	10		255.255.255.1
2019-04-03	13:44:03	75		255.255.255.2
2019-04-03	13:45:02	40		255.255.254.2
2019-04-03	13:46:00	49		255.255.254.3
2019-03-07	11:40:00	24		255.255.254.4
2019-03-08	15:16:01	49		255.255.254.5
2019-03-08	14:45:02	44		255.255.253.4
2019-02-01		52		255.255.252.7

Processor Utilization Reports				
Date	Master Time	Processor Utilization	master_host	Client MAC
2019-04-03	14:45:00	50		255.255.255.1
2019-04-03	13:44:03	72		255.255.255.2
2019-04-03	13:45:02	77		255.255.254.2

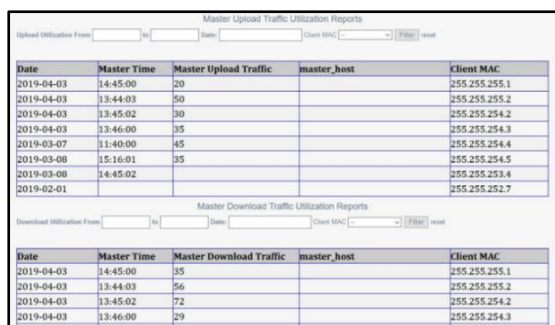
Figure 4: RAM Utilization and Processor Utilization

Similarly, the hard disk utilization is also captured for any device in the network as per Figure 5.

Hard Usage Reports				
Date	Master Time	Hard Disk Utilization	master_host	Client MAC
2019-04-03	14:45:00	72		255.255.255.1
2019-04-03	13:44:03	68		255.255.255.2
2019-04-03	13:45:02	59		255.255.254.2
2019-04-03	13:46:00	39		255.255.254.3
2019-03-07	11:40:00	45		255.255.254.4
2019-03-08	15:16:01	55		255.255.254.5
2019-03-08	14:45:02	25		255.255.253.4
2019-02-01		12		255.255.252.7

Figure 5: Hard Disk Utilization

Nevertheless, the upload and the download utilization are recorded for required actions as in Figure 6.



Master Upload Traffic Utilization Reports				
Date	Master Time	Master Upload Traffic	master_host	Client MAC
2019-04-03	14:45:00	20		255.255.255.1
2019-04-03	13:44:03	50		255.255.255.2
2019-04-03	13:45:02	30		255.255.254.2
2019-04-03	13:46:00	35		255.255.254.3
2019-03-07	11:40:00	45		255.255.254.4
2019-03-08	15:16:01	35		255.255.254.5
2019-03-08	14:45:02			255.255.253.4
2019-02-01				255.255.252.7

Master Download Traffic Utilization Reports				
Date	Master Time	Master Download Traffic	master_host	Client MAC
2019-04-03	14:45:00	35		255.255.255.1
2019-04-03	13:44:03	56		255.255.255.2
2019-04-03	13:45:02	72		255.255.254.2
2019-04-03	13:46:00	29		255.255.254.3

Figure 6: Network Traffic Upload and Down load Utilization

In the Figure 7, there is sample email notification which has been generated due to the suspicious download from a network node (DESKTOP-2JG20B8).

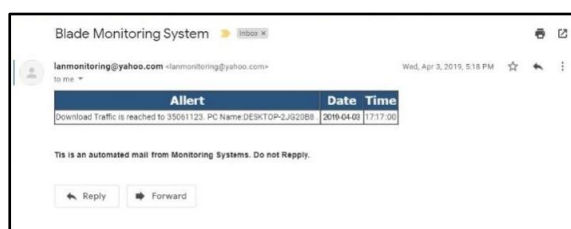


Figure 7: Email Notification Suspicious Download

### B. Evaluating the Blade NIMT

In Table 2, the new Blade NIMT is also evaluated against the eight different criteria used for evaluating similar tools under section II, and the evaluation is based on the fulfillment of the requirements of SMEs.

Table 2: Evolution of the Blade Monitoring System

Option of the tool	Blade Monitoring System
Hardware Utilization Monitoring	Yes
Network Utilization Monitoring	Yes
Internal Session Detail Monitoring	Yes
Alerting and Reporting	Yes
Device Discovering	Yes
Additional License Software Required	No
Price (USD)	450
Hardware	Yes

1) *Hardware Utilization Monitoring*: hardware utilization is utterly important to observe over 24x7 otherwise the availability of the

servers/services can be interrupted. Addressing such situation all the following tools have been provided some way of communication with network administrator/team via email, text, the dashboard in the industry.

2) *Network Utilisation Monitoring (NUM)*: NUM is also important for the medium and large-scale industries where complex networking infrastructures are available. However, SMEs are not comprised of such networking infrastructures. As a result, the comprehensive NUM is not essential for SMEs by considering the requirement, despite there is average use of NUM in some situations.

3) *Internal Session Detail Monitoring (ISDM)*: The number of connections that each computer maintains with some other computer can be captured through this feature with the details of the sessions. It is useful for recognizing the suspicious computer which is having an unpredictable connection with either internal or external device(s) because it can be due to internal/external threats. This feature is available by default only with the first option, and it is not affordable for the SMEs.

4) *Alerting and Reporting*: This is the primary option for any monitoring tool for having prompt notification in the pre-defined critical situation via email, text, mobile app, and dashboard, etc. In SMEs, the minimum level of these features should be available.

5) *Device Discovering*: The nodes of the networks are triggered via SNMP or client application focusing the traffic towards the well-known ports. However, it is not comprised as a basic feature for some cases.

6) *Additional License Software Required*: The basic version is not adequated in many cases to deploy the monitoring tools due to the requirement of the supplementary operating systems or application software. With that, it is further difficult to afford for SMEs.

7) *Price*: The NIMT is usually expensive aline with the available features. Although it is not considered with priority by SMEs due to the non-value addition for their business process SMEs should consider adopting some form of NIMT by considering uninterrupted networking facilities to streamline the business process.

8) *Hardware*: Almost all of the NIMTs are software-based implementation and it is required to adopt hardware to deploy NIMT which is not practical in SMEs because there is no strong technical workforce in most cases. As in Figure 8, the Blade NIMT is an all-in-one solution comprised of both hardware and the software together as one unit.



Figure 8: The Blade NIMT

### C. Future Work

In this phase, the Blade NIMT focuses to monitor the hard disk utilization, RAM utilization, and processor utilization, Network bandwidth utilization of session in desktop, laptop, and servers within SMEs and send alerts as email or SMS to identified responsible individuals. Further, it is essential to extend the scope of the tools by monitoring intermediate devices such as switches, routers, firewalls in the next phase. Further, it is required to improve the reports/charts and improve the system coping with the progressive evolution of the technologies. Nevertheless, the future development is aligned with improving the solution to the next level based on customer feedback to compete with the other competitive tools.

### VI. CONCLUSION

A newly introduced monitoring system provides essential functionalities as per the main requirements of problem identification by considering the requirements of SMEs. Although the commercially available high-end products in the market are performing in a mature manner compared to the Blade NIMT in different aspects, the Blade NIMT fulfill the requirements of the SMEs adequately. Despite some open source tools are available to cater to the same requirement, those have complexities with the installation, configurations, utilization, and maintenance. The choice is always with the customer to make sure whether their requirement is fulfilled with the Blade NIMT because it is available to purchase for an affordable price of USD 450. In that background,

the Blade NIMT strongly recommends for the startup companies and SMEs,

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### ABBREVIATIONS AND SPECIFIC SYMBOLS

- CLI – Command Line Interface  
 DNS – Domain Name Service  
 HTTP – HyperText Transfer Protocol  
 NIMT – Network Infrastructure Monitoring Tool  
 ICT – Information and Communication Technology  
 ISDM – Internal Session Detail Monitoring  
 NUM – Network Utilization Monitoring  
 ICMP – Internet Control Message Protocol  
 IP – Internet Protocol  
 PHP – PHP Hypertext Preprocessor  
 RAM – Random Access Memory  
 SATA – Serial Attached Technology Architecture  
 SME – Small and Medium Enterprises  
 SNMP – Simple Network Management Protocol  
 SMTP – Simple Mail Transfer Protocol  
 SMS – Short Message Service  
 SSH – Secure Shell

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# Three Address Code Based Semantics Processor for Sinhala

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**Abstract**—Semantic processing techniques have a wide interest in the field of Natural Language Processing. Processing a semantic from a natural language for human-machine communication is still a research challenge in this field. The Three-Address-Code is a type of intermediate code used by the compilers to identify the meaning of the source code or statements easily, with full accuracy. Therefore, the research captures the semantics of the Sinhala language text through this Three-Address-Code concept. This paper presents a Three-Address-Code based semantic processing system that can be used for human-machine communication using the Sinhala language. The proposed system comprises three components; namely Sinhala Part of Speech tagger, Sinhala chunker, and three-address-code based semantics generator. The system takes the Sinhala sentence as an input and generates the semantics information. This semantic processing system has been used under the PINA system for semantic processing.

**Keywords:** *three-address-code, semantics, tagging, chunking, ontology*

## I. INTRODUCTION

Search engines have been using for several decades as a most important part of our digital surfing life. We are searching over billions of web resources to retrieve information from various resources. In the beginning search engines were lexical, that is they looked for matches of the query words without understanding the meaning of the query and only gives the links that contained exact query(Rajput, 2020). But with the NLP techniques it gives more hope towards understanding the semantics("Natural Language Processing - Semantic Analysis - Tutorialspoint," n.d.). To be think of humans are particularly good at conversational context and knowledge which make them easier to deal with ambiguity of

words. But in the case of search engines when it comes to searches the problem is semantic search. So as a remedy for this problem here comes latest's insights form NLP research and resources. This can search for contents with same semantical phrases.

Natural language processing is a way to give the ability to understand natural languages for machines. Semantic processing is a sub part that is discussing in this; a way to get the meaning of a text. For that purpose, different techniques are used. A sentence has a logical concept of conveying the idea which can called as predicates. These can be identified by main verb or from the other parts of the sentence. Therefore, depending on the names given for these arguments, the method can be change. Semantic role labelling is the name given for identification of the predicate and the arguments for that predicate. There is also another kind of method called word sense disambiguation which is used by NLP for resolving various kinds of ambiguity("How Natural Language Processing will change the Semantic Web," 2016). A word can gives different meanings depending on the contextthey are being used. This makes the natural language understanding by machines more complex. These different meanings are called word senses. That is the sense of the word depends on Neighbor words around that word. Therefore, selecting the correct word sense is done by this method called word sense disambiguation. This method can have an impact on Machine translation processes, question answering and text classifications. There is another path called Named entity recognition in Natural language processing which focuses on identification of named entities such as persons, organizations, locations which can be denoted using proper nouns. The same words can represent different entities in different contexts. This method is used in text classification, content recommendations, trend detection etc. so these

are some existing semantic analysis methods used in Natural Language Processing.

In except for these methods our research is to use a compiler technique called three address code to extract the meaning of a given sentence and perform semantic analysis. Three address code technique is a compiler mechanism used by compilers to generate intermediate code which is formed by separating the given expression into separate several instructions. These instructions or the intermediate code is then can be easily translated into assembly language which can machine understand. This method is used for a generous sum of calculations. So, the research is carried out to find whether this method of calculations is possible to use in extracting meaning from a Sinhala Language context. The most important here is that whether the given context have uncertainty or not, the compilers can extract the meaning from the sentence. So, in here without considering ambiguity our main aim is to find out whether this same technique used by compilers can also be used to extract the meaning of Sinhala Language context.

The rest of the paper is structured as follows: A study on Semantic Processing is given in section 2. Section 3 discusses the Methodology and section 4 discuss How the system works and finally, section 5 will provide some concluding remarks.

## II. SEMANTIC PROCESSING

The use of semantic processing is to find the exact meaning from a given text ("Semantic Analysis In Linguistics," 2020). First part of the semantic analysis is to study the meaning of individual words of a given text and this is called as lexical semantics/processing. In the second part each word will be combined to provide meaningful sentences. A word can have several meanings based on the context of its usage in the sentence. Then they are ambiguous too, so we need to remove the ambiguity. For that we must check what is the prior sentence to that word. So, this sense we have word sentence disambiguation ("NLP - Word Sense Disambiguation - Tutorialspoint," n.d.). Lexical ambiguity, syntactic and semantic are the problems that any NLP system must undergo. For that Part-of-Speech taggers can be used to solve the problem. What will happen when parsing is done when there is no proper meaning of the sentence, so in such cases we use semantic

grammars to solve the problem ("Part Of Speech Tagging - POS Tagging POS (Part of Speech) NLP | byteiota," 2021). This grammar performs both syntactic and semantic checking.

Therefore, the extremely basic of semantic analysis is to get the proper meaning of the words or the sentence.

### 1.1. Meaning Representations

Semantic analysis uses several approaches for the representation of meaning. They are,

- First order predicate Logic
- ML-based techniques; Semantic Nets
- Frames
- Conceptual Dependencies
- Rule-Based architecture

#### 1.1.1. First Order Predicate Logic

First order logic is a flexible and computationally tractable meaning representation language. It provides a sound computational basis for the inference, expressiveness and verifiability and helps resolving ambiguity ("Natural Language Processing - Semantic Analysis - Tutorialspoint," n.d.).

*Eg: There is a teacher in town who teaches all children in town who do not have money themselves.*

$$\exists x (Teacher(x) \wedge InTown(x) \wedge \forall y (Children(y) \wedge InTown(y) \wedge \neg HaveMoney(y,y) \rightarrow teachandlearn(x,y)))$$

#### 1.1.2. ML-Based Techniques

English language is easy to identify and separate according to the meaning expressed by the text. If we consider about tokenization, it is about breaking a document or sentence into words for the ease of understanding the meaning. This is easier in English language. NLP rules are sufficient for this.

But what if we need to work with any other language except for English and here we use machine learning for tokenization. Using ML based techniques, we can train a model to identify and understand them.

There are 2 types, Supervised Machine Learning and Unsupervised Machine Learning for NLP and Semantic Analysis.

In Supervised machine learning a batch of documents are tagged with examples of what the system should look like, and these documents are used to train the model. The larger the dataset its better as it learn more about the document.

Unsupervised Machine learning train a model without pre tagging. One feature that will focus here is Clustering. Clustering means grouping similar type of documents together into sets and then these sets of clusters are sorted based on their importance. This is called as hierarchical clustering.

Another feature is Latent Semantic Indexing. This technique identifies words and phrases which frequently occur.

Matrix Factorization is another technique, and it uses latent factors to break large matrix into combination of small matrices.

Unsupervised learning is tricky but data intensive than its supervised counterpart("Machine Learning (ML) for Natural Language Processing (NLP)," 2020).

### 1.1.3. Frames

Frame is a data structure to represent same properties for knowledge representations as in semantic networks. Semantic networks include nodes that show objects and explain the relationship between those objects. Frames have same ideas of inheritance and default values. They contain instructions to be understood well for computing things stored in other frames. Frames are useful in simulating commonsense knowledge which is exceedingly difficult for computers to handle("Framing And Frames In NLP," 2016). Frame based expert systems useful in representing knowledge organized by cause and effect. Frames are designed to show either generic or specific type of knowledge.

### 1.1.4. Conceptual Dependencies

Conceptual dependency is a way to represent the meaning of natural language sentences in a way that first shows the drawing inferences from the sentences. Is a theory of NLP which deals with representation of semantics of a language. It has been argued that representation in independent from the language which the sentences were originally had. Conceptual dependency argues that representation of a sentence is awaken not out

of primitives related to the words in sentences but because of conceptual primitives that can be combined to form the meanings of the words in any language basis. In a dependency relation, one partner is dependent, and the other is dominant(Hull, 1972). The main goal of conceptual dependency base representations is to make explicit of what is implicit.

### 1.1.5. Rule-based Architecture

Rule base systems are used to store and process knowledge to interpret in a useful way. In logic we represent knowledge in a form of declarative static way. Rules in logic implicit what is true and false based on given conditions. Rule base systems are based on rules which say what to do in given conditions(Niu and Issa, 2014).A special type of interpreter controls when rules are invoked. Somehow these systems are very remarkably similar rules in logic. As for examples.

If it rains today the road will be wet today

Rains(today) → wet\_road(today)

Therefore, a system whose knowledge base is represented as a set of rules and facts is known as a Rule Based system. It consists of IF-THEN rules, and collection of facts and interpreter controlling rules given the facts.

### 1.2. Semantic Analyzer and Intermediate Code Generation

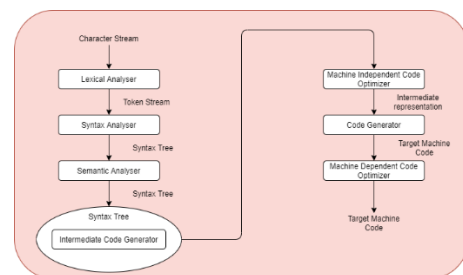


Figure 01: Intermediate Code Generation

Intermediate code is The output from the parser and the input to the code generator.

There are 3 types of intermediate representations

- Abstract Syntax tree
- Postfix Notation
- Three Address Code

### Abstract Syntax Tree

It depicts the natural hierarchical structure of a source program. A directed acyclic graph gives

the same information but in a more compact way as common sub expressions are identified.



### Postfix Notation

Is a linearized representation of a syntax tree. There are list of nodes of the tree in which a node appears after its children immediately.

As these types of representations are present but they never used for Sinhala Language semantic processing. Therefore, Three Address Code technique is never used for processing semantics.

### III. APPROACH

#### Three Address Code

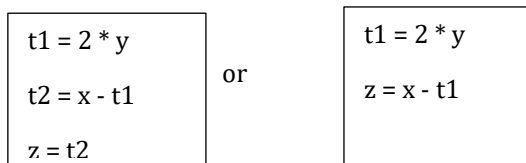
Three address code technique is used in programming languages to process unambiguity in sentences. Compilers use three address code to identify the absence of Unambiguity in the sentences. Therefore, the research is focused on use of Three Address Code on Semantic processing for Sinhala Language.

Three Address Code is an abstract form of intermediate code. The way to implement is as records with fields with the operator and the operands. At most it has three addresses in the instruction and one operator on the right hand side of the assignment.

General statement form:  $x = y \text{ op } z$

Longer expressions are simplified into small expressions.

Eg:  $z = x - 2 * y$



The contents arg1, arg2 and result are pointers to the symbol table entries for the names represented by those fields.

There are 3 representations of Three Address Code.

#### 1. Quadruples

A quadruple has 4 fields: op, arg1, arg2, result.

For example, the three address instruction  $X = y + x$  is op, y is arg1, x is arg2, X is result.

t1 = minus c  
t2 = b\*t1  
t3 = minus c  
t4 = b\*t3  
t5 = t2 +t4

op	Arg1	Arg2	result
minus	c		t1
*	b	t1	t2
minus	c		t3
*	b	t3	t4
+	t2	t4	t5
=	t5		a

$a = t5$

(Three Address Code)

#### 2. Triples

Has only 3 fields; op, op1, op2

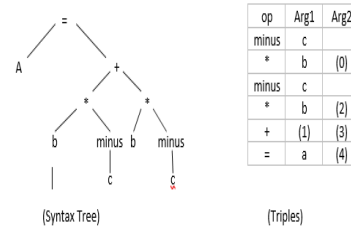


Figure 2

#### 3. Indirect Triples

Indirect triples consist of a listing of pointers to triples.

Intermediates codes are closed to machine instructions but machine independent. The given program in its source language is transform into equivalent program by intermediate code generator. Intermediate language can be many different languages and the compiler decides the intermediate language. As described above Syntax trees, Postfix notation and Three address code can be used as an intermediate language("Compiler - Intermediate Code Generation - Tutorialspoint," n.d.).

Applying Three address code for Semantic processing in Sinhala is shown in the section below.

### IV. DESIGN & IMPLEMENTATION

#### L. The architecture of the system

The following figure describes the entire design process of the suppose system. The system itself consists of 4 modules: Tokenizer, Sinhala POS Tagger, Sinhala phase base chunker and Ontology Generator.

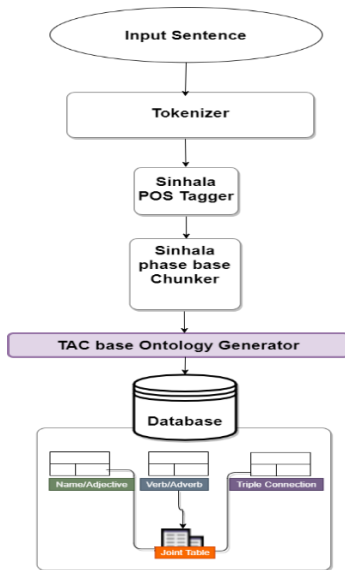


Figure 3: System Design

### Module 1: Tokenizer

This module will focus on extracting words from a given sentence.

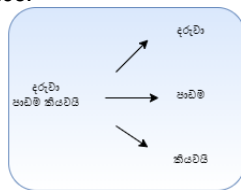


Figure 4: Tokenizing

The very first tasks performing in computing is working with textual input. Therefore, it is required to transform the textual representation suitable for computational processing. This process of transforming into a something suitable for computation is called as lexical analysis or tokenization (Pigulla, 2009). Tokenization is hard because in grammatical context it has lot of issues to address and lots of ambiguities to resolve (Zubac and Dadarlat, 2013). In (Dale et al., 2000) states that tokenization must address language dependency, character dependency, application dependency and corpus dependency. The most important section word related ambiguity concerns abbreviations, a acronym, multi part word expressions (Zubac and Dadarlat, 2013).

### Module 2: Sinhala POS Tagger

Through this module it will assign POS tags for each word which are already separated from the input sentence. Tags are assigned to identify each form of the word whether its is a noun, verb, adjective, adverb and so on.

So, the system will identify the words by its tags.

දරුවා\_NNP පාවිච්චි\_NNP කියවයි\_VFM

In traditional Sinhala grammar variations have been proposed for Part of speech. This is because of the existence of several grammatical schools in Sinhala Language. (Weerasinghe et al., 2009). Therefore depending on those classifications a Sinhala POS tag set was already implemented (Fernando et al., 2016).

### Module 3: Sinhala Phase base Chunker

This module will identify the sentence in its noun or verb phrase forms. Once the tagging part is done through the previous module the chunker will look through those tags and define what form of phrases that they are belong. From the patterns the rules are learned by considering the neighbor word and POS tags the phrase identification was done (Sangal et al., 2007).

### Module 4: Ontology Generator

This module is the final and most innovative section which is focus through this project. Here once identifying the verb and noun phrases the words in preprocessed sentences will be stored to an ontology and this extraction is done through the compiler based mechanism called Three Address Code technique which is described above.

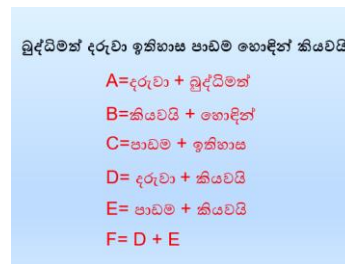


Figure 5 : Applying Three Address Code

The above figure shows how the three address code is used to extract the meaning from semantics.

The ontology will contain number of tables depending on the situation (noun table , verb table, adjective table...). And most importantly Triple Connection table. This table will maintain the original connection (i.e. where those words are come from) of the words which are now stored in the ontology. This will help to traceback the system when generating answer for a question which is exactly the reversed way of doing the same process described till now.



Therefore, through all these 4 modules the system will learn and through the knowledge it gains, the system will be able to answer any question within its domain of knowledge in Sinhala Language.

### V. HOW THE SYSTEM WORKS

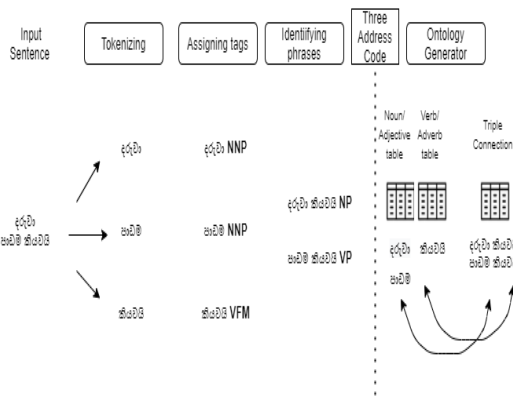


Figure 6: Working of the System

Figure 5 shows how each module of the system is contributing to the system. First the sentences in text form will be entered to the system as the input. Then the tokenizer will extract the words from the sentence separately. While gaining the original words from the input sentence it will also define every form of each word. Because in Sinhala Language the context is very much larger when comparing with English. As you already know the syntax of the Sinhala is very much differ from English.

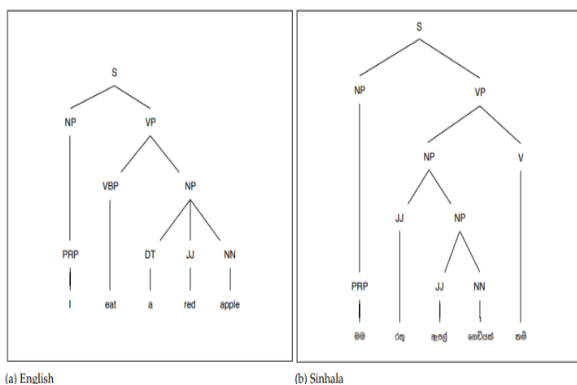


Figure 7: English syntax vs Sinhala syntax

Therefore, the order of the words when defining some context in Sinhala is not like that in English. After tokenizing the words the POS tagger will assign tags to each word after identifying its form of context.

Tag	Description
DET	Determiner
NNN	Common Noun Neuter
NNC	Common Noun
NNJ	Adjective Noun
MNR	Common Noun Root
NNS	Noun Plural
ENV	Sentence Ending
NNP	Proper Noun Singular
NNPS	Proper Noun Plural
NNM	Common Noun Masculine
NNF	Common Noun Feminine
PDT	Predeterminer
RB	Adverb
BRPCV	Particle in Compound Verbs
PRPC	Pronoun Common
PRPF	Pronoun Feminine
PRPN	Pronoun Neuter
SVCV	Supportive Verb in Compound Verb
VP	Verb Participle
PUNC	Punctuations
FS	Full Stop
NUM	Number
PRP	Pronoun Common
VNF	Verb Non Finite
POST	Postpositions
VNN	Verbal Noun
NVB	Noun in Kriya Mula
JVB	Adjective in Kriya Mula

Figure 8: POS tags

The above figure shows some of Part of Speech tags that are going to use in this system. After assigning tags the chunker will identify the grammatical context of the sentence. While referring to the tags it already assigned, the chunker will define each as noun phrase or verb phrase. Then after going through all these processes the Three Address Code technique will be applied to the produced output and the words so extracted will be stored into the database. In this way the system will record every input it gets through in the form of text. The same process will be reversed back to generate the answer when some question is asked through the learned knowledge by the system itself. In this case the previously explained Triple connection table is more beneficial since it contains the real connection of each word that are separately stored into the ontology.



Figure 9: Sample GUI

### VI. DISCUSSION AND CONCLUSION

Sinhala is the native language of Sri Lanka. Usually about over 16 million odd people are

using this language. The derived alphabet consists of vowels, consonants, semi consonants, and conjunction consonants. "In Sinhala alphabet there are 18 vowels, with 8 stops, 2 fricatives, 2 affricates, 2 nasals, 2 liquids and 2 glides as well as 41 consonants"(Rajamanthri, 2021). As well as other languages Sinhala language also have a set of grammar rules; Sinhala uses postposition instead of prepositions. Which is opposite to the way of writing of English. Common order for Sinhala context is subject, object and finally the verb. According to grammar the verb should behave with respect to noun. This context is depending on so many facts like gender of the verb, singular/plural, and the tense. This is applied for written Sinhala and in spoken Sinhala this is not very much applicable. That is whatever its gender or singular or plural it only depends upon the tense of the sentence. Therefore, by considering all above facts defining a semantic processor for Sinhala using NLP techniques is much more complex. Sinhala is a low resource language for which linguistic tools are not been properly defined. Therefore, when implementing NLP base tools, we must rely on language independent techniques(Ranathunga and Liyanage, 2021). And another problem arises here is its difficult to identify the dialect. As a solution to this problem some researchers have developed a library package which can convert spoken Sinhala words to Sinhala text called "Sphinx"(Gunarathne et al., n.d.).

This paper has reported the design of new semantic processing technique namely Three Address base Semantic Processor for Sinhala. The system is specific to develop process semantics in Sinhala using a compiler base mechanism which is not in use in existing semantic processing techniques. The system provides 4 modules to perform each task explained in entailed above and give an accurate output. The project lies on both the areas; expert systems and natural language processing and after doing thorough research on existing semantic techniques we used to have this mechanism to apply for semantic processing.

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## Communication Platform for Sri Lankan Board Game Nerenchi

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**Abstract** – Nerenchi is one of Sri Lanka's oldest folk board games in which the board has diagonal lines joining the corners and horizontal and vertical lines joining three concentric squares in the centre. It is a strategic game between two players. The game is played by ensuring that one avoids his/her opponent in forming a mill. The player should block the counters of that mill by moving and taking one of his/her pieces every time. The player who has lost all the counters and is blocked from moving will be the loser. This folk game makes much fun, but with time the use of this game has rapidly decreased as a result of the development of online games. Therefore, joining hands with new technology, the implementation of an automated version of the “Nerenchi Board game” will be much impressive. The proposed system has 3 main stages; Detecting objects, Object movement and deciding the next turn of the object to be moved. System design mainly focuses on automating the system by using sensors to detect the exact location and colour of the Nerenchi object. The paper presents a way to detect the existing state of the physical board on the Nerenchi game, and this is a new approach for designing a computerized version of the Sri Lankan folk game called “Nerenchi”.

**Keywords:** *Nerenchi, folk board game, automated version, sensors, detecting objects*

### I. INTRODUCTION

Everybody likes to play games and at the same time, they want to learn about these games. Out of these people prefer to play board games because it's a part of thinking games. A board game is a game that a collection of a set of rules and includes the counters or objects moved or put on the pre-marked surface or board. These types of board games unlike other types of non-board games are played to demonstrate the intellectual domain without the serious logistic and the resource (Meththananda and Hettige,

2015). Therefore, board games have a special place.

Board games have been extremely famous since the old days and have been played in all societies and social orders. The fundamental characteristic of all board games is that they depend on the movement of different items over an explicitly planned board as per a pre-characterized set of rules.(Pandithage and Hettige, n.d.) There is a large portion of the well-known board games in history that are a kind of adjustment of a genuine fight between armed forces. Indeed, even contemporary board games are implementing the logic of defeating the opponent... Since, in the wake of a growing interest in Roman daily life, in the 1970s,(Kruthika et al., 2016) educators working in archaeological museums have discovered Roman games, the so-called “circular merely” or “wheel-type mill” holds an unmitigated triumph. In this seen given the number of “wheel patterns” carved into the floors of Roman streets and squares, the game is considered to be one of the most popular board games of the “Romans”, if not the only board game of which the rules have come down to us

Conventional board games are the which is the genre of tabletop gaming is a social activity and the players gather around a table and together make a common, engaging, and entertaining experience, in which their actions are passed on through interactions with physical items. The important fact is the huge flat digital surfaces present the chance to configure games that consolidate the social favorable circumstances of customary tabletop games with all the more captivating interactivity, dynamic visuals, and associations of computer games. Therefore we could say digital game boards combine the advantages of traditional tables and digital media and provide the opportunity to automate some of the complex tasks during face-to-face collaborative activities.

The ancient folk game of Sri Lanka is a very valuable thing. When fixating on Folk games, as a country having a written history of more than 2500 years, Sri Lanka has come across many folk games and has been the originators to many as well. Since the ancient days, Sri Lanka has had many types of folk games like field games and board games. Some of the folk games that have been famous up to date in Sri Lanka can be listed as "Pancha damima", "Olinda keliya", "An keliya", "Porapol gasima". Among these games, "Nerenchi demima" is one of the very sophisticated Sri Lankan folk games, that is on the brink of extinction and is almost unknown within the society of Sri Lanka.

Sri Lanka has across many folk games and has been the originators to many as well. "Nerenchi" is one of the most important ancient folk games in Sri Lanka. Nerenchi is one of Sri Lanka's oldest board games, in which the board has diagonal lines joining the corners and horizontal and vertical lines joining three concentric squares in the centre.

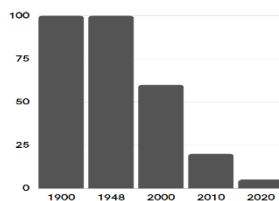


Figure 01: Folk games population in Sri Lanka

Figure 1 shows the use of ancient folk games in Sri Lanka is now rapidly declining. For considering this chart we can see a huge decrease in the tendency to focus on falk games in Sri Lanka. This game is also going to extinct. So nerenchi has mainly two parts. In the first part is the objects have to be laid on the board. In this part, 24 objects must be placed from the 12 objects each player has. When three objects are placed in a straight line horizontally, vertically, or diagonally, the player is rewarded with a bonus chance called "Nerenchi". When either the number of pieces on the board reaches 24 or one players placed all 12 objects on the board, the second part of the game begins where the players can move and capture each other's objects when the player is rewarded with a nerenchi. The behaviour of each of these phases is governed by a set of simple rules (Meththananda and Hettige, 2015). But today, it is common knowledge that these ancient folk sports are on the verge of extinction. The main reason for that the new generation is unaware of these ancient folk

games and has no interest in playing these games. As the modern world advances with technology, everyone is tempted to use technology. In the modern world, everything is automated. For this reason, people are more inclined towards these new technological things. For this reason, it is not important to automate these Sri Lankan folk games. The reason is that people are becoming more and more interested in these sports. Therefore, it is important to develop these old sports with new technology. This is why it is important to automate this Sri Lankan folk game "Nerenchi".

One of the most famous ancient folk sports in Sri Lanka in Nerenchi, it is now on the verge of extinction. The following are the main reasons for this.

- The Sri Lankan board game "Nerenchi" being under the threat of extinction.
- A lot of peoples are don't know how to play this folk game and lessening number of peoples are who knows how to play the game "Nerenchi".
- Equipment and usage opportunities in this folk game are under threat.
- The art of the game and the craft of the board being endangered.

Consider the problem, the Sri Lankan board game "Nerenchi" is a thinking game. A lot of peoples are don't know how to play this folk game and lessing number of peoples are who knows how to play the game "Nerenchi". Equipment and usage opportunities in folk games are under threat. The art of the game and the craft of the board being endangered. This game has not yet been developed that suits our culture and thinking pattern. But in this system, we will be focusing on the first part of the game like identify the Nerenchi object's colours and these values put into the array.

## II. LITERATURE REVIEW

These are some related works in my system and we have to come across much-related work, and a few works are explained below.

The main reference for my project was the Computational model (Meththananda and Hettige, 2015) developed for the game "Nerenchi" itself. In this research, they have implemented the board game as a computer game through web architecture and using the



.NET framework with MySQL. The game engine identifies the occurrences of a “Nerenchi” (placing the pieces of a single-player along aside), and it alerts the system. This research has come up with a mathematical model, where it uses matrices to calculate the occurrences and the frequency of occurring a Nerenchi.

Another paper, which has been one of the major references for my system is “Image Processing Approach to Detect Tokens on a Nerenchi board”. This system is mainly focusing on Image processing techniques. (Pandithage and Hettige, n.d.) These image processing algorithms are used to identify Nerenchi pieces. But the research project main disadvantage of this project is the inability to identify the object under the lighting condition and the disadvantage of this project is the inability to accurately identify the exact difference between white and black at any time and under any condition.

Another paper, which has been one of the major references for my system is research had been conducted where the main objective had been to better understand the abilities and limitations of retrograde analysis with the use of Nine men’s morris (Gasser, 1996). Retrograde analysis is a method of calculation that finds the optimal play for all possible board positions in a specific endgame. They have accomplished retrograde analysis with 3 procedures Initialization, Loss backup, and Win backup. With these methods, they have concluded the full analysis of the board game Nine men’s morris saying that it is a draw.

Another paper, which has been one of the major references for my system is as per how to solve Nine men's morris has discussed using ‘Retrogate analysis’, (Gasser and Eth, 1990) which is often used in chess automation and analysis. This method is more advantageous because retrograde analysis handles cycles more efficiently than forwarding search. They have also used a combination of alpha-beta search and endgame databases, where they have concluded that Nine men’s morris is a draw, and completely depends on how each player moves their pieces (Gasser, 1996)

One of the main papers I was referred for this research had created an adaptive learning program written in python to speed up the process of finding the optimal moves a player should make in a given game state. And lastly, had designed an AI to test the general patterns that

they had discovered and prove that it gives an advantage for the player. The game theory had been based on the minimax algorithm.

Deep Networks have also been tried on Nine men’s morris, where their system consists of three different neural networks, each predicting one part of the move. Then they have modelled the problem as a collection of three supervised learning tasks (Chesani et al., 2018). Their main aim had been to analyze whether such subsymbolic systems are capable of learning to play a game by the rules (Angelkov et al., 2015).

The following table shows the summary of what I have learned from the related work and what I have decided on working on in my project.

Table I – Summary of the references

Reference	Features							
	Basic analysis and solving the game	Web application to play the game with game engine	Apply retrogate analysis	Apply deep networks	Use an Expert system	Use image processing to automate the game	Automating using robot manipulation	Fully automated system with game engine
Analyzing Nine Men's Morris For g Optimal Strategy	✓							
Solving Nine Men's Morris	✓							
Computational Model for Sri Lankan Board Game Nerenchi	✓	✓						
Applying Retrograde Analysis to Nine Men's Morris	✓		✓					
Can Deep Networks Learn to Play by the Rules? A Case Study on Nine Men's Morris	✓			✓				
Automated Chess Tutor		✓			✓			
Using Image Processing Techniques to Automate Chess Game Recording	✓					✓		
Automated Chess Playing with a Robot Manipulator							✓	
Fully Automated approach for Nerenchi	✓	✓						✓

### III. PROPOSED SOLUTION

In my solution, we will consider 3 stages to automate the nerenchi game.

1. Identify the objects
2. Move the objects
3. Identify the next stage

In this paper, the solution is how to identify objects with 100% accuracy.

The proposed system comprises hardware & software modules. The hardware of the proposed system comprises the following components.

- Arduino Mega Board  
Arduino mega board is used to integrate all the functions and parameters of the IR sensor and IC.

- 24 IR sensor modules  
The nerenchi objects are detecting using an IR sensor and data is taken from its analogue out and passing to the CD4052B multiplexer.
- CD4052B Multiplexer  
All the data coming from the IR sensor is taken from this IC. Using this IC we can multiply the data inputs. We used 3 IC's because there are not enough analogue pins on the Arduino board.

The hardware modules of the system are connected as follows. Mainly our system has two main parts virtual model for Nerenchi and the Mechanical model. For the virtual model in the nerenchi part, we create software solutions for storing the array values.

#### A. Nerenchi Board

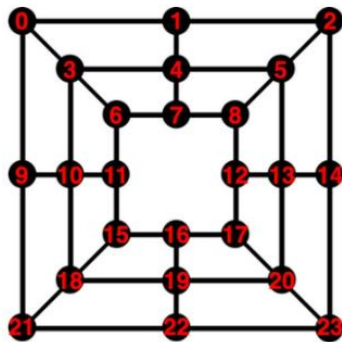


Figure 2: Nerenchi board array design

Figure 2 shows the nerenchi board is numbered. These numbers are taken as locations in the array. If there are no objects on the board the array value is 0.

Position matrix:

[0 0]

The array changes according to the way the objects are placed on the nerenchi board. The system maps to way to white colour objects are placed by the user to see where the black colour objects should be placed. Then get the array, no objects on the board put 0 value, white colour objects are 1 and black colour objects are value 2.

Position matrix:

[0 1 0 1 0 2 1 0 0 0 0 2 0 0 0 0 0 2 1 0 0 0 0]

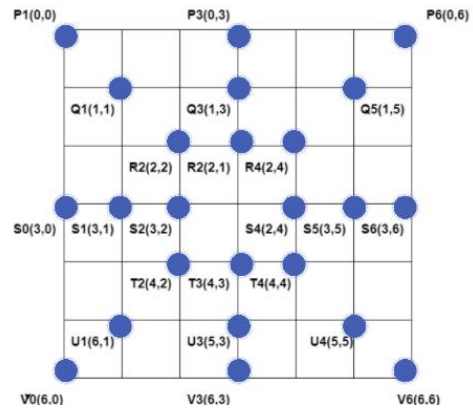


Figure 3: Nerenchi Board Matrix Design

Figure 3 shows how the matrix design is attached to the nerenchi board and put the unique mathematical point for each object in the nerenchi board.

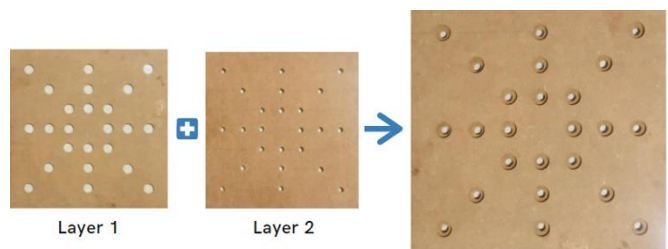


Figure 4: Nerenchi Board Design

Figure 4 shows the nerenchi board design. We used 2 layers. Layer 1 was used to hold the object and layer 2 to attach the object sensors. This complete board is used as a sensor panel and we input sensors for every hole where 24 objects are placed on the board.

#### B. Hardware Mechanism

IR sensors mainly used in creating the hardware mechanism to identify the object locations and identify the object colours.

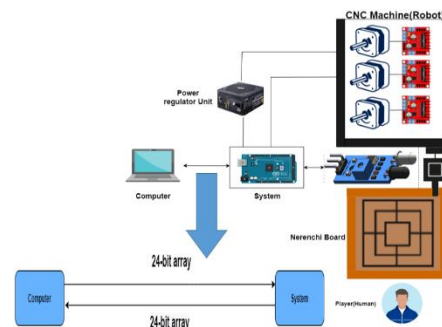


Figure 5: Proposed System

Figure 5 shows the mechanical solution for identifying the nerenchi objects on the board. The robot will develop a CNC model and all the input data are collected on the IR sensors. This system mainly connected to the computer. When the user places objects on the board a new 24-bit array is generated by the system(computer). Then this new 24-bit array is sent to the computer. The computer process this using an algorithm and creates a new array where the computer will place the objects on the board. Now the array is sent back to the system and finally, the system uses a CNC machine to position the objects in the relevant location.

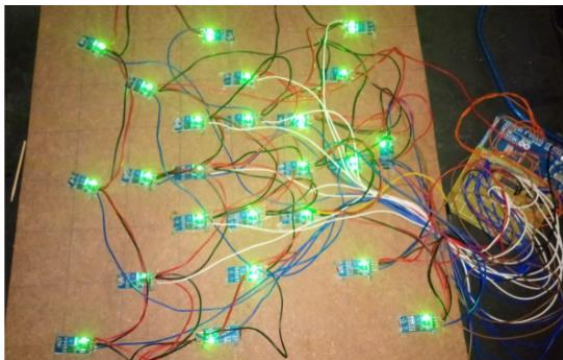


Figure 6: Nerenchi Board with sensors

Figure 6 shows input a sensor for every hole where 24 objects are placed on the board. This sensor identifies whether the object was on the board. Similarly, the sensor gives feedback to the system array about the location of the object on the board. This whole process takes place through 3 multiplexers. It uses a multiplexer called CD4052B. The output of the sensors from these 3 multiplexers is taken as an input and it is multiplexed and given to the Arduino.

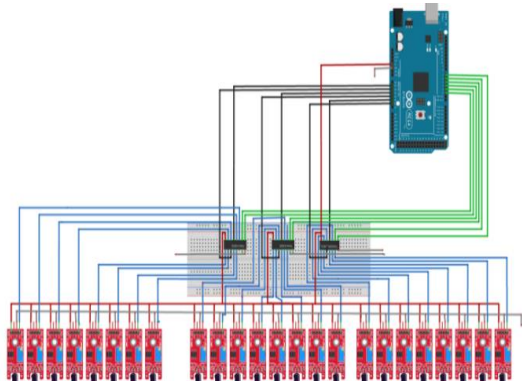


Figure 7: Circuit Diagram

Figure 7 shows the diagram of the system we created for the automated nerenchi board. This is the circuit of 3 multiplexers. There are 24 objects on the nerenchi board. All the 24 objects are taken from these 3 ICs. These ICs connect these 24 objects to the Arduino.

### C. CD4052B Multiplexer

This is the multiplexer we are used. He can do dual channel multiplexer as well as Demultiplexer. This multiplexer has an analogue switch. There are main two pins like 2 pins X COM and YCOM. These pins are Connect the analogue ping of the Arduino board to this. we've put 3 ICs like this. The pins A and B change the mod here. These are digital pins. The relevant feedback is given by 8 channels here.

### D. Output Array

8	0	0	8	0	0	8
0	8	0	8	0	8	0
0	0	8	8	8	0	0
8	8	8	0	8	8	8
0	0	1	2	8	0	0
0	1	0	2	0	8	0
1	0	0	2	0	0	8

Figure 8: Array output

Figure 8 shows the final output values of the Nerenchi board. There are no objects in the board array value is display value 0 and if there are any white objects in the nerenchi board array value is display value 1 and if there are any black colour objects in the nerenchi board array value is display value 2 in array output.

## IV. DISCUSSION AND CONCLUSION

A board game has been esteemed since the past. They consist of a set of rules which focuses on improving decision making and social skills. With the development of technology and innovation of computerized gaming and social media platforms, especially the younger generations have no interest in folk games anymore. Even the folk games also computerized now. Neranchi is one of the very famous folk game in ancient times but at present, the children don't even have a sight of knowledge about what Neranchi is. So as Sri Lankans we should have a focus on promoting our culture with the advancement of technology

without making our ancestral techniques to have vanished. Having this thought in mind, I have proposed to implement the computerized version of the Neranchi board game. A similar type of this game was implemented before and it made some difficulties when identifying the exact location and the colour of neranchi objects using Image processing techniques.

After going through other researches and related materials, as a remedy for this issue, I have proposed to use sensors to identify the locations and colour to avoid this problem. The proposed system has 3 main stages;

- Detecting objects
- Object movement
- Deciding the next turn of the object be moved.

The paper presents how to detect the existing state of objects in a physical board on a neranchi game.

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## Artificial Intelligence in the Criminal Justice System: A Literature Review and a Survey

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**Abstract-** Companies, governments and security services around the world are now trying to use artificial intelligence to detect and prevent crime. Studies have shown that crime is predictable. The need is to just filter out large amounts of data to get useful legal patterns. These types of predictions were a dream just a few decades ago. However, there is much hope now, as we learn from the fast-paced development of Artificial Intelligence (AI). When it comes to why governments and corporations are willing to try to use AI in this way, a summary of the key findings is as follows: It is estimated that in 2018, national and local governments have spent \$ 119 billion on the police, \$ 81 billion on repairs (3%), and \$ 49 billion on the courts (2%). AI has the potential to be a permanent part of our justice environment, providing assistance in investigating and allowing criminal justice professionals to better maintain public safety. The main intention and aspiration of this research is to let people be aware about AI and how it can be successfully applied to achieve excellent results in criminal justice systems, not only to detect crimes but to also predict them and prevent them from occurring. On the other hand, the extended part of this research explores the thought of measuring the ability and the possibility of applying AI in the Sri Lankan criminal justice system.

**Keywords:** *artificial Intelligence, criminal justice system, machine learning*

### I. INTRODUCTION

Let's go through the current judging system before appreciating the role of AI in the

environmental justice system. Imagine being arrested for armed robbery and suspected of being involved when you did not have a part to play, and you are completely innocent. The reason for your arrest is that you look like a suspect, and you live near a crime scene. Also, your car is the same as the statement made by witnesses. There is no more serious reason than the above, you will be made to appear before a judge after booking. The judge will then look into the situation before setting a bail order. An assessment of your aircraft risk and type of crime will be conducted, and only then will it be up to the judge to decide whether to take the call. Morning trials are often more than just seeing judges as soft. However, it was introduced before lunch. The judge, as soon as possible, set you up for bail without even having the opportunity to pay. This will send you to court, and you will be sent to prison without hesitation. It is a very serious mystery from many situations. Your case is unconfirmed, but you find yourself trapped hopelessly within the criminal justice system which leaves very little way out. The effects are already beginning to manifest themselves over your life. Normally, there is an average period of six months from your arrest to conviction. You will not have your job; the amount of bail planning will bring about a decrease in your credit ratings and many such negative effects. And while you were undoubtedly innocent, you were imprisoned with serious criminals. That's not much good news, is it? Prior to the role of AI, predicting and detecting crime was difficult as mentioned above. Since no crime finds a need for a new way to predict and detect crime it was needed.

AI was introduced to join criminal justice to make the world a better place. Artificial intelligence has



the potential to be an integral part of our justice system, providing investigative assistance and allowing criminal justice professionals to better maintain public safety. There have been wars between governments and the world's criminals. Although crime rates in many lands have dropped dramatically, criminal activity has not been done properly. According to an FBI report, the crime rate and violent crime rates have dropped by 3.3% and 6.3%, respectively, in the USA. ("The rise of AI in crime prevention and detection," 2019) There are many technologies that can help police reduce crime, and AI is one of them. Companies and cities around the world are investing in crime prevention AI and detection. The idea of investment is that crime can be predicted and easily detected using AI programs. In order for governments to prevent crime, they need to be able to organize large amounts of data to find patterns that can be useful to law enforcement, and AI algorithms can. The proliferation of AI in crime prevention and crime helps companies and governments reduce crime. AI can be used to predict crime, prevent crime, and detect crime. The goal of any society should be not just to catch criminals but to prevent crime from happening from the start. Predictability analysis is a complex process that uses a large amount of data to predict and create potential outcomes. In criminal justice, this function is mainly applied to the police, probation officers, and other professionals, who have had to acquire technology for many years. Work is time-consuming and is subject to bias and error. and the quality of legal interpretation by judges, lawyers, prosecutors, administrative staff, and other professionals. Investigators think that a computer program could automatically detect certain types of statements that play important roles in legal interpretation. for cybercrime. AI is also able to analyze a large number of records related to criminal justice to predict criminal recovery. AI can also help identify potential victims of physical and financial abuse. Finally, AI is used to predict potential victims of organized crime and organization-based violence. When it comes to crime detection the infrastructure of each city is becoming smarter as governments try to expand their countries at a faster rate. Intelligent and connected international infrastructure provides government officials with real-time information. With the help of AI, real-

time data can help detect crime as soon as it happens. Finally, AI can also be used to prevent crime. crime does not happen automatically, a collection of patterns. And AI can read patterns accurately. The use of AI technology can help monitor content. Content monitoring can help predict. And crime prevention will eventually help prevent it. AI can help monitor a person's digital steps and detect any unusual activities. The purpose of the law should not be to catch criminals but to prevent crime in the first place. ("Crime Prevention," n.d.) Let's explore how crime prevention can be achieved with the help of AI.

The rest of the paper is consisting as follows. The second section of the paper will give a brief introduction to the criminal justice systems around the worlds. As a sub part of the same section, I have described the Srilankan criminal justice systems in a nutshell. In the section three it describes the related work. There I have explained few burning areas which AI is applied in real world crime detection and prevention scenario. Section four presents the questionnaire which I to gather information about the knowledge and interest of people based on collaborating Artificial intelligence with Criminal justice system. In the next section I have done a brief analysis about the whole paper. Finally, the conclusion is presented as the last section. Then I have provided all the references that I have used to complete this research.

## **II. CRIMINAL JUSTICE SYSTEMS IN THE WORLD.**

The criminal justice system is a set of legal and social institutions to enforce criminal law in accordance with a defined set of rules and regulations. ("The Criminal Justice System | Introduction to Sociology," n.d.) Criminal justice systems include several large subsystems, consisting of one or more public institutions and their employees: the police and other law enforcement agencies; trial and appeal courts; prosecutions and public Defence offices; testing and parole units; childcare facilities (prisons, prisons, transit centers, boarding houses, etc.); and correctional departments (responsible for some or all of the probation, pardon and child custody services). ("Criminal Justice System - Structural And Theoretical Components Of Criminal Justice Systems, The Systems In

Operation, The Importance Of Viewing Criminal Justice As A System - JRank Articles," n.d.) Criminal justice systems can be freely classified as common law, public, Islamic, or scientific in nature. Today, however, many authorities have adopted hybrid models that include a variety of legal systems. ("Criminal law," 2021) Many of these programs share the same basic set of values. In addition, most criminal justice systems have adopted legal legislation. Almost all criminal justice systems are run by the same actors. An effective justice system is essential to the rule of law, as it works to reduce crime and provide victims with compensation. In particular, the resources for the criminal justice system underpinning the law should be equal, impartial, and respect the human rights of those affected - those who have been traumatized and accused. ("OHCHR | Basic Principles of Justice for Victims of Crime and Abuse of Power," n.d.)

#### A. *Srilankan* criminal justice system.

Sri Lanka has been home for many communities for a long period of time. Sinhala, Tamil, Muslim are the dominant Ethnic groups. Buddhism, Hinduism, Islam, and Christianity are the dominant Religions. Further some geographical areas are dominated by certain communities whilst other areas have mixed communities. The local laws were influenced by this multi-ethnic and multi-religious characteristic. With regard to the formation of the government, Sri Lanka became independent in 1948 and is now an independent republic within the common nations. According to the colonies under British rule, British law was gradually applied throughout the nation ("Criminal Justice System Of Sri Lanka," n.d.). However, because of the unsatisfactory nature of the existing criminal laws that led to the uncertainty, the Penal Code of Sri Lanka, then Ceylon, came into force in 1833 ("Penal\_Code.pdf," n.d.). It is said that the law was based on the corresponding Indian law. In 1974, the Administration of Justice Law was introduced but continued for only 4 years. The current law is the Code of Criminal Procedure Act, enacted in 1979. Also, the Judicature Act was enacted in 1978 ("Judicature Act | Volume IV," n.d.), which provides the basis for the administration of justice. As for the court system, the process and functions of criminal courts today are governed by the Code of Criminal

Procedure Act and the Judicature Act. The Magistrate's Court is a criminal court that will deal with a number of cases, and the High Court will also deal with other lesser crimes. Legally, other serious crimes, such as murder, attempted murder and rape, are being tried in the Supreme Court. The case in the Supreme Court is handled by a judge and a judge or a judge only. The judge is made up of seven judges, who are randomly selected from a panel of judges. An appeal or second case of criminal conviction is made by the Court of Appeal. ("Judicial Hierarchy," n.d.) The Supreme Court exercises the final power of appeal and the special power of suspension for violating fundamental rights and freedoms guaranteed under the Constitution. The Supreme Court has 11 judges, including the Chief Justice. Judges of the Supreme Court and appellate judges and high courts are appointed by the President; lower court judges appointed by the Judicial Services Commission. The Commission is the administrative body of the judiciary consisting of three judges of the Supreme Court headed by the Chief Justice. Most criminal prosecutions are carried out by investigators, namely the police themselves. However, in the case of such serious cases to be tried in the Supreme Court, whenever the need arises, public prosecutors, who have the right to be Government Councils or State Attorneys, will prosecute cases. ("Judicial Hierarchy," n.d.) These public prosecutors are under the auspices of the Department of General Law and are overseen by the Attorney-General, appointed by the President.

### III. RELATED WORK.

Artificial Intelligence or simple AI is a rapidly evolving field of computer science. In the mid-1950s, John McCarthy, known as the father of AI, described it as "the science and engineering of intelligent design". ("The History of Artificial Intelligence - Science in the News," n.d.) In theory, AI is the ability of a machine to recognize and respond to its environment independently and to perform tasks that may require human ingenuity and decision-making processes, but without direct human intervention. ("What is Artificial Intelligence (AI)?," n.d.) One aspect of human intelligence is the ability to learn from experience. So, AI programs will show at least some of the following behaviors associated with human intelligence: planning, learning, consulting, problem-solving, knowledge representation, ("What is AI? Everything you need to know about Artificial Intelligence | ZDNet," n.d.)

AI wants to replicate this human capability in software algorithms and computer hardware. For example, self-study algorithms use data sets to understand how you can see people based on their photos, complete complex computational and robotic tasks, comprehension purchasing habits and patterns online perception, motion, and manipulation and, to a lesser extent, social intelligence and creativity. Artificial intelligence has the potential to be a permanent part of our criminal justice ecosystem, providing investigative assistance and allowing criminal justice professionals to better maintain public safety (“Using Artificial Intelligence to Address Criminal Justice Needs,” n.d.). Let’s explore how AI is now being used in the context of crime and Criminal proceedings. Artificial intelligence is increasingly being used by courts in numerous countries throughout the world in their decision-making processes. In this research we thought of addressing few burning areas which AI is applied in real world crime detection and prevention scenario.

When discussing about applying AI in criminal cases it can be mainly classified into two areas as AI for crime detection and AI for crime prevention.

#### A. AI for crime detection.

##### i) *DNA Analysing.*

AI can also benefit a society that enforces the law from science and forensic evidence. This is especially true of forensic DNA tests, which have had an unprecedented impact on the justice system in recent years. Organisms, such as blood, saliva, semen, and skin cells, can be transmitted through contact with humans and objects during crime (Dupont et al., 2019). As DNA technology evolved, so did the sensitivity of DNA analysis, allowing technology scientists to discover and process low-quality, corrupted, or inaccessible evidence that could not be used before. For example, decades of DNA evidence from violent crimes such as sexual assault and cold-blooded murder cases has now been submitted to laboratory for analysis. As a result of greater sensitivity, smaller amounts of DNA can be detected, resulting in more DNA being obtained from multiple donors, or at much lower levels. (“AI could revolutionize DNA evidence – but right now we can’t trust the machines,” n.d.)

##### ii) *Gun Shot Detection.*

The discovery of pattern signatures in gunshot analysis provides another area in which we can apply AI expertise. In one project, the NIJ (“Using Artificial Intelligence to Address Criminal Justice

Needs,” n.d.) sponsored Cadre Research Labs, LLC, to analyze audio files from Smartphones and smart devices “based on the recognition that the content and quality of firearms were influenced by the type of guns and ammunition, incident geometry, and recording device used. (Dupont et al., 2019) Using a well- defined mathematical model, Cadre scientists are working to develop algorithms to detect gunshot targets, to detect bullet waves in shock waves, to determine the timing of a shot, to determine the number of available guns, to assign a shotgun, and to estimate the probability of class and size legal authorities in the investigation. (“The rise of AI in crime prevention and detection,” 2019)

##### iii) *Public safety videos and images.*

Video and image analysis is used in criminal justice and law enforcement communities to obtain information about people, objects, and actions to support criminal investigations. However, the analysis of video and image data requires a lot of staff, requiring significant investment in the knowledgeable staff of the story. Video and image analysis is also prone to human error due to the abundance of information, the rapid change of technology such as smartphones and apps, and the limited number of specialized staff with experience in processing that information (“Assistive AI keeps the human element in public safety | 2021-06-04 | Security Magazine,” n.d.). AI technology provides the ability to overcome such human mistakes and to act as an expert. Traditional software algorithms that help people are limited to predetermined factors such as eye shape, eye color, and the distance between eyes to see face or human details for pattern analysis. Video algorithms and image AI not only learn complex tasks but also develop and determine the complexities / limitations of their complex facial expressions to perform these tasks, more than people can imagine. These algorithms have the power to match faces, identify weapons and other objects, and detect complex events such as accidents and ongoing crime or behind reality. (“Using Artificial Intelligence to Address Criminal Justice Needs,” n.d.)

##### iv) *Digital Forensics.*

Digital forensics, also called computer forensics, is a function of extracting and analyzing digital content devices to prove it (“What is Digital Forensics? History, Process, Types, Challenges,” n.d.). There are many tools for that combed with

computers, mobile devices, and software views with evidence of details that might incriminate. Done wisdom works here because it increases power of digital analysis tools, highly productive the amount of data that no one has the ability to understand timely processing. One key example is software called Magnet AXIOM, developed by Magnet Forensics based in Waterloo, Canada. The tool is called “a digital investigation platform that allows researchers to discover and check the relevant information from smartphones and computers, to visualize it for better analysis.” A key feature of the software its use of Magnet.AI, which uses machine learning to perform semantic analysis or conversational content in Smartphones, computers, and chat apps. Company states that the tool is designed for cases of children exploitation and seeks to classify and flag the language conversations that can attract children. (“Magnet AXIOM Cyber | Magnet Forensics,” n.d.) Company it highlights the fact that this tool will change the way police behave their conversations and participation in arrests. It’s clear that the AI can be used in crime detection as in the same way AI can be used in crime forecasting (“Artificial Intelligence Is Now Used to Predict Crime. But Is It Biased? | Innovation | Smithsonian Magazine,” n.d.).

B. AI for crime prevention.

i) Predicting the crime spots.

Imagine a thief coming to his next heist to find out that the police are already waiting for him. Yes, it can be done using AI technology. AI programming, along with big data, can help identify crime hotspots. Crime types often interact with space and time, and crime-related information such as crime type, crime scene, and crime weapons can help predict future crime scenes. For example, an outbreak of theft in one area may help predict that similar incidents may occur in the surrounding area in the future. AI programs can help police find a place where they should consider extra vigilance.

ii.) *Predicting who will commit the crime.*

Many times, criminals talk about crimes committed online. AI can help monitor online content transfer. Algorithms can detect any unfamiliar words related to cybercrime. AI programs can then send information to the relevant law enforcement agencies about any unusual activity or communication that takes place between criminals, which can help identify potential criminals. Also, facial expressions can ultimately help to predict who will commit the crime. With facial recognition and tracking,

behavioral changes can help AI programs predict a person's future actions.

iii) *Deciding for the pretrial release.*

After indictment in any case, many suspects are usually released from prison until they appear in court. In the traditional system, judges must decide within minutes whether a person is a flying danger or a serious threat to the community, whether or not that person will harm a witness if released. The traditional system is an incomplete system open to discrimination, as judges tend to issue various judgments in their view of crime. AI can improve the current system and help determine individual release. AI algorithms can detect many dangerous objects before removing a defendant. Some of the dangers that can be considered are any cases that are still pending during the trial, conviction for violent offenses, failure to appear before a court hearing and sentencing before arrest. Based on many such factors, AI programs can accurately determine whether a person should be granted early release or not.

The use of AI in crime prevention and detection allows the company and city officials to reduce crime with precision. While crime rates have been declining for decades, global spending on law enforcement is increasing. With the benefits of AI comes a few risks in using AI to prevent and detect crime. For example, a person may be identified as a criminal or suspicious of criminal activities based on racial prejudice that may be unintentionally built into the AI system. Such risks should be clearly and explicitly assessed to determine whether the use of AI to prevent crime is appropriate or not.

**IV. RESEARCH METHODOLOGY.**

As it was mentioned earlier my main intention and the aspiration of performing this research study is to let people aware about the AI and explore how AI can be successfully applied to achieve excellent results in criminal justice systems, to not only to detect crimes but also to predict crimes to prevent them before it happens. On the other hand, the extended part of my research ran to another section which I thought of



measuring the ability and the possibility of applying AI in Srilankan criminal justice systems.

For that I have made a questioner. Its consisting of general AI related questions which was aimed for all the age ranges of Srilankan citizens. The main aim of the questioner was to get an idea about the current criminal justice system and to identify the need of applying AI to improve the traditional crime detection and prevention methods.

To gather information about the knowledge and interest of people based on collaborating Artificial intelligence with Criminal justice system, I made a questionnaire which is consist of 10 simple questions. The google form comprising of those questions were divided among both male and female respondents of various age ranges. Survey results are summarized below. From the first two questions respondents were asked to select their gender and the particular age range before answering the respective questions.

Google form was distributed among 105 people and among them 102 submitted their answer sheets.

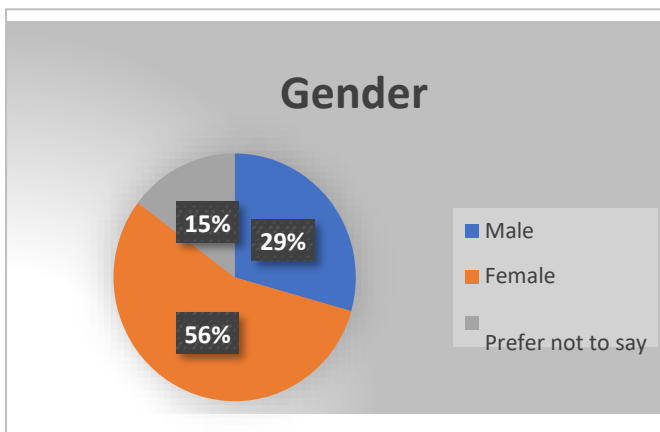


Figure 1: Result summary of Question 01

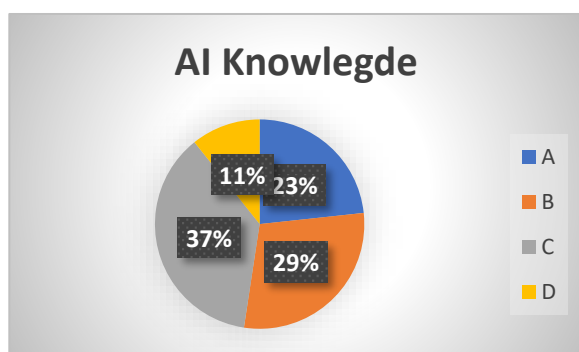


Figure 2: Result summary of Question 02

The next question was **Have you ever learnt, studied, or even heard about Artificial intelligence (AI) technology?** Four answers were given:

- ☐ A-Yes, I have learnt AI in School, in University as a course module
- ☐ B-self-studied that, so I have an idea about the concept
- ☐ C-I have heard the word Artificial intelligence, but I have no thorough idea on that field
- ☐ D-I have never heard about something called Artificial Intelligence

The aim was to get an idea about the AI related knowledge of people. Following is the summary of the results. 23% of the audience have a good idea about AI. And 11% of the respondents are clueless about AI. Most of the people in the particular audience (37%) are only familer with the word AI but have no through knowledge on that.

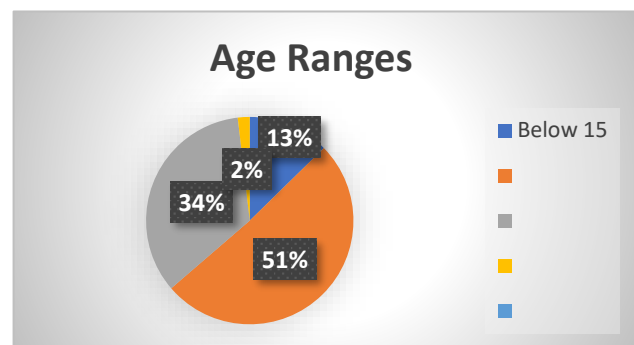


Figure 3: Result summary of Question 03

The fourth question was to get an idea about the knowledge that the particular audience has regarding AI Applications. The question was “ **AI is a blooming field that is highly used to level-up the daily life of people mostly in first world countries have you ever heard about AI applications?**”57% them have heard about AI applications. Others aren’t aware about AI applications. Starting from fifth question it was my aim to collect the ideas from the target audience criminal justice systems and about applying AI to it.



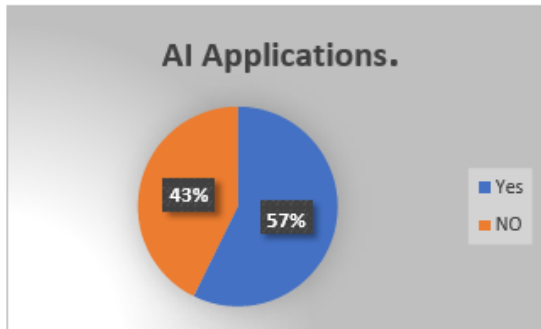


Figure 4: Result summary of Question 04

So, the fifth question was “**Are you aware about the criminal justice systems in Srilanka?**” This question was presented to the respondents to get an idea on how much of people in the society are aware, having knowledge or have studied about the criminal justice systems around the world. Three answers were given to select one among them. Yes, No and Up to a certain extent. Following are the results.

Out of the responses 25.1% do not have any knowledge about the Srilankan criminal justice system. But rest of the respondents are aware about the systems in Sri Lanka 64.% having a thorough knowledge about the subject while 11.3% respondents are having the knowledge up to a certain extent.

The next question was Are you ever suspected of being involved for a crime when you had no part to play and are completely innocent? The aim of the question was to get a simple idea about how fair the judgments are given using traditional methods. Then I realized that there are people who have been suspected of crimes without no reason (when they are innocent) Out of the respondents 28.4% for suspected of crimes without any fair reason. So, it proof that there are errors in traditional system.

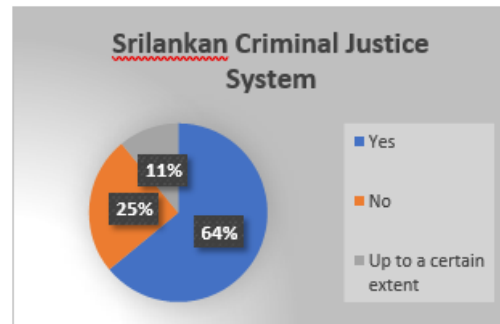


Figure 5: Result summary of Question 05

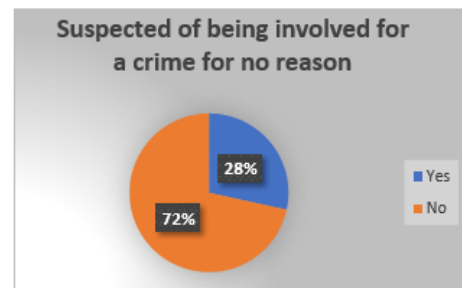


Figure 6: Result summary of Question 06

Seventh question was **Do you believe that the most accurate results can be obtained using the traditional methods of criminal justice?**

Results were as shown in the below pie chart. Most of the people believe that accurate results

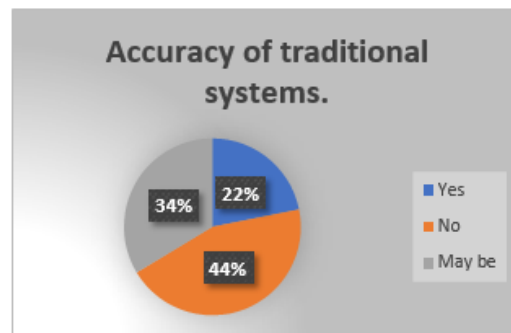


Figure 7: Result summary of Question 07

cannot be obtained using traditional method, 44.1% as a percentage.

The next question in the survey was **Are you satisfied about the current judicial decisions based on traditional crime detecting methods?** Aim of the question was to get an idea about whether the people are satisfied with the current judicial system.

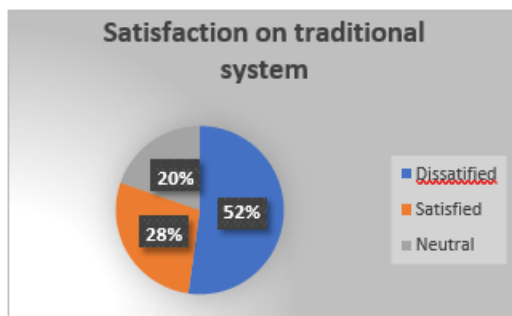


Figure 8: Result summary of Question 08

From the results gained through the survey I noticed that most of the people are dissatisfied (52%), and some of the respondents are very dissatisfied on traditional crime detecting methods. Only 28% from the sample are satisfied with the traditional methods of crime detection and prevention. So, it proves that a new method should be introduced for crime detecting. Then it was our aim to count the people who are keen to work with new technology. The question was Rate how you feel about using of new technology in criminal justice beyond the existing traditional methods?

5-point Likert scale was given to the respondents. The answers were ranged from very important to Not important. Below is the result chart. From the result it's clear that most of the people are interested on using new technology to criminal justice system.

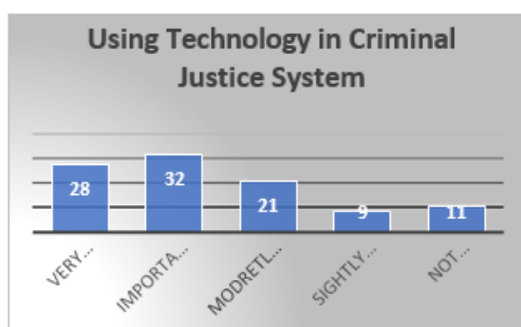


Figure 9: Result summary of Question 09

As the last question I asked respondents to **Briefly state their views on the use of this technology in Sri Lanka.** Following are some of the selected responses.

## V. ANALYSIS OF QUESTIONNAIRE.

Every day holds the potential for new AI applications in criminal justice, paving the way for future possibilities to assist in the criminal justice system and ultimately improve public safety. Video analytics for integrated facial recognition, the detection of individuals in multiple locations via closed-circuit television or across multiple cameras, and object and activity detection could prevent crimes through movement and pattern analysis, recognize crimes in progress, and help investigators identify suspects. With technology such as cameras, video, and social media generating massive volumes of data, AI could detect crimes that would otherwise go undetected and help ensure greater public safety by investigating potential criminal activity, thus increasing community confidence in law enforcement and the criminal justice system. AI also has the potential to assist the nation's crime laboratories in areas such as complex DNA mixture analysis. Pattern analysis of data could be used to disrupt, degrade, and prosecute crimes and criminal enterprises. Algorithms could also help prevent victims and potential offenders from falling into criminal pursuits and assist criminal justice professionals in safeguarding the public in ways never before imagined. AI technology also has the potential to provide law enforcement with situational awareness and context, thus aiding in police well-being due to better informed responses to possibly dangerous situations. Technology that includes robotics and drones could also perform public safety surveillance, be integrated into overall public safety systems and provide a safe alternative to putting police and the public in harm's way. Robotics and drones could also perform recovery, provide valuable intelligence, and augment criminal justice professionals in ways not yet contrived. By using AI and predictive policing analytics integrated with computer-aided response and live public safety video enterprises, law enforcement will be better able to respond to incidents, prevent threats, stage interventions, divert resources, and investigate and analyze

- Currently this technology is not using. So, it's better to involve AI in above field.
- Using AI security cameras to protect their assets
- We need to test how good that technology is. Then a conclusion can be drawn.
- I hope people are scared to move on to new technologies and new methods. We should only get the positive part and move on.
- Semantic web is all about focusing on web screening and metadata, easy findings from any site or system with digital footprints
- It will be helpful to all the people
- Technology will reduce the time taken to give away a judgement with equality to every citizen
- It will be good for Sri Lanka.
- It is very good method
- For artificial intelligence technology to be used any field the gathered results should be accurate enough to obtain at least 50% of the expected success of the particular project. So, in Sri Lanka it should be better if accurate results can be gained before starting the project.
- It will be good to have such a system. Using AI will be more accurate than existing systems
- AI will surely solve most of the problems in traditional methods
- It will be really beneficial to solve problems other than using traditional methods
  - It will be efficient and reliable

criminal activity. AI has the potential to be a permanent part of our criminal justice ecosystem, providing investigative assistance and allowing criminal justice professionals to better maintain public safety.

Extended part of my research ran to another area which I explored to gather information about the knowledge and interest of people based on collaborating Artificial intelligence with Sri Lankan Criminal justice system. Through that I found there are issues in the existing criminal justice system and most of the Sri Lankans in all age ranges without a gender difference believe that Artificial Intelligence could improve the current judicial systems.

## V. CONCLUSION

We now live in an era in which artificial intelligence (AI) is a reality, and it is having very real and deep impacts on our daily lives. From phones to cars to finances and medical care, AI is shifting the way we live. AI applications can

be found in many aspects of our lives, from agriculture to industry, communications, education, finance, government, service, manufacturing, medicine, and transportation. ("Applications of artificial intelligence," 2020) Even public safety and criminal justice are benefiting from AI. For example, traffic safety systems identify violations and enforce the rules of the road, and crime forecasts allow for more efficient allocation of policing resources. AI is also helping to identify the potential for an individual under criminal justice supervision to reoffend. Through this research it was mainly focused about how AI can be used in criminal justice system. Crime predictions, crime detections and for crime preventions. And within this research I pay my attention on how current judicial system was before appreciating the role of AI in the judicial ecosystem. Then about the future of AI in criminal justice system.

My aim through this research is to let the Sri Lanka judicial system benefitted by new technology. Make the Sri Lankan criminal justice system more loyal and fairer to everybody who needs help

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# A Review of Agent-Based Frameworks for Information Retrieval

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**Abstract**—With the development of the Internet in the digital age, operative technologies that utilize automated tools for searching and retrieving information in any domain, even those not on the web, are in great demand. However, the enormity of the World Wide Web (WWW) poses a challenge for researchers to retrieve useful and precise information to meet their requirements. An Information Retrieval (IR) system is meant to form a stored knowledge base, with items accessible to the information seeker. A major problem of the traditional IR systems is their inability to provide users with a semantic description of the knowledge needed by them. This problem is addressed by this Intelligent Information Retrieval (IIR), which is capable to give much more relevant and accurate information. The need to discover and observe the real-time mutations in knowledge and information requires new techniques in the web IR process. The results of IR contain an abundance of information that matches with the queries or searches in varying degrees of relevance. The relevance of the results is an important concern and often associates with the volume of the results: the bigger the volume of information, the better the relevance, while a lesser volume of information may have less relevant content. Seeking solutions for this issue makes Web IR an active and interesting domain of research and development. Considering the past two decades, interest among many has arisen in software agent technology and its applications. With Intelligent autonomous agents being most suitable for numerous applications in a semantic web environment, many researchers have proposed different frameworks, which comprise of details such as information collecting agents, storing agents, reasoning agents and querying agents. These structures often take into consideration semantic web and intelligent agents research, and other technologies such as information retrieval and knowledge modeling. This study focuses on a brief survey of Agent-

based IR Systems on semantic web and ontology. The performance of such intelligent systems is calculated by considering the productiveness, quality of the search and the results obtained, time performance, and whether users are satisfied with the search results.

**Keywords:** *intelligent information retrieval, intelligent autonomous agents, world wide web, knowledge modeling*

## I. INTRODUCTION

About two decades ago, humans fulfilled their requirements for information and knowledge through books. As the days went by man's search for more information and knowledge started to increase in scope and regularity. Following this, the world began to see the rapid development of technology and the Internet which grew into an environment of knowledge in which various information was incorporated in a more complex and spontaneous manner. In this digital era, millions of people use this developed Web to retrieve information often. According to an analysis conducted by the International Telecommunication Union in 2015, the Internet users per 100 people was as below.

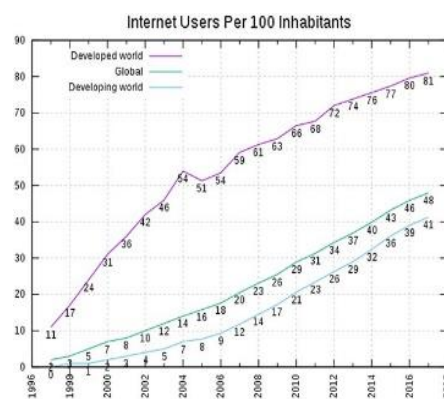


Figure 1. Analysis of Internet Users (*International Telecommunication Union, 2015*)

It is much difficult to provide effective search tools for information access with such large information which is available on the World Wide Web. This leads to developing methods for automatic information retrieval from the appropriate information sources. Traditional information retrieval (IR) methods typically generate database codes for each piece of information on one platform and use popular retrieval models such as the TFXIDF-based vector space model(Choi and Yoo, 1999). Later many approaches were presented to improve the relevance of the information, commonly known as the semantic web.

The drawbacks such as the rapidly changing information, information retrieval speed and limited search range on the Internet, along with many other challenges that came during crawling, indexing of web pages in earlier days were effectively handled by the web search engines(Bargain, 1999; Choi and Yoo, 1999; Prasad Kantamneni and Narayanan, 2001; Rajendran and Balasubramanie, 2009; LUO Junwei, 2010). Users who are not familiar with search engines also use the query interface and Natural language queries to handle problems of information retrieval such as uncertainty, incompleteness, etc. This led to weak navigation and coherence in information retrieval, hence causing flaws in providing users with specific search results depending on their interests. Many systems are being developed to address this challenge in obtaining and filtering specific information. Thus, the distributed indexes or distributed engines can lead to avoiding the bottleneck problem. In 1999(Choi and Yoo, 1999), the mobile agents and an interface were proposed as a solution for this problem where the Mobile Agents (MAs) commonly known as autonomous programs, search the network on behalf of their owners while interacting with other agents for action on the IR process for information.

## II. DATA AND METHODOLOGY

This section will discuss in detail, the methodology and the approach taken in conducting the review and coming forth with the final paper.

A Systematic type of approach was adopted when writing this review, where the area of research, focus, objectives, and title were decided upon

first. The research articles, resources and documents were searched for and selected next, out of which some resources were then used to get a better idea and understanding of the technologies, concepts, and theories. The research papers and articles found were sorted and analysed to select a few successful works on relevant systems to review further. These works were then further studied and reviewed thoroughly, to retrieve the most suitable and appropriate data and information for this research. This information was then utilized to carry out the review to compare the systems, hence resulting in the conclusion as can be seen in this paper. The figure below depicts the workflow of the writing process of this paper.

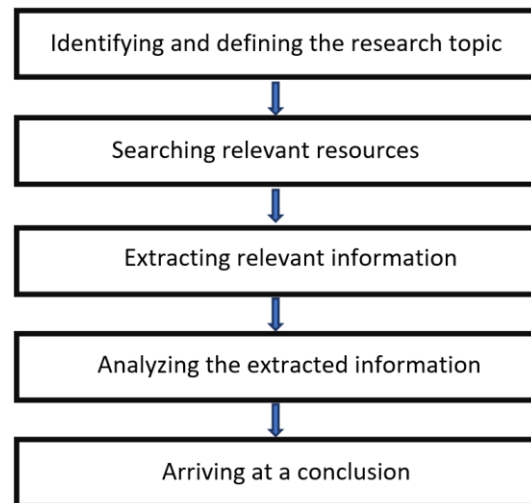


Figure 2. Methodology for the systematic literature review

The disciplines for the study were chosen as Agent-based applications and Intelligent Information Retrieval based on the research topic ‘Agent-based Frameworks for Information Retrieval’ and the keywords, Intelligent Information Retrieval, Intelligent autonomous agents, World Wide Web, and Knowledge modeling were decided upon relevance. To find the most appropriate and recent projects, research and developments done approximately within the past decade were chosen.

Various resources were referenced to search for the knowledge, information and past research required for this study. Online sources such as Google scholar, and other research archives as

well as resources such as books and repositories were used in information gathering.

The following criteria were considered when selecting the research and articles for this study.

- Works being in English and understandable
- Entire paper or article being accessible
- Research being within the period considered

Concerning these criteria works such as research papers, case studies, review papers and some conceptual papers that are useful for this research were found. After reviewing the titles and abstracts of these papers, 54 papers were selected as the final works to be referenced for this review paper.

These selected papers were then thoroughly studied, reviewed, and analysed, to understand their suggested systems, solutions, their advantages, and drawbacks as well as the technologies and approaches adopted. 10 – 12 systems such as the information retrieval system by LUO Junwei (2010), and the multi-agent framework by Shudong Zhang, Ye Qin and Naiming Yao (2010) were used for the analysis and comparison.

Factors including the techniques or areas of technology incorporated in the systems, the results of each Information retrieval system and the challenges or drawbacks of each system were analysed and extracted for comparison as in Table 2. The systems were also observed for the types of agents used in each chosen research, where the presence of certain agents such as User, Mediator, wrapper, mobile agents, and more were considered and compared as in Table 1.

The information and knowledge obtained by reviewing, analysing, and comparing these research works were finally utilized to arrive at a few conclusions regarding the traditional as well as the most recent agent-based IR systems and the technologies that are most effective in retrieving relevant information efficiently.

### III. LITERATURE REVIEW

This section illustrates the researcher's developments for the information retrieval

frameworks adopted by agent technology. The term document is widely used in articles to include any text in a machine-readable format. In the past works, the systems were not able to provide specific search results according to user's interests. Most searching mechanisms are based on keywords or phrases which browsed, so then the content cannot match with the requirement of IR. Moreover, these searching techniques are not providing the information according to relevancy or interests.

In each case, the IR system is designed to extract the best-suited products to meet the needs of the user in response to their demands. The IR system can be used to access drawings, audio and video files, photographs of museum artifacts, patents and more.

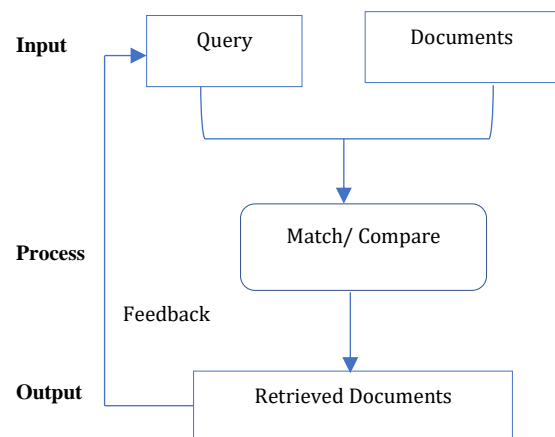


Figure 3. Historic model of an IR system

The above figure 2 illustrates a typical model of the IR system. Researchers have designed a framework (Choi and Yoo, 1999) that is a static multi-agent system for the IR on heterogeneous distributed sources, which fundamentally consists of User, broker, and resource agents, as its components. An electronic shopping agent named as BargainBot (Bargain, 1999) is structured to browse the relevant product or items on the internet.

Research (Travis Bauer and David B. Leake, 2001) has suggested a multi-Agent framework for Handling Complex Information Environments. The name of the system is Calvin. This system observes users as they access documents and proceeds to find related and relevant documents to then provide a unified

interface to the information environment. Calvin is a system built on top of a new Java middle-ware system named 'Geneva,' which is a genebuiltti-agent system framework that supplies the resources required to support personal IR. This Java middle-ware system serves with functionalities such as basic agent communication, authentication, and encryption functionality, and utilizes open Extensible Markup Language (XML) specifications for agent communication.

Another work (Xiao, 2007) proposed the framework for intelligent retrieval model which deploys a Resource Description Framework (RDF) Model to recognize the web resources to performing the tasks of web modelling and content representation. For RDF data storage and inquiries, the design is adapted to the corresponding database program according to the RDF data model, and XML data can also be used according to the characteristics of the RDF. The comprehensive semantics provided by the Web Ontology Language (OWL) will enable knowledge modelling in specific domains. It provides a knowledge base (KB) for semantic-based reasoning.

A blueprint for Intelligent and Dynamic Business Information Retrieval adopted by the agent concept was presented by Hua Hu, Bin Xu in 2007. The purpose of the A2DT project is to build the framework for the retrieval and analysis of information of dynamic businesses using agent-based technology. This framework which constitutes of agents performing detection, collection, generation, and propagation of information, and policymaking in the framework was established in the A2D project. The authors stated this blueprint is much faster than traditional retrieval. Further, the dynamic retrievals of dynamic results resulting in better performance were highlighted as advantageous. It was mentioned how dynamic information retrievals make the system an intelligent and dynamic process model. However, they faced issues with dynamic retrieval use more storage, and contain more low relevance rank data.

An investigative study on a new information retrieval system incorporating Semantic Web with Multi-agents (LUO Junwei, 2010), analyses the system's ability to process, recognise, extract, extend and match content semantics to attain the

following objectives: (1) integrate a Resource Description Framework (RDF) to analyse and understand the semantic features of the queries, to derive a newer algorithm in order to retrieve the semantics in the context and build up the database consisting semantics; (2) to build a matching algorithm with the use of the semantics retrieved from the content, to be feedback as appropriate, precise and accurate information to satisfy the users' requirements; (3) to bring forward a new Multi-agent based Information Retrieval method, where the Agents within the new model can utilize the users' interests, collect useful information depending on users' behaviours, and extract semantics from the internet to feed it back to distribute this information between many different users, so that the system can retrieve much more accurate information that align well with the requirements of the users and can serve the users in completing complex functions and tasks.

In 2010, researchers developed (Shudong Zhang, Ye Qin and Naiming Yao, 2010) a framework that uses agent technology to extract multi-slot web information. The intention of this multi-slot extraction mechanism while addressing information extraction rule learning and repair is to boost the adaptability of this system. Based on the structure, agents are classified and designed for the user, intermediary, wrapper, data store and page pre-processing. where each of these agents incorporates their own Knowledge Bases (KB), the KB classified considering user, PageRank, extraction, trackback, URL, respectively. Throughout the process of this framework, the user agent retrieves and optimizes the user queries and requests to then forward them to a mediator. The agent for the mediator chooses the URL seeds relative to the requests and hands over the queries and URL seeds to a wrapper. The Web resources of this framework are categorized by page pre-processing agent. The wrapper agent obtains the results extracted from the pages through methods such as data extraction, data tidying, etc. These results are finally returned to the mediator agent where they are integrated and submitted to the user agent for presentation. Furthermore, the author proceeds to point out the better adaptability and expansibility of this model.

An investigation was done with more than eight autonomous agents by Shakti Kundu in 2011. That design was built to be used in agents-based eCommerce applications for web data mining. They implemented an agent that functions to identify vital trend mutation as well as new and emerging information. They appear to have been considerate when Collect user registration information so that user privacy is not infringed through the web data mining process, hence making web data mining with an intelligent system their proposition for future development.

An Author (EFFANGA *et al.*, 2011) constructed a Java Agent Development Environment (JADE) mobile agent system, which proposed a web-based Graphical User Interface (GUI) framework for the JADE mobile agents to show the states of the platform, comprising of retrieved information that is stored in a database. This mobile-agent software incorporates a mobile agent platform (executable environment), a mobile agent program (code), and a program based on GUI. This system can perform operations such as Creating, Cloning, Dispatching or Migration, Retraction, Activation, Deactivation and Disposal. At the beginning level, the system was executed with some technical issues such as problems in deploying mobile agents which concerned security, privacy, reliability, integrity.

A structure (Menacer and Guenaoui, 2016) proposed an approach designed using integrated mobile agent technology for IR on www. Mobile agents can be used securely through a market-based framework to reveal user queries and execute distributed index.

### *M. Types of Agents*

This section illustrates the types of agents that were developed to perform Agent-based Information Retrieval tasks from the studies mentioned in the literature review. There are some agents commonly implemented in several studies. At the same time, some researchers described their framework by using only mobile agents. Have a deep look into the multi-agent topic all are agents designed to perform some specific tasks allotted to them.

#### *1). User Agent*

This is the special agent designed to interact with the end-users. Commonly the job of a User-Agent

(LUO Yingwei, 2003; Hu and Xu, 2007; Liu *et al.*, 2007; Xiao, Xiao and Zhang, 2007; Shudong Zhang, Ye Qin and Naiming Yao, 2010) comprises environmental concept, memory base, knowledge base, learning of machine and inference of machine, which means it provides users an interface to provide them with definite query requests and to extract information, to then submit these queries. But some of the frameworks have separate agents to carry out procedures such as information and query.

#### *2). Search Agent*

These agents are assigned to find and locate relevant information for negotiation by the users' requests. In other studies, the author indicates them as information gathering or collecting agents.

#### *3). Storing Agent*

The metadata from agents collecting intelligence and information is restored and stored properly, by these agents.

#### *4). Retrieving Agent*

These agents generate matching algorithms to enable a fast process of matching and searching for suitable content. They consist of constituents such as Knowledge Base, Model Base, and Semantic Matching.

#### *5). Mobile Agents*

Mobile agent-based technologies have been incorporated in various areas to perform tasks from network management to information management. The utilization of these agents in the wireless environment implies the need for the application to support disconnected mode. Mobile agents are programs that possess the ability to migrate among a network's hosts or to an arbitrary position of their choice.

Considering the characteristics and responsibilities of these agents, most frameworks are being built with the following tools:

- A specific programming language such as Java, C, C++, and Prolog
- Communication languages such as KQML, ACL
- Database languages like SQL, RDF
- String's representation such as XML, RDF



Table 1. Types of agents used in the studies mentioned in the literature review.

Agent Types														
	User, Interface	Mediator	Wrapper	Store	Page pre-processing	Querying	Search, gathering, Collecting	Provide, Retrieval	Reasoning	Information generation	Information propagation	Information policymaking	Extract	Mobile
Past Investigations														
2016 Djamel														✓
2011 Shakti Kundu	✓			✓			✓	✓	✓					
2011 EFFANGA														✓
2010 Shudong Zhang	✓	✓	✓	✓	✓									
2010 LUO Junwei	✓						✓	✓					✓	
2007 Yi Xiao	✓			✓			✓	✓	✓					
2007 LUO Yingwei	✓				✓		✓	✓						
2007 Lizhen	✓	✓	✓											
2007 Hua Hu	✓						✓			✓	✓			
2003 Dimitri	✓													
2000 Travis Bauer								✓						
1999 Yong S. Choi								✓						

Analysing this table, it is noticeable that in most of the studies, researchers have developed User/Interface, Search/Information gathering/Information collecting or Provide/Retrieval agents in their works.

A study (Travis Bauer and David B. Leake, 2001) implemented that his framework was designed using the retrieval agents, Google bot and Alta bot. As discussed previously the multi-agent concept encourages each agent to make full use of their autonomy and intelligence to function collectively to proceed towards the common goal of the WebIE system.

#### IV. COMPARISON BETWEEN IR SYSTEMS

The diversity of the Internet is characterized by open, complex, dynamic, and distributed properties that pave the way for the development of agent technology, and that agency technology offers many advantages over traditional methods. The agent itself is an autonomous computing entity that can find and utilize various information resources and services to solve problems and provide service for users independently. This section elaborates on the comparison between the discussed frameworks (Jian-Shuang Deng, Qi-Lun Zheng and Hong Peng, 2005).

Table 2. Analysis of Agent-based IR Systems

System	Techniques/Area	Results	Challenges/Drawbacks
(Choi and Yoo, 1999)	Artificial neural network, Back Propagation Neural Network, Yahoo! <i>Korea</i> ,	Efficient Effective	Expense
(Hu and Xu, 2007)	XML, Java	Much faster, Dynamic Results, Better performance,	More storage, More low relevance rank data
(Kundu, 2011)		Meets user's demands	Privacy
(Liu <i>et al.</i> , 2007)	Resource Description Framework, JavaBean, XML	Uniform quick query, Retrieval service to users, Easy to integrate, flexible and extensible.	
(LUO Junwei, 2010)	Bayesian Probability Model, Support Vector Machine, Neural Network Algorithm	Obtain required information, used in knowledge & document management, search engine, and other applications that require searching large quantities of information to achieve the purpose of reusing and sharing information.	
(LUO Yingwei, 2003)	Java, XML	Interoperation among spatial information,	
(Menacer and Guenaoui, 2016)	SB-framework, Java, JADE SB-IR prototype, XML	Mobility capability	Lack better relevancy
(Shudong Zhang, Ye Qin and Naiming Yao, 2010)	URL KB, DOM, XML, ACL	Act according to web page changes, Information extraction, Relying on sample learning, Multi-slot-based extraction rules Pattern match technology	Adaptability Expansibility
(Xiao, Xiao and Zhang, 2007)	OWL, XML, RDF, SQL, JAVA	Solve the bottleneck	Construction Maintenance User privacy

However, the implementation done by the past researchers shows that each of these frameworks includes at least one unique characteristic. Most of the investigations were done by XML, Java, and RDF (Resource Description Framework) result can be drawn upon further observation.

#### V. CONCLUSION

Based on these analyses, it can be concluded that a sequence of research on Agent-based IR systems that have been conducted in the past two decades has brought about new insights related to multi-Agent systems. The studies done around the semantic web as well as intelligent agents,

along with other different technologies such as information retrieval, knowledge modelling and ontology construction through years have led to the development of agents-based intelligent retrieval frameworks in the semantic web. The Traditional information retrieval methods are directly influenced and managed by the user, whereas newer and more dynamic methods of retrieving information are prompted by data inputs and events. For traditional information retrieval, relevant data for different criterion are extracted on demand and does not require to be stored, though for dynamic information retrieval setting and storage of such data will take place in advance. As they work on-demand, the results given by Traditional information retrieval methods are both static and retrieved once at a time. Meanwhile, the latest techniques to retrieve information along with their many dynamic updates, bear the ability to give results that are visibly evolving. Some data that are of lesser relevance can be collected with dynamic information retrieval techniques, resulting in low information veracity. The rules should be set and stored in advance in dynamic information retrieval. The need for temporary results to be restored gives rise to the need for more space in dynamic retrieval, in the system.

Since relevance and ranking in dynamic information retrieval only handle the changes occurring in the information, the effort exerted in computing can be cut down significantly, which results, in much faster, accurate and effective information retrieval compared to traditional retrieval methods.

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# Building a Sinhala-English Parallel Corpus for Neural Machine Translation Based on Exam Questions

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**Abstract**— In any neural machine translation between two natural languages, parallel corpus is a compulsory part of the training process. The most crucial step in an MT system is to develop an effective method for gathering parallel corpus. The construction of a parallel corpus, on the other hand, necessitates substantial knowledge of both languages and is a time-consuming procedure. Due to these limits, digitizing documents becomes extremely challenging, lowering the quality of machine translation systems. This research offers a method for producing an English to Sinhala parallel corpus that is both faster and more efficient, while requiring less human intervention. This system generates a parallel corpus for language pair using the following steps: scanning the exam question papers using a special type of scanner, Image optimization for Optical Character Recognition (OCR), text extraction from images and converting unstructured text into structured form as parallel corpus.

**Keywords:** *parallel corpus, image optimization, text extraction, neural machine translation*

## I. INTRODUCTION

English is widely used in both formal and informal communication nowadays. The mother tongue, on the other hand, continues to have a profound influence. The ability to think creatively and acquire global knowledge requires the use of one's mother tongue. According to Hettige et al., (2016) the Sinhala language is spoken by around 16 million people in Sri Lanka, and 80% of Sinhala speakers struggle to read and write English.

This is a language barrier that impedes the acquisition of world information. The most realistic answer to this challenge would be a

computer-based machine translation system from English to other languages (B.Hettige & Karunananda, 2010)

Current machine transformation research necessitates large parallel corpus SMT and NMT systems based on probability models created utilizing parallel corpus components (Premjith, et al., 2019). However, one of the fundamental disadvantages of SMT systems is the lack of a parallel corpus. As a result, designing a machine translation engine for low-resource language pairs is extremely difficult (Doru, et al., 2018). The challenge of creating such corpses is regarded as enormous due to the considerable number of human resources required and the time required to produce a corpse with such many words. (Premjith, et al., 2016)

A parallel corpus is a collection of text translated into another language or saved in a machine-readable format from one or more languages. At the sentence or word level, a parallel corpse can be arranged (Hameed, et al., 2016) The quality of the parallel corporation used for system training is critical to the relevant system's success. With such a vast amount of data, it is simple to choose a domain-specific parallel company, and the full training data may be processed in a short length of time (Doru, et al., 2018). The length of the sentences is also a significant factor in determining the translation's quality. It should not be too short or too long in length. This is because deep learning architecture is incapable of absorbing the extensive dependencies seen in phrases. Word phrases have a vital role in domain-specific machine translation, according to Teenage et al. They investigate effective strategies of employing phrases to increase NMT performance under the low Resource Languages heading (Tennage, et al., 2017). Because these languages' morphological richness lies on opposite extremes of the spectrum, translation

can be improved by including linguistic features in the phrase (Premjith, et al., 2019).

## II. LITERATURE REVIEW

### A. Neural Machine Translation

Neural Machine Translation is becoming the current state of modern machine translation technology. Although NMT has been successful for resource languages, its relevance in less resource settings are still controversial (Tennage, et al., 2017). However, Neural machine translation is a recently proposed approach to machine translation. Unlike traditional statistical machine translation, it aims to build a single neural network that can be tuned together to maximize performance (Bahdanau, et al., 2015).

### B. History of machine translation

In the seventeenth century, the dream of the translation of natural languages by machine became the reality in the late twentieth. (Hutchins, 1995). The first automated translation systems were developed in 1933 by Georges Artzoni and Peter Troyansky. Warren Weaver briefly touches on early perception research as an effective way to transform machinery in 1949 and the first set of proposals for computer-based machine translation was put forward in 1949 by Warren Weaver. Sixty years later, neural networks have made considerable progress in other areas but are still unable to convince translators. The use of MT accelerated in the 1990s. This increase is most noticeable in commercial companies, public service, and multinational companies. Where translations are mass-produced, primarily technical documentation (Hutchins, 1995). The first active neural language models powered by repetitive neural networks appeared in 2011 (Scao, 2020).

### C. Existing Work

Machine translation systems are divided into four categories: human-assisted translation, rule-based translation, statistical translation, and example-based translation. Each of these approaches to machine translation has its own set of benefits and drawbacks (Hettige, et al., 2011). Agent-based Multi-agent system for language processing applications such as English to Sinhala (Hettige, et al., 2016) Another group, Wijerathna et al and De Silva et al, used a statistical methodology to attempt English-to-

Sinhala machine translation. The authors collect bilingual corpora and examine parallel corpora; many corpora have 100,000 parallel sentences per language pair. NMT is discussed in many studies, with a focus on zero shot neural machine approaches.

(Hettige, et al., 2017). Another group attempted English-to-Sinhala machine translation by using a statistical methodology. Wijerathna et al. and De Silva et al. presented simple rule-based translators. Hettige et al. have provided a theoretical-based method for English-Sinhala machine translation based on the Sinhala concept of Varanagema (conjugation). Varanagema is a Sinhala language theory that deals with nouns, verbs, and prepositions, among other things. Tennage et al. developed a domain specific NMT system for both Sinhala and Tamil, the official languages of Sri Lanka. The translation of official government documents was focused on that research. They used the NMT architecture suggested by Bahnao et al. and Cho et al. For all experiments. From the Sinhala language point of view only a few research have been done for machine translation. Vitanage's English to Sinhala translator and Silva and other Sinhala to English translator are some of the prototype projects for the weather forecasting domain. There have been some attempts at machine translation from Sinhala to Tamil and from Japanese to Sinhala machine translation (Hettige & Karunananda, 2010)

Kumar and Sarawagi investigated calibration of state-of-the-art models that can be improved by a parametric model, resulting in a slight increase in BLEU score. However, neither work investigates the relation between label smoothing during training and calibration. (Kumar & Sarawagi, 2019). B. Hettige and Karunananda (2010) found that, in the post-editing phase of the translation process, using human intervention could solve the problems caused by the lack of dictionary and semantic information for high quality translation. (Hettige, B. et al., 2017) Minh-Thang Luong et al. demonstrated the effectiveness of both approaches on the WMT translation tasks between English and German in both global and local directions. (Minh-Thang Luong, et al., 2015) Thilakshi Fonseka et al. introduced an effective NMT system along with Byte Pair Encoding (BPE) for the English-Sinhala language pair focusing on the Sri Lankan official government documents. It addressed the OOV problem and the data sparsity



issue when translating to a more morphologically rich language. (Thilakshi Fonseka, et al.,2020). Toshiaki Nakazawa et al. developed the "Kyoto-U system" that attended the IWSLT06 Japanese-English machine translation task. The system consists of two modules, the alignment module for the parallel sentences and the translation module for obtaining and integrating appropriate translation examples. (Toshiaki Nakazawa, et al.,2006). Francisco Guzman et al. introduced the FLORES evaluation datasets for Nepali English and Sinhala- English, based on sentences translated from Wikipedia. Their experiments represented current state-of-the-art approaches that work poorly with these new benchmarks, with semi-supervised, especially multilingual neural methods, all other models they have considered. (Francisco Guzman, 2019).

### III. PROPOSED SOLUTION

The proposed method is creating a parallel corpus in an effective and efficient manner by using ScanJet Pro 2000 Scanner and Google Optical Character Recognition (OCR). For turning photos into text format, the approach makes use of Google OCR's efficiency. A scanner can scan a wide range of documents, and this scanner can scan any document quickly and without causing any damage to the original (as we do with typical scanners). It can scan papers in the following sizes: A3, A4, B5, B4, and so on. For scanned images, Google OCR produces satisfactory results. The OCR technique can be used to automate several photos with only minor changes. The parallel sentences must be aligned, which necessitates text normalization effort. Then we normalize raw data set to database. Finally, we are generating a parallel corpus.

#### A. Image Pre-processing

Because the amount of picture and video data generated and consumed daily is expanding, the need for better and more efficient image modification techniques is also expanding. Recent advancements in image processing have sparked renewed interest in neural networks. In the field of image processing, a type of neural network known as Convolutional Neural Networks is particularly intriguing since it offers a novel method to comprehending image data. For this project, many documents were digitized from numerous sources that included both English and Sinhala materials. Even though identifying and collecting documents with such

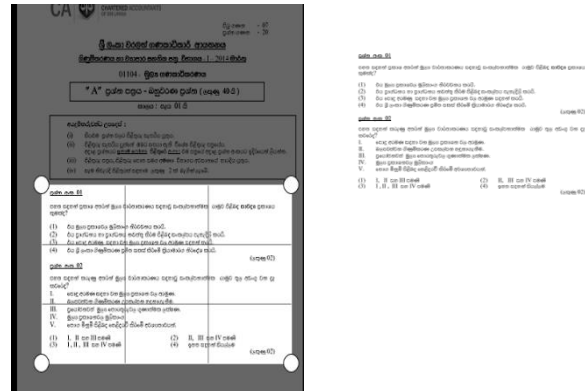


Figure 16. Image Cropping

paper pairs was a big undertaking, countless exam papers were checked, and many parallel papers were picked out. A few preparations must be completed before scanning can begin. Documents must be put at a

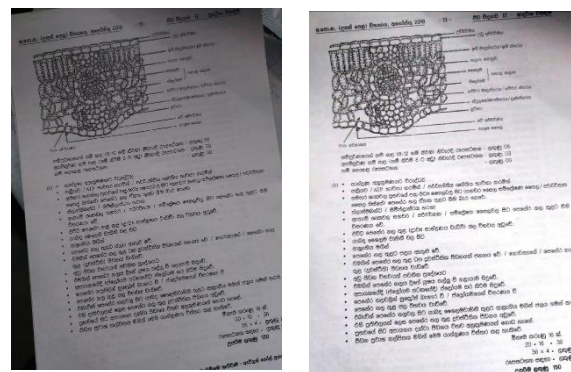


Figure 18. Original Image (Left) and Transformed Image (right)

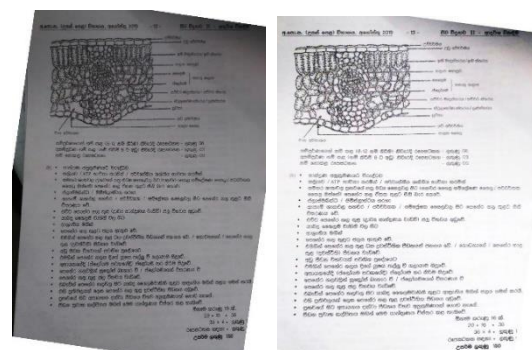


Figure 17. Color Correction

reasonable height because the scanner light is very intense. The positioning of documents is another key factor to consider. We will not acquire a good OCR of the appropriate document if the alignment of the document is not correct and if the document is tilted or shaken during

scanning. Even if we scan papers with the utmost care, some pre-processing is required because Google OCR produces excellent results for high-quality results reprocessing on the scanned pages, such as skew correction and cutting out of unwanted elements, is done before uploading to Google Cloud Storage. Brightness, contrast, and sharpness can all be tweaked to further improve image quality if necessary. This pre-processing stage can be completed with application. Parallel sentences were collected from sources such as GCE OL, AL, and available competitive examinations papers (both English and Sinhala medium). When scanning low-quality documents, such as old manuscripts, we get excessively noisy images, making excellent OCR impossible. This means that a text document with adequate alignment and lighting will produce accurate results using Google OCR. PDFs with many pages from these sources are split to obtain one PDF. PDF with two-column structures must be cut into two separate papers with the order. Cut the text in the bottom line and the heading of the paper. (Figure 1) Because the high-quality size must be lowered, scanned images can have a large size. The higher the quality of the source image, the better the OCR accuracy. There are certain factors that can be considered in the source image to measure the quality of the source image. Characters should stand out against the background: Character borders that are sharp, Characters / Words with a High Contrast Alignment: Proper letter, word, and line segmentation is ensured by good alignment. Image alignment and resolution (Figure 2,3). There is less noise. From an OCR standpoint, the qualities stated above improve the document quality. The quality of the source picture for OCR is determined by several parameters, including the presence or absence of noises/distortions, proper image and text alignment, image resolution, and local contrast. The standard recommended resolution for OCR is 300 DPI (Dots Per Inch) However, based on the font size used some OCR engines internally scales the original image. Image Binarization is the process of converting a colored image (RGB) into a black and white image.

Most of the OCR Engines does this process internally, Adaptive binarization works based on features of neighbouring pixels (i.e., local window) Sharp borders between characters will be helpful for character recognition. Image Despeckling is a common technique used in the OCR noise removal step which is an adaptive

bilateral filtering technique (Figure 4). It removes noises from the scanned image while preserving edges and other complex areas from blurring. When applied incorrectly it may remove commas and apostrophe from the image by considering them as noise. Such changes should be made in this step. Image data collection diagram for corpus creation are given below. (Figure 5)

#### *B. Extract Text from Images*

Google Optical Character Recognition (OCR) is a software which works for over 248 languages in the world. It can detect many languages with over 90% of accuracy and it is simple and easy to use. This technology extracts scanned printed text, text from images and even handwriting. It uses the dependencies from Tesseract and released as a free software. This method utilizes the Google OCR as an API (application programming interfaces) and Google Cloud as a service for increasing the processing speed with the large amount of data. The optimization of Google OCR is at an elevated level and after conversion, information can be analysed with multiple different methods. Uploading an image or a pdf to Google Cloud Storage and using it as an input bucket yields Combustible uploading and OCR creation were automated because Google Cloud Storage only permits one document to be created at a time. Applying OCR for image/PDF diagram are given below. (Figure 6) Even if we upload high-quality documents, there is a chance that the OCR will contain errors. Manually correcting errors like spelling fixes, eliminating unwanted spaces and unwanted characters, and adding missing spaces and missing characters is simple. This method, in our experience, generates OCR of both English and Sinhala text documents with 98 percent accuracy, resulting in a high-quality input document. The final phase in constructing the parallel corpus is the most time-consuming because it necessitates a great deal of focus. Initially, we split one paper that includes many pages into one page PDF. This process will increase the amount of data in the corpus.

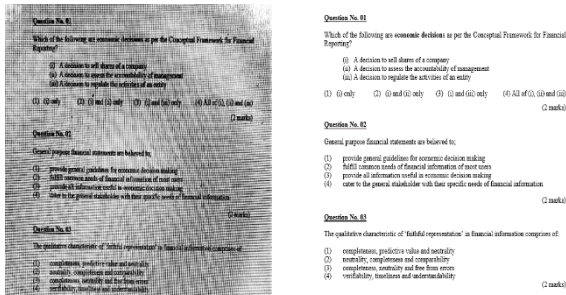


Figure 20.Original Image (Left), Despeckled Image (Right)

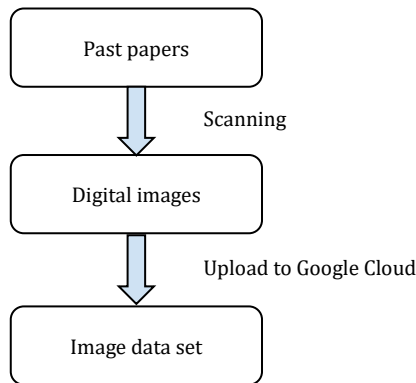


Figure 20.Diagram of image data collection

### C. Text Normalization

After extracting sentences from the images, it is required to normalize the raw data. unstructured raw data contains image data, data of the footer section, instructions, logos, table contents, and other unwanted information. In normalization remove that unnecessary information. Manual work is required for parallel sentence alignment and text normalization. Regular expression is used to create text that conforms to the relevant question pattern. Text normalization diagram are given below. (Figure 7) Regular expression is one of the most useful tools in computer science. It is used in phonology, graphics, text analysis, information extraction, and speech recognition. Regular expressions are placed in the matching pair and describe the strings of characters. It is a pattern that matches certain strings and doesn't match others. Regular expression is a set of characters that define a pattern (Kaur, 2014).

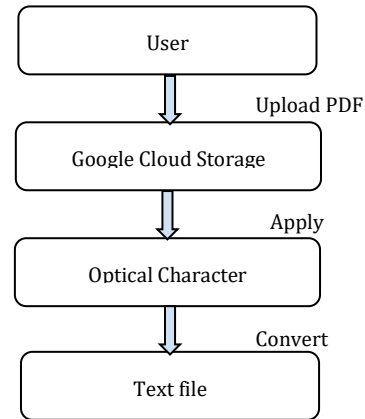


Figure 21.Diagram of applying OCR.

### D. Parallel Corpus Generation

A parallel corpus is a corpus that contains a collection of original English writings as well as translations into the Sinhala language. Parallel corpora often contain data from only two languages. Building parallel corpus diagram are given below. (Figure 8) 'Comparable corpora,' which are intricately connected to parallel corpora, consist of texts from two or more languages that are similar in genre, topic, register, etc. but do not include the same content. This is a parallel bilingual corpus.

To create high quality custom engines, we need to have enough domain-specific open parallel corporations and both tools and methods to create this body (Dogru, 2018). One of the reasons for the low resource language scores lower in machine translation evaluation is that machine translation systems are usually trained with a small amount of data or low-quality data (Dogru, 2018)

### E. Text format

To prepare for an exam, you must first determine not just the substance of the test, but also the types of questions that will be asked. Diverse types of questions necessitate different study

methods. There are many distinct types of questions, as well as varied study and preparation tactics for each. Multiple choice, True/False, Matching, Short answers, Numerical, and Essay are some of the question types used to store text data taken from papers. Multiple-choice tests usually begin with a question or statement to which you must respond by choosing the best option from a list of options. True-false tests ask students to mark whether certain assertions are true or false. All aspects of a statement must be true for it to be true. True-false tests, in general, assess your understanding of facts. Preparing for true-false examinations requires the same general study abilities and best practices as studying for other types of tests. Students must respond to assertions or questions in essay questions. Short-answer questions or statements are like essay questions in that they require only a few words or sentences to answer. They assess basic information, which is usually factual. It is crucial to pay attention to the directive words in each item when answering short-answer questions.

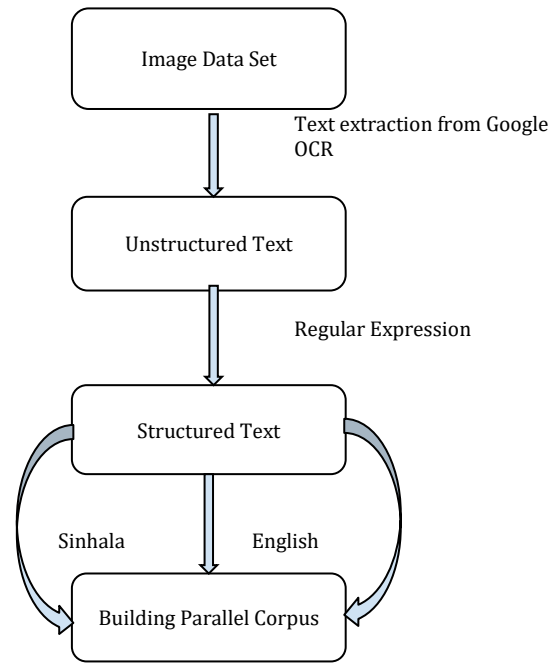


Figure 22. Diagram of building parallel corpus

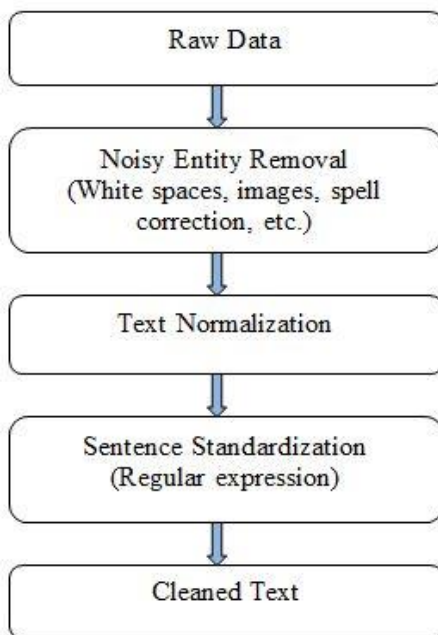


Figure 7. Diagram of Text normalization

## V. EXPERIMENTS AND RESULTS

First, scanned the exam question papers and prepared them as PDFs or images. A lot of documents collected from various resources which contain both English and Sinhala were scanned for this work. Many exams were searched and many parallel sentences in different languages. This was a massive task, but the results were incredibly good.

The educational realm is the focus of our model. As a result, government exam papers in both languages are originally collected. A particular data pre-processing approach is used to the papers. That is, text from all languages must be aligned so that corresponding segments, phrases, or paragraphs can be matched. The data set was first scanned. They must be scanned in a high-quality format that allows the text to be read clearly. The dataset is then saved on the cloud, making OCR easier to apply. Image removal, spell correction, and corrections in superscript subscript style are all required alterations to the text file created by OCR. The parallel corpora are required for the study. For pair of languages (English – Sinhala, English – Tamil) a parallel corpus is constructed. Models is included in the study, one for pair of languages. The data must be pre-processed before the model can be trained.



Because the models are based on the seq2seq architecture, an encoder-decoder architecture. It is made up of two LSTM (Long Short-Term Memory) networks [34], which are a form of RNN (Recurrent Neural Network). The encoder LSTM is one, while the decoder LSTM is the other.

Each RNN's input differs from the others. The encoder's input the images are shown in Figure 9.

**Question No. 01**

Which of the following components of financial statements most accurately shows the changes in financial position of an entity for a given period?

- (1) Statement of Comprehensive Income
- (2) Statement of Financial Position
- (3) Cash Flow Statement
- (4) Statement of Changes in Equity

(2 marks)

**Question No. 02**

Which of the following component / components of a financial statements is/are prepared for the period ended?

- (a) Statement of Comprehensive Income
- (b) Statement of Financial Position
- (c) Cash Flow Statement
- (d) Statement of Changes in Equity

- (1) (a) only
- (2) (b) and (d) only
- (3) (a) and (c) only
- (4) (a),(c) and (d) only

(2 marks)

**Question No. 03**

Which one of the following accounting concepts requires an entity to measure inventories at the lower of the cost and net realisable value?

- (1) Going Concern Concept
- (2) Prudence Concept
- (3) Matching Concept
- (4) Historical Cost Concept

(2 marks)

**Question No. 04**

Some activities carried out by the committees established within business organizations are listed below.

- (a) Review of internal audit plan
- (b) Deciding pricing policies
- (c) Ensuring that the accounting activities are carried out in accordance with the accepted

Figure 23. Image of scanned paper

The PDF or image prepared in this way is broken down into individual pages and stored in the Google Cloud Storage (Figure 10).

They are then taken out of the bucket and applied to it. Subsequent texts are rearranged using regular expressions and stored as parallel corpus. After extracting sentences from the images, it is required to normalize the raw data (Figure 11).

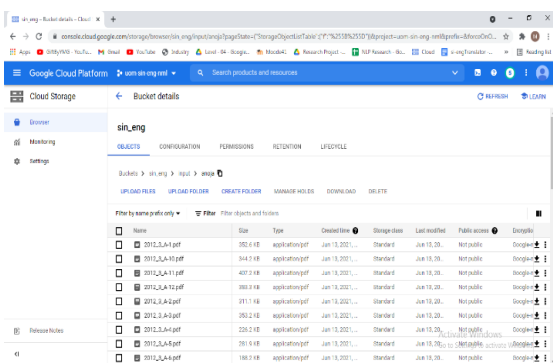


Figure 24. Image of Google cloud storage.

Normalization removes image data, data of the footer section, instructions, logos, table contents, and other unwanted information. Manual work is required for parallel sentence alignment and text normalization (Figure 12).

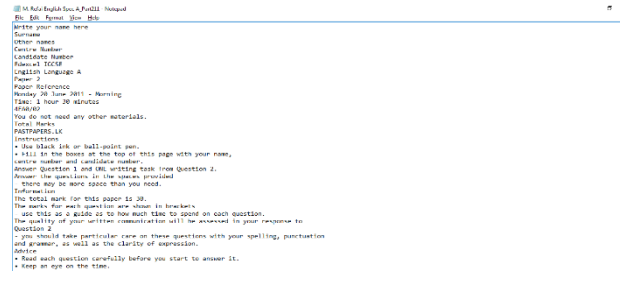


Figure 25. Image of before apply normalization to

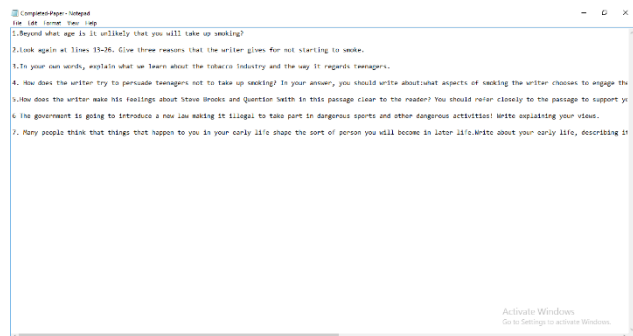


Figure 26. Image of normalized paper

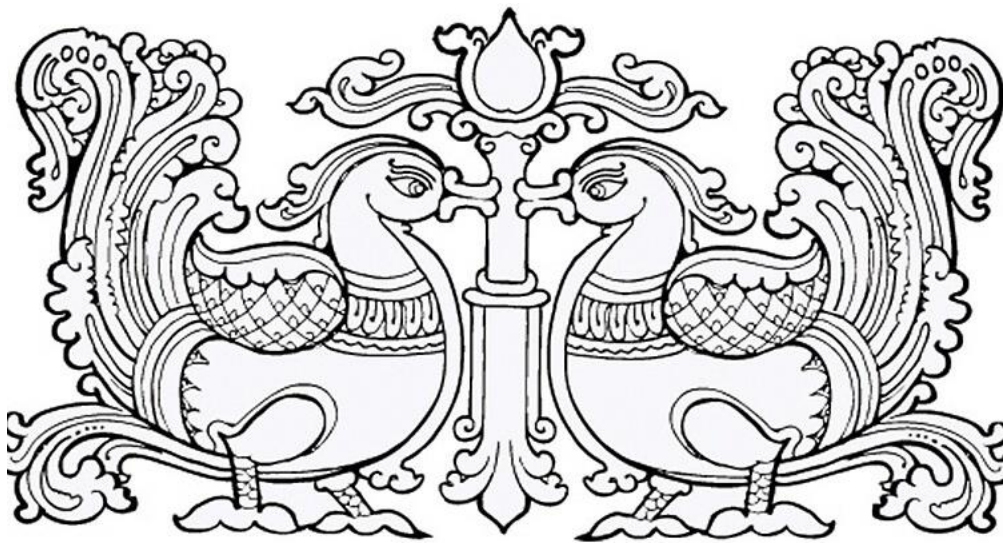
## V. CONCLUSION AND FURTHER WORK

The purpose of this research was to develop Sinhala-English Parallel Corpus for Neural Machine Translation using an OCR Scanner and Google Optical character recognition (OCR). Exam question translation was focused on this research. Translation between English and Sinhala is difficult due to the different language structures in English and Sinhala. The lack of parallel corpus is a major drawback for SMT systems and therefore, designing a machine translation system for low resource languages is exceedingly difficult. However, a crucial factor to consider when preparing a parallel corpus is that the person who is preparing the corpus should have a good knowledge of both languages. However, using the proposed system could generate many parallel corpus without much knowledge of both languages in a brief period. The main task to be done further in this project is to develop an English-Sinhala Machine Translation System.



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# POSTER SESSION

# An Overview on Massive Open Online Courses (MOOCs) as an E-learning Platform: A Review

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**Abstract**— Massive Online Open Courses (MOOCs) have peaked in popularity with the vast improvement in technology with minimum infrastructure to connect to the Internet, thereby allowing learners to access the massive number of courses available through accredited universities and academic institutes. Coursera, edX, Udacity are some of the platforms in MOOCs that enable learners to get certified and gain knowledge in relevant fields. This paper focuses on signifying the importance of assessing the ideal effectiveness of the MOOCs platform, while conducting a review and identifying motives to enrol, pros and cons, and factors to drop out of MOOCs. The authors have identified four research questions in relation to the above facts in concern regarding the MOOCs platform, and a literature review has been carried out in this study by addressing the said research questions. The results of this review suggest that there exist multiple motives for the learners to enrol in MOOCs, and there is also a considerable attrition rate of the MOOCs learners from those courses. The reasons to drop out of MOOCs is therefore a significant area that must be discussed, and there are both pros and cons of this e-learning platform. Further, there is no proper method to assess the effectiveness of MOOCs and therefore, such an assessing procedure is a timely need, due to the fact that it is an online education platform, where individuals can gain access to plenty of courses available, irrespective of geographical boundaries and time constraints.

**Keywords:** *MOOCs, online education, self-learning, affective education*

## I. INTRODUCTION

As the name implies, MOOCs are an online open-source educational platform that enables learners worldwide who have a desperate need

to gain knowledge through online platforms to get certified and enhance knowledge on the field they are interested. MOOCs have been rating at the top since its introduction in 2008 while now it's been recognized as one of the most popular and easiest ways of getting certified from world-renowned and competitive universities and educational organizations instead of wasting time and money in attending the real-time classrooms and lectures needed for the relevant courses.

Therefore, the trend now is to get hands-on experience and knowledge on the interested fields through online video lessons, tests, interactive questions while and after the video lectures and peer- reviews provided by the MOOCs platform, which may vary according to the courses to be accessed. Nevertheless, through MOOCs, university students are also able to gain credit by participating in some of the courses available on the platform. The main pillars in the MOOC platform include the providers such as Coursera, edX, Udacity, and Udemy.

Generally, there are two types of MOOCs namely, Connectivist MOOC (C-MOOC) and Extended MOOC (X-MOOC). In C-MOOC, the learners are treated both as a teacher and a student whereas in X-MOOC each learner is treated either as a teacher or a student. Moreover, C-MOOCs are the original MOOCs that consist of less content and structure and rely on social learning, self-governance, and chaos for knowledge formation whereas, X-MOOCs have been outlined for mass teaching and mainly associated with more conventional pedagogical perspectives (Iqbal, et al., 2015).

Figure 1 depicts how the number of courses provided through the MOOCs platform has evolved since 2012 (Shah, 2020).

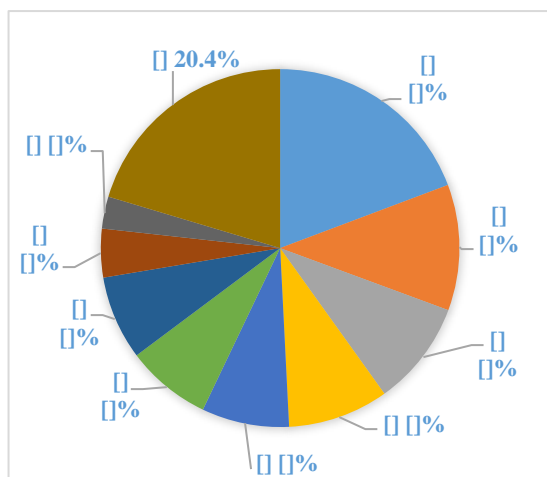


Figure 1. The User Growth in MOOCs  
Source: Class Central Data 2020

Therefore, from the above statistics, it is clear that the number of courses provided through MOOC web-based platform has rapidly risen throughout the past few years, and this proves the fact that online learning through MOOCs has provided an extraordinary learning option to learners around the world which are still being embraced by individuals all around the world.



Figure 2. Course Distribution by Subject  
Source: Class Central Data

As shown in Figure 2 (Shah, 2020), MOOCs can be classified according to 10 subject areas that are being provided to learners around the world. Therefore, through the above diagram, it is clear that Business has been the highest offered subject area in MOOCs whereas Mathematics being the least while Technology is the second-highest offered subject area out of the overall number of subject areas.

This paper focuses on addressing the driving factors to enrol in MOOCs, reasons to drop out of MOOCs and signifies the effectiveness, pros, and cons of MOOCs platform, and makes use of a literature review section to identify key considerations on the MOOCs portal.

## II. RELATED WORK

Distance learning has fostered several technologies to enhance education, such as teleconferences, webinars, podcasts, and online courses. However, the limitations of those technologies also have increased the dropout rate of e-learners (Kalansooriya L P, 2016).

Within the e-learning platform, MOOCs have become very popular, and the very first MOOC was established in the year 2008, and afterward, the number of MOOCs has been expanding. An initial summit could be identified in the year 2012, which was named the Year of MOOCs. Furthermore, it initiated a discussion interrogating the standard of MOOCs and their educational quality as learning encounter and learning mechanism which has resumed to date (Stracke, et al., 2018).

MOOCs have impacted the traditional education system in a beneficial way that has improved the flow of knowledge in serving learners, educators, professionals, and even researchers through digitalization which improved in the last few decades (Sachdeva, et al., 2015).

Research (Reda & Kerr, 2018) has proposed a MOOC policy framework that augments three educational factors namely, achieving a complete MOOC degree from a recognized academic institution, expandable international assembly and freemium payment formula for open accessibility. After analysing the above framework, four prospective MOOC BAs have been presented for the bachelor's degree at the University of Naples Federico II with a focus on dominant expository aspects.

A study (Hew & Cheung, 2014) has explored the main motivational drivers which pursue to enhance the use of MOOCs and has reviewed challenges in MOOCs platform and also to spot issues that need to be solved. The findings from the above-stated research suggest four motives

for students to enrol for MOOCs namely, the desire to master about a contemporary concern or to widen current knowledge, curiosity on MOOCs, for personal provocation, and the desire to accumulate as many completion certificates as possible.

Another research (Stracke, et al., 2018) conducted with a focus to determine the perspectives of MOOCs learners and designers on the interaction and experiences in MOOCs and to achieve this objective, this study has made use of the initial discoveries from the Global MOOC Quality Survey while comparing the learners' and designers' perspective on interaction in learning with MOOCs. Moreover, the study has spotted the fact that the designers have underestimated their design effort, whereas the MOOC learners have provided higher ratings for their learning experience. Nevertheless, it has also been identified that there is a gap in understanding the demands of the MOOC learners by the MOOC designers.

MOOCs have been the most in-demand theme in recent years when the e-learning concept is taken into consideration. Since 2012, MOOCs have enticed universities around the world. Moreover, the process of MOOCs is moderately growing. Among MOOC platforms, the most famous portals are Coursera, edX, and Udacity.

Coursera is a profit organization founded by Andrew Ng and Daphne Koller at Stanford in 2012 and currently top rating in popularity among the MOOC portals. Coursera collaborates with educational institutions all over the world to provide a few of their courses in the domains such as mathematics, humanities, machine learning, engineering, social science, biology, physics, and computer science to the online crowd.

EdX is a non-profit MOOCs portal founded jointly by Harvard University and Massachusetts Institute of Technology (MIT) and has reached a higher number of learners. EdX collects much data from research to get better knowledge in user experience, such as what times the learners prefer to learn.

Udacity MOOC platform is built by Sebastian Thrun, David Stavens, and Mike Sokolsky in 2011

which initially began with providing university courses whereas now providing courses for professionals as well. Udacity deviates a little from the Coursera and EdX due to the hallmarks such as putting more emphasis on skill training for professional requirements and non-cooperating with universities while breaking the contemporary educational model in universities. Furthermore, Udacity is considered to be more influential since it offers more impactful certificates than the other two popular platforms (Chen, et al., 2014).

The researchers (Chen, et al., 2014) have built a distributed data warehouse and analysed the course log data in Coursera platform. Further, it evaluates the quality of online course education in terms of country distribution, grading policy, homework completion, and peer review assessments. Finally, the authors propose a new grading policy and peer assessment procedure where a data warehouse of grading history and the weight is calculated according to the learners' grading history.

Therefore, from the above review, it can be identified that there has been great work towards the MOOC platform since its invention in 2008, and to date, there is rapid development and suggestions to improve the quality of the services provided through this.

### III. METHODOLOGY

E-learning has received significant recognition in the last few years. MOOCs allow individuals to enrol in courses and get certified without any constraints on time and geographic locations. Nevertheless, with the vast progress of online education, many people concentrate on the expansion of their network rather than having the focus on the quality of learning gained through MOOCs.

Therefore, it can be concluded that there should be much concern about this aspect and must be discussed broader in order to enhance the quality and value of the education provided through this online portal.

Hence, identifying research questions would be supportive to determine the scope of the study on MOOCs.

#### A. Research Questions



Research Questions are predominant when pinpointing the scope of this study. Following are the research questions which are the motives to perform this study and would be discussed further in the next section.

RQ1: What are the main driving factors to enrol in a MOOC?

RQ2: What are the pros and cons of MOOCs?

RQ3: What are the factors that underlie to drop out of the enrolled courses?

RQ4: Are MOOCs effective in gaining knowledge?

### *B. Data Collection*

For the literature review and in addressing the research questions mentioned in section A, the collection of research papers was done from the IEEE Xplore and the Google Scholar and the papers that are published after the year 2012 were selected for the literature review.

## **IV. DISCUSSION**

### *A. Driving factors to enrol in MOOCs*

Research undertaken by (Guo, et al., 2019) has categorized the factors which drive to enrol in MOOCs belong to the dimensions: Cognitive interest, Career development, Interpersonal relationship, Get-rid-of the routine, External influence, and Social service. The cognitive dimension's motives include personal interest and desire of learning, intention to be more intelligent, interest in the course content, and a sense of achievement. The career development dimension comprises motives such as seeking career progress, enhancing the curriculum vitae, preparing for a career switch, and improving the salary. The desire to be accepted by others and create a network with instructors in the courses is a motive that belongs to the Interpersonal relationship dimension. Relieving job burnout and reducing the stress of life is connected with the Get-rid-of routine dimension. External dimension motives include an undertaking assigned by a senior, meeting the expectations of an expert. The social service dimension focuses on serving the society by enrolling in the course such as contributing to the workplace and intending to do civic duty.

From this study (Guo, et al., 2019), it has been identified that learners who participate in MOOC learning have the strongest motivation in Cognitive interest and Social service, whereas Getting-rid-of the routine dimension is with the lowest score. Moreover, the well-experienced course instructors in relevant subject areas, experience the courses provided by a prestigious institution, limited access to other educational resources affordable costs for the courses are some other motives that influence learners to enrol in MOOCs.

According to (Li & Wan, 2016), learners with the intention of self-improvement have a greater possibility of completing the courses that they have enrolled in through the MOOCs platform. Further, the course completers were found to have previous learning experience in learning through MOOCs portal and found only a little difficulty in following the courses. In addition, internal motivation was found to be influencing the learner most than to obtain the certification.

Another study has spotted the fact that knowledge construction and information exchange are the most vital considerations in learner's perception of online interaction, whereas equipping tech help in numerous ways and briefing the online discussions after each discussion are the significant facts when the instructor's perception of online interaction is considered (Khalil & Ebner, 2015).

Research done by (Sooryanarayan & Gupta, 2015) has considered that the motives for the MOOCs enrolment as the desire for learning, experience the courses provided by a prestigious institution, limited access to other academic resources, quality education free of cost, network with interesting people, supplement learning at work/school/university and enhance the resume. The results found that all the above-stated factors could be identified as the primary motives where limited access to other academic resources was rated the highest.

### *B. Pros and Cons*

MOOCs as an online education platform consists of both pros and cons related to Information Technology for Self Education. Some of the pros of self-education based on the Internet are cost and time efficiency, easing of the evaluation

procedure, and expanding of involved learners. However, according to (Chen, et al., 2014), the improper grading policy that involves the learners in grading is a con of this MOOCs portal when the assessment to be graded is more professional.

Research done by (Kruchinin, et al., 2018) exposes the fact that some points such as unlimited education, up to today knowledge, information Studying vs. information consumption, and information search cannot be precisely categorized under pros and cons due to the fact that the assessing those criteria may vary with the definition. Moreover, owing to the reason that transaction cost is much expensive, self-education in rural areas has obtained much benefit from the information technology implementation. Therefore, it is much evident that e-learning has provided significant benefits for the MOOC platform as well.

Also, MOOCs have provided computer simulations for expensive laboratory practices in engineering education, and that is incredibly vital since engineering education deals with applying engineering discipline in the practical scenario with the use of theoretical aspects (Iqbal, et al., 2015).

Active learning, quick feedback, self-engagement, and peer learning are the building blocks of MOOCs. When learners engage in learning, a higher engagement is obtained, and in massive online platforms, learners participate in courses referring to the learning material, prevent persistent misunderstandings and self-learning (Mitros, et al., 2013). Therefore, compared with a traditional learning environment, MOOCs provide numerous benefits when the above facts are considered.

A drawback found in MOOCs is that although the grading system is much easier to deal with since the computer-generated or peer review assessments are mainly used, the structure of the assignments and exams provided through MOOCs might differ when compared with the traditional system. Also, student reviews differ obviously from instructor reviews (Kulkarni, et al., 2013).

In addition, MOOCs have also been introduced for university degrees rather than providing certificates for general courses. The critics also point out that the MOOCs scarce sufficient learner-instructor interaction and university life, that are the fundamental concerns of university

education, and the exposure to the educational material doesn't impact personal growth (Iqbal, et al., 2015).

Nevertheless, the original concept of MOOCs was to provide free and open education for all but not for credit, but with the further developments in this portal, the MOOC providers concerned on establishing a fee for certification and even a fee for sitting the examination although the tuition is free (Brown, 2013). Therefore, for the learners who are in need of financial helps, this aspect has been a great con.

Actually, the language also might be a barrier when referring to the resources and accessing the exams, and individual attention is also not prevalent in MOOC learning. Increased number of course dropouts, difficulty in measuring learner involvement, and inability to access the courses with insufficient network bandwidth are some other cons of MOOCs.

### *C. Reasons for dropping out of MOOCs*

A study (Sachdeva, et al., 2015) has found an increased dropout rate from online courses since learners find offline courses more engaging. Therefore, it is proposed that in order to make those courses more fascinating, the process of gamification should be introduced. Also, to achieve gamification, a credit-based system where the learners receive some incentives based on their performance can be cited.

Furthermore, in another research (Mamgain, et al., 2014) conducted to identify the effect on video viewing features with the feedback from learners, it has been determined that edX provides more complementing subtitle features than Coursera since those subtitles block the course slides and the learners' preference was to short videos as those ensure the non-distracted concentration to the video lesson.

Research done by (Hew, 2015) has identified the main reasons for the dissatisfaction of the learners who drop out of MOOCs as peer review activities, forum management, unhappiness about the claims, perceived biases, topics in teaching, reading academic papers, and assignment-related issues. Further, the authors of this research (Hew, 2015) suggest to minimize the reading of academic papers as a part of the course completion and to enhance the

distribution of handouts that summarize the significant findings in the academic papers.

According to (Xie, 2020), diverse expectations and motivations, and satisfied or done with the part of the course content that the learner expected to obtain knowledge are some other reasons that make the learners to drop out of the MOOCs.

Researchers (Palvia, et al., 2018) have identified that high bandwidth connectivity of telecommunication infrastructures, improving the online course deliverance as equal to the contemporary face to face in class education, and blending the online and offline education there by maintaining a healthy balance between online and traditional education as significant concerns that must be focused when the online education system is to be upheaved. Further to summarize the challenges that are pinpointed in this research, the authors have listed the country-level factors that influence the quality of online education and the factors include, ICT capacity, internet/mobile technology diffusion, income, country laws, and digital divide as the factors that hinder the use of online education. Since MOOC is also an e-learning platform, the above discussed factors apply to the MOOC platform as well.

#### *D. Effectiveness of MOOCs*

There are many studies and researches that have been undertaken to evaluate the effectiveness of the MOOCs portal and still it is being discussed due to the fact that the criteria for evaluating the effectiveness cannot be interpreted exactly.

A study (Iqbal, et al., 2015) has been conducted with the use of the findings from the Global MOOC quality survey, which was distributed among learners, designers, and facilitators of MOOCs with the motive of recognizing the gap between MOOC designers and learners on the interaction and experience in MOOCs. From the above study, it has been identified that the MOOC designers do not seem to understand the needs and demands of MOOC learners.

Furthermore, teaching methods and grading policy have not met the real targets in the MOOC platform, owing to the reasons that the instructors do not have individual attention on

the learners involved in the courses, and cheating has also become a real concern on the online platform. Although many MOOC providers employ some mechanisms to prevent cheating, most of them have not been successful (Pappano, 2012).

A study conducted by (Gamage, et al., 2015) has identified ten dimensions that affect to an effective MOOC from the learners' perspective using the Grounded Theory methodology and the dimensions include, interactivity, collaboration, pedagogy, motivation, network of opportunities/future directions, assessment, learner support, technology, usability, and content. According to the authors, the 'network of opportunities/future directions' dimension is a unique dimension that they have found out which suggests that the learners should have the opportunity to practice the course content they have learned in MOOCs.

According to (Reda & Kerr, 2018), when providing university degrees through the MOOC platform, the MOOC providers grant full degrees in terms of quality, scalability, and accessibility. The term quality here refers to the standards that must be adhered in providing the certifications and courses through the MOOCs portal and scalability is broadening the MOOC network to a huge amount of learners in multiple cultures, while accessibility is allowing the learners to access the course content before enrolling themselves in degrees.

Actually, low completion rate has also become a significant issue since abandoning the courses occurs at the very beginning, soon after the course enrolment in MOOCs. Also, it has been found that if educational institutions provide degrees via MOOC, the completion rate for each course will be lower than 10% because once the needed credits are obtained, the learners tend to leave the course. Further, the authors bring out the fact that MOOCs are not filling gaps in the undergraduate education and its preliminary contribution is to professional development. (Brown, 2013). However, certificates offered through the MOOC platform are not valuable and quality like the certificates provided by traditional universities (Parr, 2013).

A research (Moreno-Marcos, et al., 2020) has analysed the factors such as previous grades, forum and exercise variables, course duration, clickstream data, exam question layout, etc. to identify the influencing factors that predict the performance of the MOOC learners and it is found out that exercise variables are the best predictors for the student performance while the forum variables are found to be useless.

Learner engagement is another factor that must be considered when assessing the effectiveness of MOOCs. The research done by (Guo, et al., 2019) has questioned on the learner intention of engaging in learning materials namely, videos, discussions, assignments, and homework. According to the results obtained, majority of the learners were willing to engage in homework, assignments, and videos while participating in discussions was with less rating. Nevertheless, a limitation identified is that, although the participants to the survey have rated in this manner, there is the need of monitoring the learners in terms of their log data since this results in obtaining the actual engagement of the MOOC learners.

## V. CONCLUSION

Through the conduct of this study, it has been identified that with the rapid development of the Internet, the popularity and concern for MOOCs have risen and with that, it has attracted millions of individuals who are keen on involving in courses online and gain knowledge. Nevertheless, there exist both pros and cons of the MOOCs portal, that should be concerned while assessing the effectiveness of MOOCs. Therefore, this study has aimed to minimize the gap between the unexposed facet of the MOOCs thereby establishing the fact that MOOCs as an online educational platform cannot replace the traditional education system when the effectiveness of the grading and teaching system in MOOCs is considered. Furthermore, when gaining knowledge on the relevant courses, it is in the hands of the learner to decide whether the course is carried out to gain the knowledge in core subject matters or to just earn a certificate for the betterment in their resume. On this basis, it is evident that the need to overview on MOOCs is strenuous in order to identify the real aspect of this online learning portal. In fact, the MOOC

providers should also be much vigilant and must focus on minimizing the issues and dissatisfactions of the learners around the world.

## VI. FURTHER WORKS

Further works of this research include applying the outcomes of this research to identify the driving factors to enrol, reasons to drop out, and assessing the effectiveness concerning the MOOCs platform when compared with the traditional in class courses, through the conduct of a survey.

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# On Scene Crime Reporting System for Law Enforcement in Sri Lanka

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**Abstract** - Police may offer crime reporting also as a service. The number of reported criminal cases has increased over time. Law enforcement discovers a distinction between reported and unreported offenses, and a variety of factors could cause this gap. It is not an honourable thing to allow criminals to remain safely within the community as innocent persons, stimulating criminals to commit more crimes. This would result in the community being in grave danger of being victimized. Like criminal justice, members of the community would seem to be unable to do their tasks, although many crimes are not recorded. This may have an impact on ongoing investigations as well. In some cases, to cover this void from police killings, certain law enforcement authorities impact digital crime reporting platforms via the general public which could report offenses. This paper explains how crime reporting systems are assisting law enforcement and continuing investigations, and the general public's participation in any of these systems. The efficiency of the system in terms of policing is often explored in this study.

**Keywords:** *application, crime reporting, privacy*

## I. INTRODUCTION

Public opinion now demands to know about safety alerts in their vicinity. In everybody's life, security is essential. For this aim, the function of the police in society is highly significant. The police is a government body and responsible for protecting the country's people lives and riches.

Many tourists visit Sri Lanka but have difficulty locating police station phone numbers. People are reporting offenses to police-provided evidence as just a solution. Users have turned

into peacekeepers, attempting to prevent awful events from occurring, which is a huge relief for law enforcement. It is difficult to locate adjacent police stations or their corresponding locations in Sri Lanka. Frequent traffic offenses occur; however, police frequently fail to apprehend them due to a lack of evidence. People should report more crimes than ever been whether there is a place to transmit information and videos to those same police anonymously. The goal is to develop a "PROTECTOR" on-the-scene criminal reporting system. The focus is to eliminate the number of crimes, violence, and unlawful activities (Jayasinghe and Perera, 2021). Fake identities and false alerts confuse law enforcement and ongoing investigations. This seems to be expected, but there is no method of determining whether the reports are accurate or fake unless investigated. Current programs use a variety of methods to address various challenges. However, they are ineffective. As a result, among those situations, actual patients had to rush as well. Moreover, because it takes much time for police to investigate or respond to reported crimes or clues, the public is discouraged from reporting the incident to the police. Unless a victim reports a crime, they expect the police to be sympathetic. However, when the police take their opportunity to answer, people are dissatisfied.

It might happen because of far too many crimes being reported, but perhaps the problem would be that it discourages victims. As a result, people demand effective and convenient responses to their cases through such a violent crime system. The Section II of this paper includes the literature review of this study. The Section III discusses the research methodology, while the Section IV gives the complete details about the data analysis and results. Finally, the

Section V includes the implications and recommendations to the followers, limitations of this research, future directions, and the conclusion.

## II. LITERATURE REVIEW

A crime is defined as an offense that should be condemned and punished by the community. It can often be separated from such a tort, which seems to be a criminal prosecution brought against a private individual. The state or the Commonwealth usually prosecutes criminal offenses. In most cases, it is left to a government employee to file civil legal proceedings. Some offenses would both be capital crimes and civil misdeeds simultaneously (Dhinakaran and Ambikapathy, 2020).

This is commonly agreed that perhaps the necessary equipment concerning any crime has become a voluntary effort subsequently lack, despite the usage from a particular cognitive regime. However, a workout can also maintain any framework beyond spontaneous ethical behaviour. Motions performed during an emotional breakdown do not appear towards being movements, neither do strikes launched by either a somnambulist before awakening, so salvo that consequence of either the number of casualties upon every person. The criminal burden, like a consequence of either the result, furthermore necessitates that the harm done be preserved as having originally produced either by the defendant (Deri et al., 2020).

There is an area of interest between took place crimes and crimes get reported. Police should fill this hole and the public points a prior record of information leading to the public from the enforcement. Many Asian international locations have this difficulty of no precise thanks to document street visitors violations (Omondi, n.d.). The victim is willing; they think about the privateness and protection of their lives. The media constantly searches for warm information and victims do not want to be warm inside the news. The victim is effortless to talk about the incident to the family, friends, and relatives. Because they continually are favourable for the victim (Raza et al., n.d.). Recent research exhibit that willingness is exclusively supported by gender and age. Older victims are going to be greater likely to record crimes to the police than youthful victims. Privacy issues, consent, and police brutality will pave the way for the more extended period of these technologies. Police want to discover a way higher way to take care of human beings to continue to be safer (Gopalakrishnan, 2012). Update their structures

well-timed with the most recent technological know-how and guarantee privateness of the information (Lakshmi, n.d.). Police should motivate society to use their crime reporting system (Shetty et al., 2018).

Tip Submit approves residents to post crime suggestions securely and anonymously. The survey confirmed that the public would utilize an online machine, with nearly 64% of those interviewed. 53% of crime victims take over an hour ready at the police helpdesk to solely document their crimes. Violating visitors' guidelines violation may be a crime that nobody reviews to the police until an accident. If these crime reporting structures can document visitors' violations which will be an exquisite comfort for police and other regulation enforcement units.

The public asks authorities to trade the way of policing as a reality of that. Road visitor's accident in India is growing regardless of Current legislative amendments, attention applications and enforcements of site visitors' rules. Enforcement devices introduce a gadget to supply recommendations or records about site visitors' rule violations. People will record crimes if the gadget gives all fundamental privations and facts defensive measures to shield sufferers and witnesses (Daubs and Manzerolle, 2016). Every party expects to form a safer place to remain and catch each criminal who dwells amongst society (Boateng, 2018).

### *Policy Strategies*

The FIB funded RTI International, and therefore the Law Enforcement and judicial Research Forum, to investigate the types of technology that US law enforcement officials are acquiring and implementing. The major purpose would have been to conduct a large-scale investigation into the harshness of police technology. Instead, the data from national and browser references have been combined to form the goal: reading on the subject foundation to guide police personnel in emerging technologies (Jesil and Basant, n.d.).

#### *A. Smart Police Station System*

Cloud computing appears to be an effective programming paradigm for on-demand consumption. Law enforcement plays an important function in communities in terms of maintaining silence. However, due to a complete lack of resources, the police are frequently reluctant to carry out their tasks and obligations

appropriately (Nicolosi et al., 2020).

Table 1 Summary of Existing systems

Topic	Variables
Willingness of reporting crimes	<ul style="list-style-type: none"> <li>• Marital status</li> <li>• Age</li> <li>• gender</li> </ul>
Existing crime fighting application	<ul style="list-style-type: none"> <li>• Advantages</li> <li>• Use of application</li> </ul>
Privacy and protection of the user	<ul style="list-style-type: none"> <li>• Anonymity</li> </ul>
Android base proposed crime fighting applications	<ul style="list-style-type: none"> <li>• Disadvantages of existing applications</li> <li>• Attraction on android base crime reporting</li> </ul>
Road rule violation	<ul style="list-style-type: none"> <li>• Accidents</li> <li>• Road rule violations</li> </ul>
Importance of reporting a crime	
Enhancing crime reporting and monitoring	<ul style="list-style-type: none"> <li>• Use of web and mobile technologies</li> </ul>
User privacy protection	<ul style="list-style-type: none"> <li>• Cloud storage</li> </ul>
Secure crime reporting	

### B. Existing Systems

With time each crime reporting gadget desires to be up so far or exchange the system. That does an advantageous impression on humans as formerly Canadian research confirmed a declining willingness to record crimes [6] makes communities hazardous and obtain tougher to try topolice within the vicinity for regulation enforcement units. So, they observe a definite machine to inspire humans to document crimes. To contain them in policing, this is often an exact trick to urge extra crime reporters alternatively than not reporting. Every one of us of America got to defend its citizens to try to do that, and they need to require some precautions.

The latest cell software named Mobile Vic PD was once launched through the Victoria police in Canada for struggle crime. The cellular utility is often wont to file minor crimes, provide nameless recommendations to police, remain up so far on crimes ongoing, acquire lacking infant reviews or take a glance at on transferred property because the crook

records are not reachable remotely there is a conversation hole between the police investigating any case. The downside of this utility was once that it wont to be inclined to pretend to report a crime and there was once no different thanks to affirming that the incident was once real (Tundis et al., 2020). This software was once in a position to reap the aim of Canadian regulation enforcement gadgets expected. To trade public willingness to record crimes. As within the past discussed, utility this software additionally anonymously crime reporting to police. However, these purposes are not any longer use for emergency purposes. They want to assist regulation enforcement gadgets to preserve the world safer. Not contacted for emergencies or to document a significant crime. These purposes can motivate the general public to remain vigilant and support the regulation enforcement devices to police, raiding, and assist for ongoing investigations (Avdija, 2019). These reporting details are saved on the database. After a politician confirms the details or guidelines, they got. They dispatch those facts to the applicable parties. If these functions are capable of affirming the knowledge, proper after they mentioned the price of the statistics would be excessive and it will assist in expanding the effectiveness of the crime reporting structures effectively. Many nations use structures to seize the crimes above table 1 summarized crime-fighting applications (van de Weijer et al., 2019).

This paper exhibits purposes every software offers specific facets to the victims and witness anyway their remaining purpose is to aid enforcement gadgets to continue to be safer the world. As an impact, we strive to use this function to guarantee their safety (Singhal and Shukla, 2012). The recurring element in most of the functions supplies danger to record anonymously. People like to be nameless and grant the data to guard their identity so that they do not want to fear their safety. Some purposes use a sincere technique to affirm the knowledge. By verifying the expertise, the usage of the broader public as an instance if they acquire an anonymous tip about the endured robbery, they notify the closest tipsters spherical the situation. So, these tipsters can additionally inform anonymously

is genuine or false, the use of the equipment so, it is an environment-friendly technique to reply to matters shortly as possible. Every software makes use of exceptional techniques to acquire information. Mostly these facts shop in cloud storage. Security of these strategies is excessive and shortly can retrieve the info.

Many Asian nations nonetheless use file base guide systems. These do not seem to be fine when examining these applications. These present purposes can show that we constantly remain nameless and document crimes. In Canada, the app known as “Mobile Vic PD” is equipped to show that due to the fact there is research indicates that people do not incline to record crimes (BinDhim and Trevena, 2015; Mathur and Sharma, 2020). After this software is launched, willingness is modified. This lookup indicates human being’s attitudes toward the prevailing device and technology-based system. There may be a survey therein paper that proves society is inclined to document crimes on technological know-how base structures alternatively of a fashionable machine (Tundis et al., n.d.). If the gadget presents anonymity so, human beings are inclined to record police. Albeit it is about police brutality. A man or woman who cannot attend the police and file a crook offense towards the police will know not to be inquired. However, in software that proved safety, human beings do not hesitate to file incidents. Police additionally understand that if they did not inquire, it would purpose a multitude. Now truly can see that except for these kinds of structures, police cannot manipulate all the items alone. However, if these structures exist, police additionally getting into bother if they broke the law. In southeast Asia, USA regulation enforcement uses a guide technique to file a criminal offense. Mostly use the eBook to write down. However, if the e-book is free or a person tears the online page within the book. Relevant inquiries will and crime reviews will disappear. Due to that, the sufferer will discourage from recording crimes to the police which will lead criminals to remain safe as innocents amongst the society, public and police relationship will fail, the wide variety of crime case reviews will limit evaluation to actual crook cases and additional regularly

public will misplace the willingness to file crimes.

When police verify the rules from the tipster, they need to motivate them to file extra crimes. Until the public and police preserve their relationships closer, the vicinity that lives will find safer for all. Not solely tips. Crime reviews also do an incredible influence because a proper investigation can trap criminals easier. Technologies do an excellent job of contemporary policing the world. Within the survey, the bulk invites online structures thanks to the fact that they trust this is often superb thanks to informing regulation enforcement devices about the crimes and providing guidelines about the crimes. Within the current file base crime reporting processes, the citizenry remained for a longer duration to try to whole the method. When it involves the online system, they are doing not need to waste their time. Quickly they will respond. Following table 2 illustrates the existing system technologies with relevant applications.

Table 2 Existing system technology

Application	Advantages and technologies	Platform
Submit tip	<ul style="list-style-type: none"> <li>• Allows Anonymous tips</li> <li>• Tracks location of uploads</li> <li>• Use PL/SQL for Database</li> </ul>	Android/iOS
Web Cast	<ul style="list-style-type: none"> <li>• Associates crimes with places where they occur</li> <li>• Use Google maps and cloud services for Database</li> </ul>	Web based
Mobile Vic PD	<ul style="list-style-type: none"> <li>• Allows Anonymous tips</li> <li>• Allows updates of crime in progress</li> </ul>	iOS
Accurint	<ul style="list-style-type: none"> <li>• Verification of information in the field</li> </ul>	iOS
Cop link	<ul style="list-style-type: none"> <li>• Quick situational awareness and geospatial searches</li> </ul>	Android/iOS
IPOL Mobile	<ul style="list-style-type: none"> <li>• Latest crime awareness</li> <li>• Vehicle-ownership checks</li> </ul>	iOS

Because of the amplitude of a visitor's breach, policy violations because of visitors, corruption trouble, amongst many other issues arise. Until every device operates manually, and no one runs to grab the nice automatically. As nothing more than a result, corruption is on the rise. If somehow the gadget is computerized, high-quality devices will be given robotically to the person who violates the law. Corrosion is also decreasing rapidly.

Because cheating is difficult. These kinds of structures will help to start reducing visitor concerns and reduce visitor policy infractions. Most present criminal reporting purposes were never intended to document infractions committed by street site users. However, this would frequently be an important aspect that just about every utility should contain. For example, many visitors violate the rules in Sri Lanka. In urban locations, such as Colombo, three-wheelers are known to breach site visitor guidelines ("International Journal of Scientific Research in Science, Engineering and Technology, IJSRSET," 2018). These movements can cause traffic congestion on the site. So, because the existing functions should be expanded to include that function, it will become a massive help to drivers, law enforcement, and pedestrians. No count how top the gadget is launched. It is all remembered of willingness to record crimes. People will record crimes if the machine gives all vital privateness and records protecting measures. That geared up to defend sufferers and witnesses. As enforcement difficulty is about the understanding, they get hold of if the gadget is equipped to show the reliability of the understanding that received, the device will be approving the enforcement productivity. Inside the end, each party expects to structure a safer location to measure in and caught each crook who lives inside the society. That was once the most purpose to realize. To realize it public, enforcement, victims, and witnesses should work collectively and maintain a higher relationship. These varieties of crime reporting structures assist in striving to do that. Technology helps to continue to be all safer. They have an impact on these structures that is extraordinarily high. It assists in providing top exceptional of existence and offers a threat to measure barring fearing anyone. Family, kids, females, elder human beings can stay safely and fortunately due to these systems. Those that figure out to commit crimes get worried about attempting to crimes. Because they comprehend these structures are existed to caught them. It is hard to stay secure after doing a crook offense. Subsequently, crime-free societies are going to be created for all.

### III. METHODOLOGY

This literature review evaluates previously

utilized articles, journals, and papers. Previous crime reporting relevant research was used for this paper through reading. Those study records were acquired, examined, and revised to be entered into the current research. In addition, previous surveys done by various researchers were utilized. Due to all the pandemic conditions, it is not practical to collect primary data; therefore, this article relied on secondary records for its study. All information was taken from publications. Numerous of them are being received through the lookup gate net application, along with all the information received was formatted precisely to keep the flow of such lookup to form interest, important, and clear for readers. Every one of the sorted statistics is sorted according to the importance, including its knowledge to be evaluated, and some are excluded since they are not relevant to the query only within publications. When selecting information, consider the reliability as well as the relevance of the data to the research. This could help to boost the research's productivity. The purpose of this paper seems to be to discuss the significance and influence of crime monitoring mechanisms to authors, including citizens who have been involved in this controversial issue.

### IV. ANALYSIS

This article addresses how crime reporting systems can assist law enforcement units in making the community safer. When a victim or a witness reports a crime, the actions of law enforcement forces have an impact. People's willingness to report it to the police is the most important aspect in determining whether to report a crime. Encourage the public, criminal justice units must increase security and privacy, and a crime notification system is essential. These systems provide anonymity and other security characteristics to safeguard people and report more incidents to the police. These systems outperform old manual solutions in terms of effectiveness and efficiency. It increases the trustworthiness of crime reporters. Victims can file a crime report in a short amount of time. Another advantage of this crime reporting method is that it is simple to authenticate information, and current offenses will be reported to confirm the information. Various systems employ various ways.



## V. CONCLUSION AND FURTHER WORKS

In the investigation of large and large-scale crimes, a computer is a tool. Investigate any category; apart from i2 and Watson, the bulk of the existing systems are meant to be utilized and have specially developed for a specialized market. When assessed against its intended application, each system works effectively. The systems, however, rely largely on users who ask for issues to help in the research process. The user cannot determine specifically in the context of mass crime which issue is significant and cannot link comparable incidents effectively in a series.

Across both criminal categories, the human investigator is responsible for asking the correct questions or interpreting the information processed. These demands growing sophistication and expertise to achieve the greatest software outcomes and establish trust in the methods. Most police officials of Sri Lanka use detective officers' specialty teams, assisted by qualified Civil Support personnel, including trained crime analysts, to obtain the best outcomes. The degree of skilledness with different parts of crime requires time for development and might vary. There is need of a crime reporting system in Sri Lanka, because there is no existing system to report a crime. In future planning to build a crime reporting system for law enforcements. AI methods should now be used to review and provide information automatically. This would be partly because computer literacy is often not adequate and because systems need considerable information that users might disagree with and that the knowledge could be up-to-date and difficult to upgrade.

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# Use of an Improved Online Job Recommendation System to Search Job Roles and Vacancies

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**Abstract**— Finding the perfect job is the main purpose of Higher Education for young individuals. For this purpose, nowadays, there are a lots of job portals available in Sri Lanka, where job seekers discover work opportunities and vacancies according to their preferred job titles. Yet for this, the seeker has to have a clear idea about at least several job titles or roles in a company. Not every person who uses these portals has knowledge of jobs and job positions, and most might know only a few job positions, while they might not have ever heard of some. With the outbreak of the COVID-19 pandemic situation, the whole world has been suffering for almost 2 years now. Changes have happened in every sector in continuing with daily processing during the pandemic. Many researchers have already proposed matching approaches by developing ontologies as a reference to mediate matching accuracy approximately. However, these approaches do not prove how closely matched applicants are in relation to their core skills. This research paper proposes a method that uses a proper approach for improved keyword searching, by influencing the comparability between concepts in the judgment, which represents the core skills and qualifications needed for a job to decide how closely matched an applicant is during the job searching process, mainly focusing on two recommendation processes; job role recommendation and job vacancy recommendation.

**Keywords:** *job portal, job search engine, online jobs, job role recommendation, job vacancy recommendation*

## I. INTRODUCTION

The Internet has become the primordial medium for everything by now. The same situation applies for recruitment and employment processes as well. There are plenty of global job

portals available and they also have included Sri Lankan Job opportunities as well. This indicates an upward ambition in existing job portals being a top player in modern-day job recruitment process.

Most elegant search mechanisms are adopted by online job recruitment portals which rely heavily on subordination of keywords in free text before search results are shown. These mechanisms were there even before the pandemic but mostly used during the COVID-19 pandemic. This may produce a collection of results from the submitted keyword or phrase but most of those results may not be relevant to user's need. Also, all the job portals that can be found related to Sri Lankan job industry follows the same concepts and most of them are contained with similar functionalities. All of those job portals are designed by targeting the job vacancies of various companies. As a result of that those job portals are targeted to fulfil the needs of the audience who are available for what they supply. This research paper focuses on how the online job portals have helped people and how useful these online platforms are in seeking jobs in any industry. With the COVID-19 outbreak most people had to change their industrial statuses and companies as well. Further the implications of curfew for a long-time durations and travel restrictions have made most companies in a difficult situation and the companies that was unable to adapt to the situation has been closed by now. Due to these reasons more people are unemployed and searching for jobs with higher demands and stable future statements. There are many people who still depend on old job searching methods like Newspapers and articles. But technology can make it easier than ever, if it is used properly and effectively. There are various job recommendation systems in Sri Lanka and each job portal has common features and qualities. People are used to choose the platforms which are more likely comfortable for

them to use. The next factor that effects these job portals is the technology and search mechanisms that is used. With the improvement of the technology there has been changes also in these common web applications too. As an example, most web-based applications are now turning in to Semantic web application as it gives better search results rather than the traditional web applications. By considering all the above facts through this research, it focuses on the pros and cons of the existing job recommendation systems and how the proposed method can affect the job seekers in an efficient way than existing job recommendation systems.

## II. LITERATURE REVIEW

There are several research papers published related to online job portals already using various technologies in semantic and web technologies. But none of them explains how these systems are useful in pandemic situations. Therefore, it is essential to gather information through a survey regarding the situation to combine the existing job recommender system technologies with the selected problem domain.

Amity university researcher named Seema Wadhawan has gathered information on factors influencing young job seekers' perceptions towards job portals. According to them with the development of the modern technologies, youngest job seekers are interested in online job portals. Most of the top-rated companies in India use online job portals for hunting the best talents. They further conclude that handing out the information to job seekers about the relevant open vacancies is not only one of the factors to build the perception towards the job portal. Numerous other factors like usefulness, ease of use, widespread services, potential career opportunities, quality of the system, and trustworthiness that conduct the determinations are discovered (Wadhwan, 2018)

According to Uma Pavan Kumar's research paper on Concept-based Dynamic Ontology construction for job recommendation system ontology is a polite detailed classification of shared inspiration that provides common semantics for agent communication. They strongly believe that their system will give the best outcome in case of suitable job recommendations for both employers and job seekers without spending much time. To attain that first, they have gathered the data from

various web pages and stored the collected data into .csv files. In the second level, the stored input files are used by the common numerator measurements and ontology creation module by generating the equivalent Web Ontology Language (owl) file. The third stage is creating the ontology with the generated. owl by using the dependent tool. Finally, the created ontology shows available jobs related to the given skills. Further, they generate reports considering relationships and attributes. (Kumar, 2016)

Joachim HASEBROOK and Ankit SAHA ISNM International School of New Media at the University of Luebeck Germany has observed about Job hunting and how students look for jobs online. Their survey results certify significant strengths and weaknesses of various aspects of online tools and services used in the job surfing process. They further locate that student from some regulations are more accomplished than others at the effective use of online tools and services. Even though the majority of participants have identified themselves as heavy Internet users, there seemed to be a lack of awareness of some developing web technologies too. Younger people below 30 years old mostly use online tools effectively than their earlier generation does (HASEBROOK, 2007).

According to the Global Job Seeker Survey held in 2016 and sponsored by 'madgex-Job Board Doctor' conducted in the U.S, The U.K and German to identify and evaluate job opportunities, they found out that there were many similarities between job seekers in the U.S., U.K., and Germany – but also some significant differences. There were also comparatives in behavior – perhaps not doubtfully – when responses were analyses by ages. None of the respondents in all three countries found it useful to upload a video CV/resume and according to them the most critical factor in choosing a job search tool for all three countries was “Jobs in my location & Jobs in my industry/sector”. The top job seekers in all three countries, locate jobs, and apply on the employer's site, research jobs, and identify employers. Employers that include salary with their job postings are much likely to collect responses from job seekers (Dickey-Chasins, 2016).

The research on Integration of Job Portals through Meta-search by Jürgen Dorn and Tabbasum Naz Vienna University of Technology, Institute of Information Systems, List down the

trends towards an online exchange of information about human resources with examples. They have developed a prototype for affiliating information on different job portals into one meta-search engine. They have investigated existing job portals and uninspired XML schemes from those job portals. Then, translation rules for translating each schema to a centralized HR-XML-conform schema were stated. They conclude that the main difference between their work and existing works were that they used HR-XML for schema unification and the research paper s doesn't explain how to symbolize XML Schema substitutes for HTML elements, i.e. text boxes, text areas, radio buttons, checkboxes, select lists, and generation of XML Schema for HTML search UI/UX (Naz, 2014)

Shalini Lihitkar, Department of Library and Information Science, Rashtrasant Tukdoji Maharaj Nagpur University in India has routed a survey and published a research paper on LIS (Library Information System) job portals and it says that "The study revealed that 1433 educational & research institutes have posted job opportunities in the LIS jobs.com, GSLIS Gateway, and Info librarian.com. Originating out of 635 jobs advertised for the academic libraries in three LIS job portals 412 jobs for university library followed by 174 jobs for college library and 134 jobs for the school library and most of the institutes has recommended to look their website for further information & other institutions (439) are not posting their information of websites" (Lihitkar, 2009).

Another research has led by four talented authors of Atharva College of Engineering, University of Mumbai. Mumbai, India on Job Portal using Data Mining Techniques for dynamic Analysis in 2016 and analyzed that the data mining techniques were used to list out the company details. That also helped the companies tied up with the job portals to shortlist the users to fill the job vacancies and the requirements of the users were managed through data mining techniques. They have further informed that their system more importantly solves the problem on both ends with certain clarity to protect user privacy. Also, it is to be noted that their system doesn't prove a job to any user as it depends on set of skills and vacancies of jobs of the applicant (Patil, 2016).

In 2012 P. Niaphruek Department of Computer Science, Faculty of Science, Rajamangala

University of Technology Thanyaburi has published a research paper on A Job Recruitment System Using Semantic Web Technology and that paper presents A Job Recruitment System Using Semantic Web Technology and it has introduced an information model to represent a CV (curriculum vitae) by creating the CV Ontology based on exiting well-known standards such as Europortfolio Europass CV, Description of a Career, FOAF and VIVO. The survey results express that this proposed system is better than others, especially in supporting RDF, supporting ontologies and vocabularies, supporting SPARQL, and enabling linked data by SPARQL endpoint. Their study has designed only an information model of CV for an applicant. (Niaphruek, 2012)

According to the paper under the topic, Ontological User Profiling in Recommender Systems done by STUART E. MIDDLETON, NIGEL R. SHADBOLT AND DAVID C. DE ROURE Intelligence, Agents, Multimedia Group, the University of Southampton in 2015 they explore a fresh ontological approach to user classification within several recommender systems, while working on the issues of recommending online academic research papers. The research paper is categorized using ontological classes and interactive recommendation algorithms used to recommend papers seen by similar users on their current titles of interests. They list down the advantages and disadvantages of their ontological recommendation system at the end (STUART E. MIDDLETON, 2009).

Sudiana, Computer Science Graduate Program, Bina Nusantara University, Jakarta, Indonesia in 2014 brings a discussion on Users' Interest Assessment on Job Portal and they conclude those job portals allow users to search for employment to move forward with their careers, or to market themselves in the industry without much effort. They gather out some complaints regarding features of job portals that are unable to fulfill the users' needs and those complaints have caused in declining the number of users. They say their research summarized that there were four factors like context, content, community, and commerce that affected users' interests toward online job portals (Sudiana, 2014).

### III. METHODOLOGY



This paper proposes a proper approach for an improved job recommendation system that allows the users to get knowledge about the job posts and job roles. There are already plenty of job portals in Sri Lanka, but all those portals provide job vacancies based on keywords. This paper is based on a survey to identify the engagement of the youngsters with the job portals and the features that need to be changed in existing job portals in Sri Lanka. Mostly the final year undergraduates are the people who seek jobs and internships during this period, as a result, majority who participated in this survey are final year undergraduates and unemployed people during this pandemic situation.

The methodology of this research consists of four major steps. They are Problem identification, Conducting a survey, Result analysis, and Result evaluation. Parallely the implementation of an improved job recommendation web application is done as the final year project. The survey results with descriptive discussions and conclusion of this research paper will affect in developing that job recommendation system. As the first stage of this research is identifying the problem domain. The problem domain discussed here is how online job portals affect people's lives during this COVID-19 pandemic situation. Then as the second stage of the methodology, referring existing research papers about the problem domain and job portals to find the solutions to the problem domain. Also in this stage, the survey is created and distributed. As the problem discussing here is a timely topic the best way to come to conclusions is by conducting a survey and analysis of the survey results. For that, the questionnaire must be symmetrically divided into all the criteria that needed to be addressed. The third step has to be the questionnaire. This paper is based on a survey to identify the engagement of the youngsters with the job portals and the features that need to be changed in existing job portals in Sri Lanka.

As the fourth step, the gathered data and information from the questionnaire have analysed and find the solutions to the problem domain. The last step is the outcome or the final decision or conclusion of the discussed results.

The Semantic Web is an outstanding extension of the existing web, in which information is given a figurative explanation and is machine operatable. Ontologies have become crucial element of semantic web technologies introduced before.

The source of the term ontology is in philosophy, where it is mainly focused on the study of the behaviour of existence. As mentioned before a survey was created to get enough responses covering the area of existing job portals and the engagement of the unemployed and employed youngsters with those job recommendation systems in Sri Lanka. The contribution of this study is to review the engagement, identify the mistakes, challenges when surfing a job using the existing job portals, and to get the audience suggestions related to Job recommendation system. With all those gathered information the implementation has done. According to the situations discussed here the best solution that can be included is developing a job portal which has the ability to search for the eligible job roles by entering qualifications and interests of the user and at the same time including the facility to search for the job vacancies with proper description and detailed information to have a better understanding. Descriptive search results will help the job seeker to take the best decisions on behalf of himself. When talking about the implementation process it is important to pay more attention to the user interface and the content of the web page. Otherwise, it will not be much useful because the most common disadvantage most of the job portals are the poor user interfaces. For the recommendation, purpose an algorithm has used and for the filtering purpose content based filtering and collaborative filtering has used,

#### **IV. RESULTS AND DISCUSSION**

The questionnaire is conducted to gather and analyse information about existing job recommendation systems in Sri Lanka and encapsulate the most useful and effective features for an online job recommendation system. The questionnaire contains complete nine questions and under question number eight there are five more rating questions for the audience for a better understanding. The questionnaire was distributed among 130 people and had received more than 100 responses within three days targeting students Undergraduates and postgraduates.

When discussing the survey results majority who have responded are women and the percentage is 70.5%. As this survey is focused on youngsters like undergraduates and postgraduates the unemployed percentage is in a higher stage. That

means among the responders 83% are unemployed, 8.5% are working under part-time employment, 7.5% are working under full-time employment and 1% are contract employers. In a world that is filled with so many online job opportunities, it is sad to believe that more than 80% of the undergraduates and postgraduates are unemployed.

Another thing to consider is the knowledge about job searching. Above mentioned pie chart shows the percentages. According to this survey, 24.5% say that their knowledge about job portals is in a poor stage and 7.5% say it is very poor. There are only five people out of 106 responders who say they have excellent experience on job portals. This leads us to the reason for the responses to the previous question.

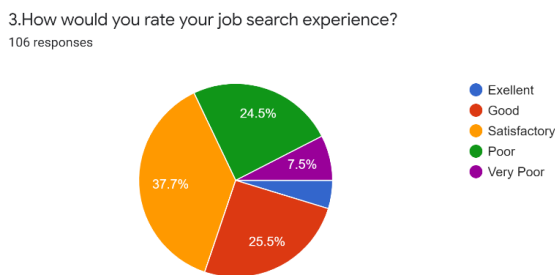


Figure 1: Rating of job search experience

In the questionnaire, there is a question that asks about the top 10 existing job portals in Sri Lanka and the responses are unexpected as 23.6% of the responses say that they haven't even visited any of those job portals. Topjobs.lk, Xpressjobs.lk, IkmanJobs.lk, Jobpal.lk, Observerjobs.lk, CV.lk, Myjobs.lk, Dreamjobs.lk, and Jobenvoy.com are the top 10 job portals in Sri Lanka. Topjobs.lk is the most popular site out of those 10 job portals and that percentage is 52.8%. The second most popular job portal is Ikmanjobs (32.1%) and third place goes to Myjobs that has 31% responses. The rest of the results gained by other job portals are mentioned below in the graph.

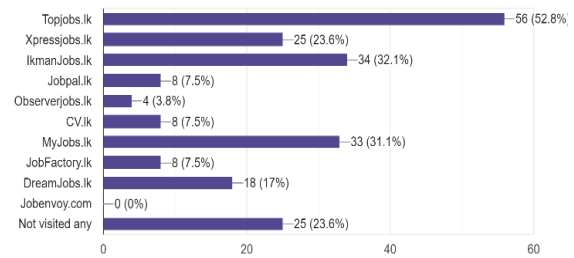


Figure 2: Existing Job Portals

When talking about the existing job recommendation systems there are both pros and cons of those job portals. Some of the pros and cons of those existing job portals which was found within this research is listed as bellow.

Table 1: Pros and Cons of Existing Job Portals

Job Portal	Pros	Cons
<b>Topjobs.lk</b>	<ul style="list-style-type: none"> <li>Ability to check job application status (applied, shortlisted, and Offered with the Job / Not Successful).</li> <li>Special offers and organizational benefits for registrations.</li> <li>Ability to submit the job application to employers directly.</li> </ul>	<ul style="list-style-type: none"> <li>Search option needs to be improved</li> <li>UI is not user-friendly.</li> </ul>
<b>Xpressjobs.lk</b>	<ul style="list-style-type: none"> <li>Offering career guidance for job seekers.</li> <li>Providing unique and convenient price packages for the recruiters.</li> <li>Easy and convenient search options.</li> </ul>	<ul style="list-style-type: none"> <li>Job seekers cannot directly send the CV to the because of the privacy and filtering purpose of the companies.</li> </ul>
<b>IkmanJobs.lk</b>	<ul style="list-style-type: none"> <li>Offer app facilities</li> <li>Support multilingual languages (English, Tamil, Sinhala)</li> <li>Job seekers can reach employers directly without signing up.</li> </ul>	<ul style="list-style-type: none"> <li>Do not provide sufficient job descriptions on the feed.</li> </ul>
<b>JobPal.lk</b>	<ul style="list-style-type: none"> <li>Providing valuable resources of Human Resource Management</li> <li>Job seekers can reach employers directly</li> <li>Instant job alerts via SMS or Email</li> </ul>	<ul style="list-style-type: none"> <li>Needs multilingual languages implementation.</li> </ul>
<b>CV.lk</b>	<ul style="list-style-type: none"> <li>Having a wide variety of job categories in local and overseas.</li> <li>Offers candidates for a wide range of firms and job vacancies.</li> <li>Make the whole recruitment process effective and less time-consuming.</li> </ul>	<ul style="list-style-type: none"> <li>Search option needs to be improved.</li> <li>multilingual Languages implementation is needed.</li> <li>Poor UI design.</li> </ul>

There are many things that people focus on the most when searching for jobs. In the survey there are some of those factors are listed. Role or the job title, Salary, Work-life balance, Workplace, and company culture and colleagues are those listed factors. According to the survey responses analysed by the google form most of the people are focusing on salary (65%) as the first thing and then there comes the role or the job title (62%) and work-life balance (52.8%) and colleagues (12.3%) at the last. Also, the questionnaire results say that when searching for jobs majority use Job search engines mentioned earlier and that percentage is 59.4%. 51% also are familiar with searching for jobs on social media like Linked-in, Facebook, Twitter, and Instagram. Further, the survey results prove that LinkedIn is mostly (59%) used social media in job searching and the second-most used social media platform is Facebook (29%). A small number of votes has gone to social networks like Instagram (4.7%), Twitter (2.8%), Google, company websites, and friends.

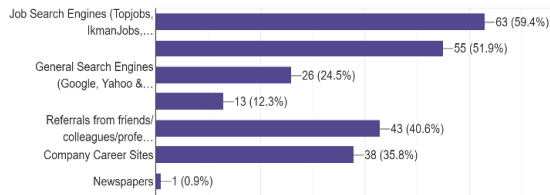


Figure 3: Job searching methods

In the questionnaire, there are five features mentioned in order to get the ideas of the responders. First feature is the ability to make the resume anonymous could be useful, and for that feature majority (62) agrees then the strongly disagree (2) responses. In the second feature, it is mentioned as the ability to filter job titles according to the existing qualifications makes the searching process easier. That is the main function which will be implemented at the end of this project. Almost all the users agree with that and the strongly agree response rate is also at a higher level than the other four features. according to the responses of the third feature most of the users expect more details about the suggested job roles from any job portal. Also, the user expects to upload the CV easily into the system and there must have a method for the receivers to filter and analyse the responses (CV) for their vacancies. And the final feature of the job portal related questionnaire is about expert support and guidance. Most of the users ask for expert support and guidance in choosing jobs through job portals. As the final question of the questionnaire, the responders are allowed to provide their suggestions and feedbacks regarding online job portals. Among those suggestions, there are some interesting suggestions too. A responder says "It would be easy if we can open and select jobs in a new tab or put selected jobs into a cart and after selecting all the jobs can apply those jobs which we put into the cart one by one" This comment is a suggestion that none of the job portals have.

When implementing the system, it is important to consider almost all the things discussed earlier. As mentioned before there are two recommendation processes in the portal and they are Job Role recommendation and Job vacancy recommendation. Further for the other sub filtering purposes it is needed to use collaborative filtering and content-based filtering. Also detailed information is needed to display every time in the search results because

most of the users use job portals for the research purposes and decision making and as a result of that information is much more important here. The following attachment shows how the detailed descriptions are added in the implementing system.

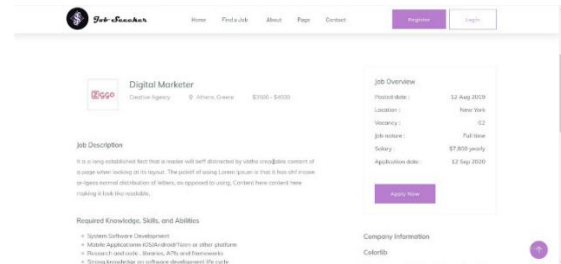


Figure 4: UI Job vacancy search results page

The idea can be improved and for job portals, the developers can add "into cart" option as well. Another good suggestion which came within the responses is that ability to apply for online jobs separately and include the details and guidance details about online jobs in the job portal. If a system comes with job applying feature, will be a good platform for anyone who is having difficulties when finding for jobs. This also proves that the idea of an improved job recommendation system for Sri Lanka well come idea.

## V. CONCLUSION

After detailed analysing the data contained in many ontology-based research papers and the conducted survey, could decide that most of the undergraduates are unemployed and when searching for jobs most of them are willing to use various job portals and social media platforms. This research proved that the Mostly known job portal was Topjobs.lk and the most used social media platform is LinkedIn. The majority had a little amount of knowledge on online job portals and that has to be changed. Because using a job portal makes so many opportunities than other job-seeking methods as it practically allows access to the platform anytime anywhere for anyone even without any human connections. All the applicants or the seeker need is the ability and the true qualifications. Also, through the survey, it proved that Salary, job title, and work-life balance are the basic things people mostly focus on when seeking jobs. As it is mentioned before the main purpose of this research is to find about the engagement of the youngsters with online job portals and to know what do they think about the existing job portals in Sri Lanka to

design and implement an improved job recommendation system.

As mentioned, before it is more appropriate to use social media platforms and online job portals in searching jobs under the current situation all around the world. It also gives the users many advantages like they can search for what they like within milliseconds and that doesn't waste any money. The ability to apply for any job role preferred by the user is also an advantage and no additional cost is applied. With the current situation COVID-19 pandemic the job seekers can filter their preferences like whether they need a physically attending job or a work from home job and after deciding, apply. Further most of the companies conduct their interviews using social media platforms and meeting applications like Zoom, Google Meet, Microsoft Teams and Skype. As a result of that it is safer in using these modern technologies rather than following the traditional methods. There are also few new job portals are rising in the society Rooster Jobs is an example for such platforms and people are more in to online stuff mostly the youngsters and the main reason for that is the COVID-19 situation.

The research statistics are based on google form diagnostics and the same survey can be done using more complex analytical tools like SPSS, Minitab in the future to get highly discriminating data that can be depended on for further productive results.

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KHNK Kumarasinghe is a 4<sup>th</sup> year undergraduate student of the Information Technology department at General Sir John Kotelawala Defence University. She was

actively involved in creating the survey based on the topic and focused on the results and discussion in this paper. She also covered all the areas of this research paper

including the Abstract, Introduction, Methodology and Conclusion.



# SQL Injection Detection and Prevention Solution for Web Applications

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**Abstract**— Presently, the most highly used method of global communication is web applications. It is used for long-distance communication, online marketing, health services, research and development, distance learning, e-banking and social media networks. Since web applications are available for global community with access for anyone at any time, web applications are confronted with numerous challenges that comprise of security issues, specifically owing to web-based cyber-attacks. The SQL injection attack is the most prevailing global web-based cyber-attack, and it belongs to high rank classifications. Because of the increased number of global online services with a high rate of cyber-attacks, SQL injection attacks also are amplified rapidly. Most of the SQL injection attacks are successful, due to lack of proper validation. However, a successful SQL injection attack highly interferes with integrity, availability and confidentiality of the data in the databases. Therefore, there is a vital global requirement to overcome SQL injection attacks. Towards overcoming predominant issues, a periodically and continuously running PHP based programme, which is able to identify patterns of SQL injection attacks recorded in PHP Apache log files, and is capable to block the identified suspicious IP addresses was designed as the adopted methodology. In this empirical research, statistics of total suspicious IP addresses and blacklisted IP addresses with their hitting counts and time were obtained, while preventing access of blacklisted IP addresses to the Apache web server. The proposed solution facilitates for continuous monitoring of suspicious activities, while blocking vulnerable hosts using its IP addresses automatically with securing web servers from the SQL injection attack.

**Keywords:** *SQL injection attacks, web applications, communication*

## I. INTRODUCTION

Right now, the most highly used method of global communication are web applications. Web applications are used globally for long distance communication, online marketing, health services, research and development, distance learning, e-banking and social media networks. Ever since, the web applications are accessible for the global community with having access for anyone at any time, web applications confront with numerous challenges comprising the security issues, specifically owing to web based cyber-attacks. Among various cyber-attacks, the Structured Query Language (SQL) injection attack is the most prevailing web based cyber-attack globally, which belongs to high rank classifications. In view of that, the line of codes describe the basic SQL injection attack is as follows:

```
The statement = "select * from customers where
name = " + customerName + ";
```

Above mentioned SQL code is created to pull up all the records of the user specified "customer name" from the table "customers". Conversely, if the "customerName" variable is crafted, which is designed as specific way by one of the vulnerable users, the SQL statements may perform more other than the author intended. For instance, setting the "customerName" variable using as follows:

```
' OR '1'='1
```

or consuming comments even to block the rest statements of the query (In here, mentioned 3 types of different SQL comments). All the lines

have a specified space in the end of the each of three statements as follows:

- i. 'OR '1'='1' --
- ii. ' OR '1'='1' {
- iii. ' OR '1'='1' /\*

The above codes render one of the above mentioned SQL statements by parent language as follows:

- i. `select * from customers where name = " or '1'='1';`
- ii. `select * from customers where name = " or '1'='1' --';`

When these codes are to be consumed in an authentication role procedure, then above example could be utilized to force to get selection of every field of data (\*) from customers SQL table, excluding one specified customer name as the author intended, due to the evaluation of code '1'='1' is normally always true. The above value of "customerName" in the statement mentioned below, would cause to deletion of the "customers" table (SQL) as well as get selection of all the data from the "customerinfo" table (in essence that revealing the information regarding every user), using user API that allows more sql statements:

```
a'; DROP TABLE customers; SELECT * FROM customerinfo WHERE 't' = 't
```

Such input renders the executing final SQL statements as follows:

```
select * from customers where name = 'a';drop table customers; select * from customerinfo where 't' = 't';
```

To prevent SQL injection cyber-attacks, web application developers may use specific tools for check availability and prevention of SQL injection attacks. At present, such tools are WAF (Web Application Firewall), "Positive Tainting", "SQLrand", "CSSE", "CANDID" etc.

Nevertheless, the web application security is extremely vital in preventing SQL injection attacks. Because of the improper security coding practices, the developers are subjected to numerous cyber-attacks, particularly with malicious source code injecting cyber-attacks. Further, several improper and insecure coding practices are frequently used with low encryption, which are subjected to the lack of

protection. SQL injection cyber-attacks conduct with segment of malicious code into SQL query through none or without proper validated environment and that will be received by the web servers. Such malicious codes, which are inserted by the cyber attackers are pretend as the legitimate SQL query statements. Hence, sequential execution of such malicious codes by the web servers affect to the internal system and database management systems, which leads to SQL injection cyber-attacks in order to execution of improper SQL commands. Most of the SQL injection attacks are effective due to deficiency of proper validation. Though, a successful SQL injection

attack vastly interferes with integrity, availability and confidentiality of the data in the data bases. In addition, based on the research findings and prevailing statistics, as well as based on the available data in the internet, such SQL injection cyber-attacks have a serious impact with global organizations. Accordingly, there is a vital global requirement to overcome SQL injection attacks with an effective solution. With this view, there are three key objectives in this research. The first objective is to detect the SQL injection attacks affect to the web servers. Afterwards, the second objective is to explore the preventive solution for SQL injection attacks affect to the web servers. Finally, the third objective is to share the knowledge on SQL injection attacks with other researchers.

## II. LITERATURE REVIEW

At present, majority of people use web applications, which are accessed through World Wide Web, precisely for long distance communications, online marketing, distance learning, e-banking and social media networks. Amongst the web applications, the most of them are available for anyone globally without any restrictions. Because of such reasons, it is exposed to confront with many challenges comprising more security issues cum cyber-attacks via internet. Consequently, Lijiu (2010) revealed about the web application vulnerabilities, such as malicious file execution, cross site scripting, SQL injection and cross site request forgery, which have the connection with secure coding of web applications. Further, Mark (2006) also studied regarding security

vulnerabilities related to web applications including different types of analysis tools. Moreover, Mark (2006) identified different types of analysis tools such as, source code analysers, Black box scanners, DB scanners, Binary analysis tools, Runtime analysis tools, Configuration analysis tools and Proxy analysis tools. Accordingly, the tool termed “MUSIC” tool is used to check the mutants in the SQL source code queries. Further, the tool termed “SUSHI” is used to resolve existing constrains in the strings. Moreover, another tool termed “Ardilla” is used to create SQL injection attacks and to test the web scenarios. In addition, the tool termed “String Analyser” is used to analyse the web strings.

In the prevailing literature, the usage of web applications with validation using cryptographic modules and increasing cyber threats related to security of web applications have been explored (Dima, 1999). In view of that, web applications are able to use the modules for password cryptography, password generating and so on (Dima, 1999). Further, Dima (1999) explored the usages connected to web application components as well as how they develop overcoming increasing cyber threats. Further, the usages related to firewalls as a way of network site protection against external intrusions and attacks also were explored in the prevailing literature. Moreover, it was identified about the explorations of components, which are basically included in a firewall policy including filtering of packets, proper authentication and application gateways (Dima, 1999).

Among the web based cyber-attacks, which are occurred as SQL injection attacks, prevail globally and cause serious impacts with web applications. SQL injection attacks conduct with including segment of malicious code into SQL query via none or without proper validated environment and that will receive by web servers. It was found that, there are faults regarding web applications, the most hazardous types of vulnerabilities are Cross site scripting and SQL injection attacks (Jose, 2008). It was identified the different types of issues related to web application cyber-attacks such as injection of commands, traversal of path, LDAP injection, SQL injection and Spoofing of content (Sven, 2008). Further, the more critical vulnerabilities are occurred due to cross site scripting and SQL injection attacks (Jose, 2008).

Moreover, Lijiu (2010) revealed that, web application vulnerabilities such as malicious file execution, cross site scripting, SQL injection and cross site request forgery, which have the connection with secure coding of web applications. It was explained regarding vulnerabilities of SQL injection attacks & cross site scripting which caused harm to a number of web applications (Andrea, 2012).

Based on the prevailing literature, several researchers have explored and introduced different SQL detection and preventive solutions. Accordingly, Rai and Nagpal (2019) studied on SQL injection attacks and proposed methods and tools for detection and preventive solutions, while discussion their effectiveness. Further, Singh et al. (2014) also proposed a model to block the SQL injections, while analysing the existing detection prevention techniques against SQL injection attacks. Moreover, Jemal et al. (2020) also proposed the solutions to mitigate SQL injection, specifically through ontology and machine learning. A differential process to safeguard against SQL injection attacks, which is used in ASP.NET apps has been introduced (Kausar et al., 2019). In addition, Hu (2017) introduced a defence resistance and remedy model of SQL injection attack, which is established from the perspective of non-intrusive SQL injection attack and defence.

### III. METHODOLOGY AND EXPERIMENT

In achieving the objectives of the study, the methodology adopted by the researchers was creating an environmental variable for “php.exe” file as the first step. As the second step, a “bat” file for run “sql\_injection\_block.php” file was created. As the third step, a “task scheduler” adding “bat” file to run the “sql\_injection\_block.php” file continuously with appropriate time intervals was created. As the final step, APACHE log files to the proposed application with the given command prompt command was linked. The adopted method of SQL injection attack identification ip address blocking process is descriptively displayed (Figure 1).

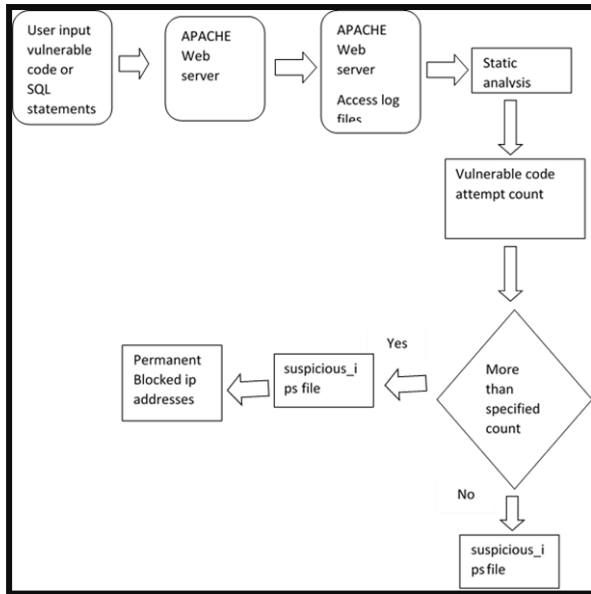


Figure 1. SQL Injection attack identification IP address blocking process  
Source: Developed by the researchers based on the research study

Accordingly, when the user input malicious code or any input for SQL injection attack or any purpose, then it will compare with SQL injection attack patterns and if the user input compares with specified patterns, then that the user input attempt will take as suspicious attempt. If such number of attempts exceeded more than specified number of attempts, then that host ip address will be blocked automatically. All the suspicious attempts will be stored in the “suspicious\_ips” file. Blocked IPs too added to another file called “blocked\_ips”. If it is required to remove blocked IP address from blocked IP addresses list, then

this solution has a facility to do that. User input time also will be stored in the “suspicious\_ips” file and it will be able to analyze later too.

#### A. Access Log Analysis Methodology

First have to set the path to APACHE access log files in the “apache\_access.bat” file. Then it has to connect to the task scheduler and it is required to set the interval of time that want to run reiterate. Source code files have located and it is required to give path of the “sql\_injection\_block.php” with suitable parameters in the bat file. All the installation process and operatable process will be mentioned later in detailed manner. After installation Apache access log files will be analyzed after specified time period in the task

scheduler and all the suspicious user attempts in the Apache log files will be stored in the “suspicious\_ips”. If user suspicious attempts more than specified count of the source code, then that user will be blocked automatically and added to “blocked\_ips” list. If it is required to remove some identified blocked ip from blocked ip list, then it will be able to remove such ip from blocked ip list. Such operations are mentioned in detailed manner later. POST or GET user inputs will be analyzed and therefore any POST or GET malicious user inputs will be blocked with this solution.

#### B. Specified SQL Injection Comparing Patterns

```

apacheaccesspaterns[] = "/|select[\*]from|select \* from|select\*from|'or'1'=1|/i"
apacheaccesspaterns[] = "/or1=1|update set|insert into|delete from|/i"
apacheaccesspaterns[] = "/order by|1'1|select count([\*])|1 and 1=1|/i"
apacheaccesspaterns[] = "/&#49|&#32|&#79|&#82|&#61| &#39|1 UNION ALL SELECT 1,2,3,4,5,6,name FROM sysObjects WHERE xtype = 'U' --|/i"
  
```

#### C. Installation Process for Manual Process

This solution was designed for Windows Operating System, but later the research will be continued for Linux Operating System too. This solution was designed with “XAMPP” installer. At first, it is required to install “XAMPP” software. Then it is required to set environmental variable path to php folder as follows;

- First, go to control panel.
- Then, go to “system”.
- Next, go to “change setting”.
- Then, go to “Advanced” tab.
- Then, go to environmental variables.
- 
- Then, select the “Path” environmental variable (Figure 2) and go to “Edit” and click.
- Then, click new and type or copy and paste the path to the “PHP” folder (Figure 2), select area and click “ok” button.

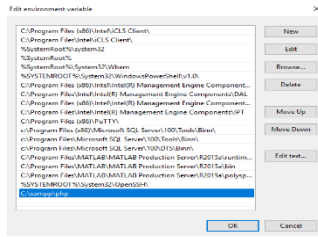


Figure 2. New Environmental Variable for “PHP” Folder

Source: Developed by the researchers based on the research study

Afterwards, it is required to locate the “sql\_injection\_block” folder as your preference. Then, it is required to open command prompt and change the command prompt location to “sql\_injection\_block” directory.

#### D. Manual Operating Process

At first, it is required to take the command prompt location to “sql\_injection\_block” directory location and enter the command, “php sql\_injection\_block.php”, “php sql\_injection\_block.php -h” or “php sql\_injection\_block.php --help”.

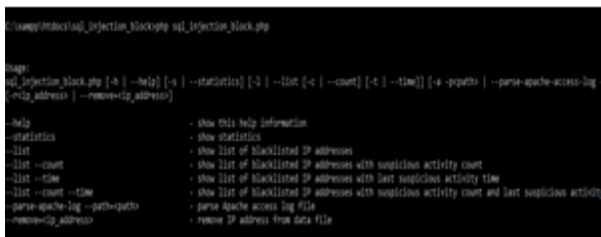


Figure 3. Obtaining user operating options  
Source: Developed by the researchers based on the research study

Obtaining user operating options and details option 1

```
C:\xampp\htdocs\sql_injection_block>
php sql_injection_block.php
```

Obtaining user operating options and details option 2

```
C:\xampp\htdocs\sql_injection_block>
php sql_injection_block.php -h
```

Obtaining user operating options and details option 3

```
C:\xampp\htdocs\sql_injection_block>
php sql_injection_block.php --help
```

1) *Obtaining Statistics:* Firstly, it is required to take the command prompt location to “sql\_injection\_block” directory location and enter the command, “php sql\_injection\_block.php --statistics” or “php sql\_injection\_block.php -s”.

Obtaining statistics option 1

```
C:\xampp\htdocs\sql_injection_block>
php sql_injection_block.php -s
```

Obtaining statistics option 2

```
C:\xampp\htdocs\sql_injection_block>
php sql_injection_block.php --statistics
```

When entering the above-mentioned command at the first time, it will be appeared as “No data!” due to the absence of “suspicious\_ips” file. Before obtaining the statistics it is required to parse the Apache log files as below Figure 4 entering command “php sql\_injection\_block.php --parse-apache-log --path=C:\xampp\apache\logs\access.log”.

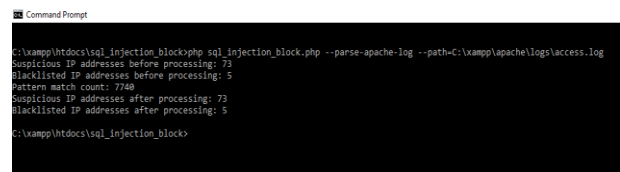


Figure 4. Parsing APACHE access log files

Source: Developed by the researchers based on the research study

Initially, it is required to take the command prompt location to “sql\_injection\_block” directory location and enter the command, “php sql\_injection\_block.php --parse-apache-log -path=C:\xampp\apache\logs\access.log”.

Parsing APACHE log files option 1

```
C:\xampp\htdocs\sql_injection_block>
php sql_injection_block.php --parse-
apache-log -
path=C:\xampp\apache\logs\access.log
```

Parsing APACHE log files option 2

```
C:\xampp\htdocs\sql_injection_block>
php sql_injection_block.php -a -
C:\xampp\ apache\ logs\access.log
```





files as below Figure 7 entering command “php sql\_injection\_block.php --parse-apache-log --path=C:\xampp\apache\logs\access.log”.

#### 4) Obtaining Black Listed IPs with Suspicious Activity

**Time:** Initially, it is required to take the command prompt location to “sql\_injection\_block” directory location and enter the command “php sql\_injection\_block.php -list --time” or “php sql\_injection\_block.php -l -t”.

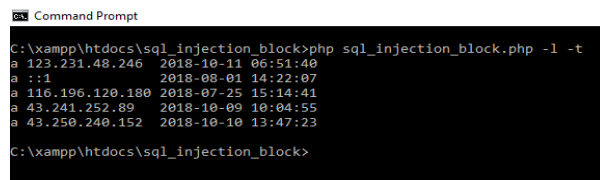
Obtaining black listed IPs with suspicious activity time option 1

```
C:\xampp\htdocs\sql_injection_block>
php sql_injection_block.php -l -t
```

Obtaining black listed IPs with suspicious activity time option 2

```
C:\xampp\htdocs\sql_injection_block>
php sql_injection_block.php -list --time
```

When you enter first time above mention command, then you will get as “No data!” due to absence of “suspicious\_ips” file. Before obtaining statistics, you have to parse the Apache log files as below Figure 7 entering command “php sql\_injection\_block.php --parse-apache-log --path=C:\xampp\apache\logs\access.log”.



```
Command Prompt
C:\xampp\htdocs\sql_injection_block>php sql_injection_block.php -l -t
a 123.231.48.246 2018-10-11 06:51:40
a ::1 2018-08-01 14:22:07
a 116.196.120.180 2018-07-25 15:14:41
a 43.241.252.89 2018-10-09 10:04:55
a 43.250.240.152 2018-10-10 13:47:23
C:\xampp\htdocs\sql_injection_block>
```

Figure 7. Black listed IPs with last activity time

Source: Developed by the researchers based on the research study

#### 5) Obtaining Black Listed IPs with Suspicious Activity

**Count and Time:** Initially, it is required to take the command prompt location to “sql\_injection\_block” directory location and enter the command, “php sql\_injection\_block.php -list -count --time” or “php sql\_injection\_block.php -l -c -t”.

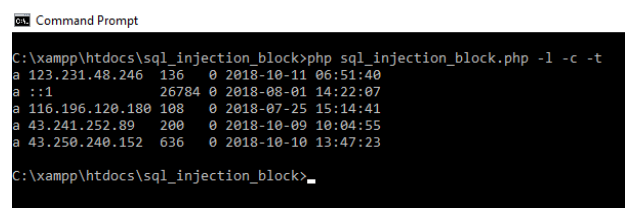
Obtaining black listed IPs with suspicious activity count and time option 1

```
C:\xampp\htdocs\sql_injection_block>
php sql_injection_block.php -l -c -t
```

Obtaining black listed IPs with suspicious activity count and time option 2

```
C:\xampp\htdocs\sql_injection_block>
php sql_injection_block.php --list --count
--time
```

When entering the above mention command for the first time, it is appeared as “No data!” due to absence of “suspicious\_ips” file. Before obtaining statistics, you have to parse the Apache log files as below Figure 8 entering command “php sql\_injection\_block.php --parse-apache-log --path=C:\xampp\apache\logs\access.log”.



```
Command Prompt
C:\xampp\htdocs\sql_injection_block>php sql_injection_block.php -l -c -t
a 123.231.48.246 136 0 2018-10-11 06:51:40
a ::1 26784 0 2018-08-01 14:22:07
a 116.196.120.180 108 0 2018-07-25 15:14:41
a 43.241.252.89 200 0 2018-10-09 10:04:55
a 43.250.240.152 636 0 2018-10-10 13:47:23
C:\xampp\htdocs\sql_injection_block>
```

Figure 8. Parsing APACHE access log files obtaining black listed IPs with suspicious activity count and time

Source: Developed by the researchers based on the research study

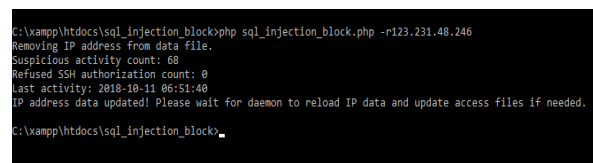
#### 6) Removing Black Listed IP Addresses and Adding to White List:

Removing black listed IP option 1

```
C:\xampp\htdocs\sql_injection_block>
php sql_injection_block.php -r123.231.48.246
```

Removing black listed IP option 2

```
C:\xampp\htdocs\sql_injection_block>
php sql_injection_block.php --remove=123.231.48.246
```



```
C:\xampp\htdocs\sql_injection_block>php sql_injection_block.php -r123.231.48.246
Removing IP address from data file.
Suspicious activity count: 68
Refused SSH authorization count: 0
Last activity: 2018-10-11 06:51:40
IP address data updated! Please wait for daemon to reload IP data and update access files if needed.
C:\xampp\htdocs\sql_injection_block>
```

Figure 9. Removing black listed IPs

Source: Developed by the researchers based on the research study

### E. Installation Process for Automated Process

This solution was designed for Windows Operating System and later research will be continued for Linux Operating System too. This solution was designed with “XAMPP” installer and. At first, it is required to install “XAMPP” software.

#### 1) Setting the Environmental Variable Path to PHP Folder:

Setting the environmental variable path to PHP folder as follows;

- i. First, go to control panel.
- ii. Then, go to “system”.
- iii. Next, go to “change setting”.
- iv. Then, go to “Advanced” tab.
- v. Then, go to environmental variables.

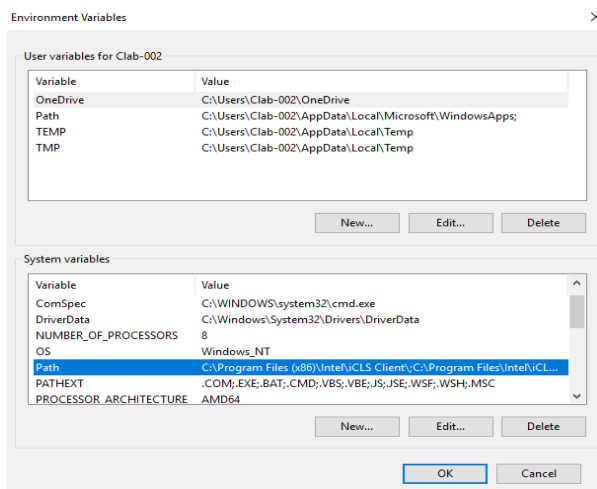


Figure 10. Environmental variables

Source: Developed by the researchers based on the research study

- vi. Then, select the “Path” environmental variable as in the above “Figure 10” and go to “Edit” and click.
- vii. Then, click new and type or copy and paste the path to the “PHP” folder as in the below Figure 11, selected area and click “ok” button.
- viii. Create “sql\_injection\_block.bat” file as in below (Figure 11).

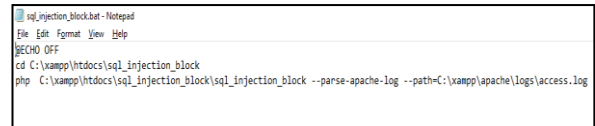


Figure 11. sql\_injection\_block.bat file

Source: Developed by the researchers based on the research study

In here, “cd <sql\_injection\_block directory path>” “php <path to the Apache access log file>” are inserted.

- ix. Then locate the “sql\_injection\_block.bat” file in the sql\_injection\_block directory.

#### 2) Adding the Bat File to the “Task Scheduler”:

- i. Go to start menu and type “control panel” and click it.
- ii. Then, go to “Administrative tools”.
- iii. Then, go to “Task scheduler”.
- iv. Create new task “sql\_injection\_block”.

It is required to set triggering settings at least thirty minutes and repeat activity after every thirty minutes and it is required to make sure not to set run multiple processes. The, it is required to set settings as Queue.

- v. Then run the task “sql\_injection\_block”.

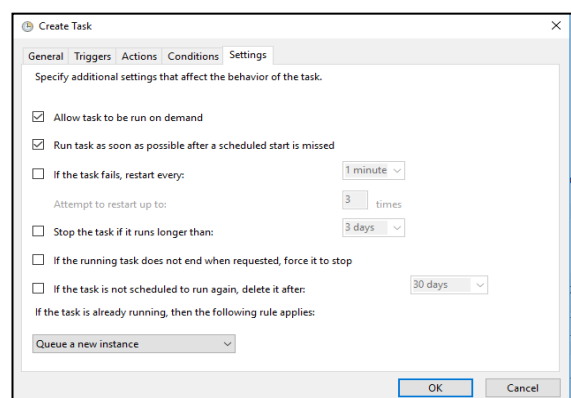


Figure 12. Queuing in Task Scheduler

Source: Developed by the researchers based on the research study

### F. IP Addresses Blocking Process

After detection of the vulnerable IP addresses, the identified IP addresses will be added to the “suspicious\_ips” file. Then, that suspicious IP address will be added to the “.htaccess” file for access deny. When it is required to remove blocking IP address, then IP address will be removed from the “.htaccess” file.

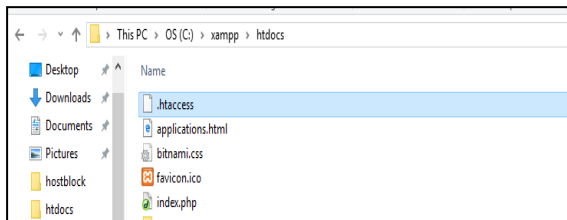


Figure 13. .htaccess file

Source: Developed by the researchers based on the research study

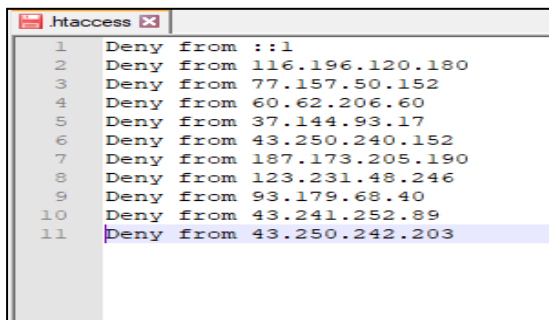


Figure 14. .htaccess file inside

Source: Developed by the researchers based on the research study

### G. Performance Analysis and Evaluation of the Current System

When user requests and inputs malicious codes or any input that caused to SQL injection attack or any user valid purposes, then it will be compared with SQL injection primitive attack patterns and then user requests and inputs will be compared with specified patterns in the proposed system. As well as, if such user requests are matched with specified malicious patterns in the proposed system, then such user input attempts will be taken as suspicious attempt and the IP address such attempts coming will be

taken as the suspicious IP address. If such number of attempts are exceeded more than specified number of malicious attempts, then that host IP address will be blocked automatically. All the suspicious attempts will be stored in the “suspicious\_ips” file. Blocked IPs too are added to another file called “blocked\_ips”. If it is required to remove the blocked IP address from blocked IP addresses list, then this solution has a facility to do that. It was explained earlier. User input times also will be stored in the “suspicious\_ips” file and it will be able to analyse later too.

As the first step, it is required to set the path to APACHE access log files in the “apache\_access.bat” file. Then it is required to connect to the task scheduler and it is required to set the interval of time that want to run iteratively. Source code files have to be located and it is required to give path of the “sql\_injection\_block.php” with suitable parameters in the bat file. All the installation process and operatable process will be mentioned later in detailed manner. After installation of the Apache access log files, it will be analysed after specified time period in the task scheduler and all the suspicious user attempts in the apache log files will be stored in the “suspicious\_ips”. If user suspicious attempts are more than specified count of the source code, then that user will be blocked automatically and added to “blocked\_ips” list. If it is required to remove some identified blocked IP from blocked IP list, then it will be able to remove such ip from blocked IP list. Such operations mentioned in detailed manner earlier with commands. POST or GET user inputs will be analysed and therefore any POST or GET malicious user inputs will be blocked with this solution. After processing of the “suspicious\_ips” file, if suspicious pattern matching count is exceeded the specified count in the proposed system, then such IP addresses will be added to the “.htaccess” file as “deny access <IP address>”. Then that IP address will be blocked for external users for the internet access.

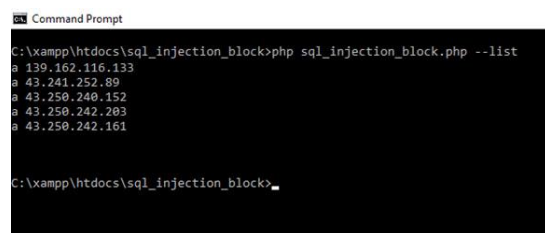


Figure 15. Blacklisted IP addresses

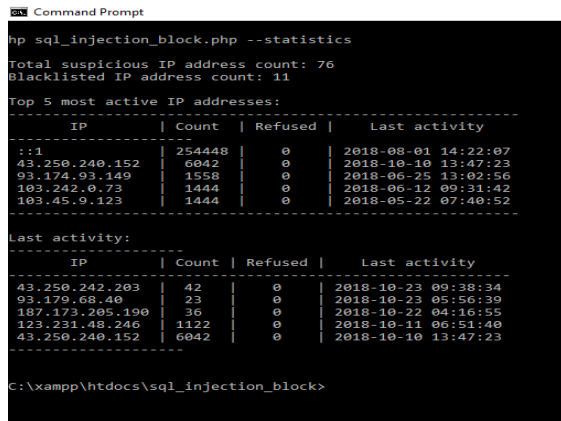
Source: Developed by the researchers based on the research study

The detailed results are descriptively elaborated under the section of Results.

#### IV. RESULTS

Under this section, the statistics of the user requests are explained. Through the result issuing command namely, “—statistics” the most active top five addresses termed, 127.0.0.1, 43.250.240.152, 93.174.93.149, 103.242.0.73 and 103.45.9.123 were obtained. The recorded occurrence of the IP address of 127.0.0.1 was 254448. The recorded occurrence of the IP address of 43.250.240.152 was 6042. The recorded occurrence of the IP address of 93.174.93.149 was

1558. The recorded occurrence of the IP address of 103.242.0.73 was 1444. The recorded occurrence of the IP address of 103.45.9.123 was 1444.



```

C:\xampp\htdocs>php sql_injection_block.php --statistics
Total suspicious IP address count: 76
Blacklisted IP address count: 11
Top 5 most active IP addresses:
-----
IP          | Count | Refused | Last activity
-----
127.0.0.1   | 254448 | 0        | 2018-08-01 14:22:07
43.250.240.152 | 6042  | 0        | 2018-10-10 13:47:23
93.174.93.149 | 1558  | 0        | 2018-06-25 13:02:56
103.242.0.73 | 1444  | 0        | 2018-06-12 09:31:42
103.45.9.123 | 1444  | 0        | 2018-05-22 07:40:52
-----
Last activity:
-----
IP          | Count | Refused | Last activity
-----
43.250.242.203 | 42    | 0        | 2018-10-23 09:38:34
93.179.68.40  | 23    | 0        | 2018-10-23 05:56:39
187.173.205.190 | 36    | 0        | 2018-10-22 04:16:55
123.231.48.246 | 1122  | 0        | 2018-10-11 06:51:40
43.250.240.152 | 6042  | 0        | 2018-10-10 13:47:23
-----
C:\xampp\htdocs\sql_injection_block>

```

Figure 16. Analysed user request statistics

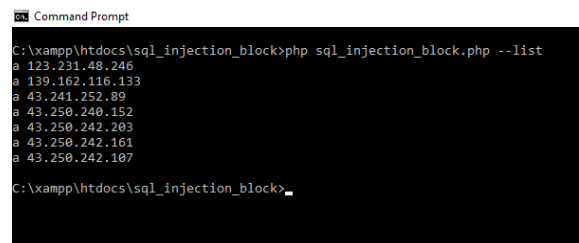
Source: Developed by the researchers based on the research study

The analysed and processed statistics of user requests, which were requested by the users, are descriptively displayed (Figure 16). The counted malicious attempts and the most top five IP addresses are descriptively displayed in Figure 16. Further, the last activity time figures also are displayed. The last activity recorded date and time for IP address 127.0.0.1 was 2018-08-01 at 14:22:07. The last activity recorded date and time for IP address 43.250.240 was 2018-10-10 at 13:47:23. The last activity recorded date and time for IP address 93.174.93.149 was 2018-06-

25 at 13:02:56. The last activity recorded date and time for IP address 103.242.0.73 was 2018-06-12 at 09:31:42. The last activity recorded date and time for IP address 103.45.9.123 was 2018-05-22 at 07:40:52. According to the second table of Figure 16, last five IP addresses with the last activity details are displayed.

#### A. Listing of Black Listed IP Addresses

The results according to Figure 16 were obtained by using “--list” command in the console. IP address blacklist was happening due to the host trying for vulnerable patterns as http requests in several times. After exceeding of the predefined maximum count, IP addresses were blacklisted as vulnerable IP addresses. The results of listing of black listed IP addresses is descriptively displayed (Figure 17).



```

C:\xampp\htdocs\sql_injection_block>php sql_injection_block.php --list
a 123.231.48.246
a 139.162.116.133
a 43.241.252.89
a 43.250.240.152
a 43.250.242.203
a 43.250.242.161
a 43.250.242.107
C:\xampp\htdocs\sql_injection_block>

```

Figure 17. Listing of blacklisted IP addresses

Source: Developed by the researchers based on the research study

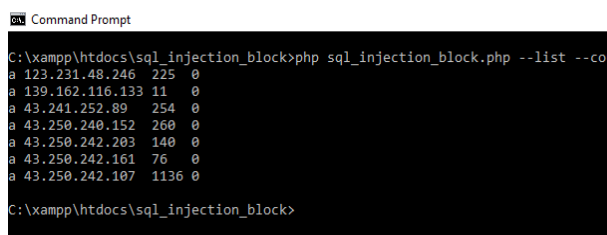
Above mentioned “Listing of blacklisted IP addresses” in the “Figure 17” shows the Listing of blacklisted IP addresses that user requests coming from. From such IP addresses mentioned in the “Figure 15” shows requested vulnerable requests more than specified vulnerable attempt count in the proposed solution. After entry of the statement termed, “Deny from <IP address>” to the “.htaccess” file, accessing the webserver was blocked for that specific IP address. “403 forbidden” Error was occurred after that host tried to access again. The blacklisted IP addresses such as; 123.231.48.246, 139.162.116.133, 43.241.252.89, 43.250.240.152, 43.250.242.203, 43.250.242.161, and 43.250.242.107 were received after analysing of apache access.log file. If it is required to remove some IP addresses from the blacklisted list, then it will be not



appeared in the blacklisted IP address list and that IP address will be able to access the web server continuously without any hindrance. Then, IP details of “suspicious\_IPs” file will be updated stored in the “suspicious\_IPs” file. “--remove = < IP address >” command used to remove IP address from the blacklisted IP address list. After analysing Apache access.log files these blacklisted IP address details will be stored in the “suspicious\_IPs” file and then later also could be able to analyse and will be able to get the backup copies. When using “--list” command other details such as; blacklisted time, suspicious occurrences count, last activity time like such details regarding that IP address will not be displayed and only the IP address will be displayed. If it is required such details then it is required to enter other commands and that commands will be explained in detailed manner later.

#### *B. Listing of Black Listed IP Addresses with Suspicious Attempt Count*

According to Figure 18, the results of listing blacklisted IP addresses with count of vulnerable activities tried as http requests are descriptively shown. When using “--list --count” command other details such as; blacklisted time, last activity time like such details regarding that IP address will not be displayed and only IP address with count of occurrences of vulnerable activities as http requests will be displayed. If it is required such details then it is required to enter other commands and that commands will be explained in detail later. After issuing “--list --count” command, blacklisted IP addresses with vulnerable activity count is shown in Figure 17, “5.3 listing of black listed IP addresses with suspicious attempt count”.



```

Command Prompt
C:\xampp\htdocs\sql_injection_block>php sql_injection_block.php --list --count
a 123.231.48.246 225 0
a 139.162.116.133 11 0
a 43.241.252.89 254 0
a 43.250.240.152 260 0
a 43.250.242.203 140 0
a 43.250.242.161 76 0
a 43.250.242.107 1136 0
C:\xampp\htdocs\sql_injection_block>

```

Figure 18. Listing of black listed IP addresses with suspicious attempt count

Source: Developed by the researchers based on the research study

Above mentioned “Listing of black listed IP addresses with suspicious attempt count” in “Figure 17” shows the listing of blacklisted IP addresses that user requests coming from with their suspicious attempts count in front of them. In here 123.231.48.246, 139.162.116.133, 43.241.252.89, 43.250.240.152, 43.250.242.203, 43.250.242.161, 43.250.242.107 were the blacklisted IP addresses. The blacklisted IP address 123.231.48.246 was recorded with count of 225 vulnerable activity counts. The blacklisted IP address 139.162.116.133 was recorded with count of 11 vulnerable activity counts. The blacklisted IP address 43.241.252.89 was recorded with count of 254 vulnerable activity counts. The blacklisted IP address 43.250.240.152 was recorded with count of 260 vulnerable activity counts. The blacklisted IP address 43.250.242.203 was recorded with count of 140 vulnerable activity counts. The blacklisted IP address 43.250.242.161 was recorded with count of 76 vulnerable activity counts. The blacklisted IP address 43.250.242.107 was recorded with count of 1136 vulnerable activity counts. After analysing Apache access.log files, these blacklisted IP address details were stored in the “suspicious\_IPs” file. There is a PHP function called “parseFile” in the Apacheaccesslogparser.php file and within that function new IP details were added to the “suspicious\_IPs” file. When issuing command “--list --count” then these details were taken from “suspicious\_IPs” file. When using “--list --count” command other details such as; blacklisted time, last activity time like such details regarding that IP address were not displayed and only blacklisted IP addresses with vulnerable activity count were displayed. If such details are required, then it is necessary to enter other commands and that commands will be explain in detailed manner well ahead.

#### *C. Listing of Black Listed IP Addresses with Last Suspicious Attempt Time*

The results of listing of black listed IP addresses with last activity time is displayed in the Figure 19. The results were obtained using "--list --time" command in the console. After analysing Apache access.log files these blacklisted IP address and other details will be stored in the "suspicious\_IPs" file and when issuing command "--list --time", then these details will be taken from "suspicious\_IPs" file.

```

C:\xampp\htdocs\sql_injection_block>php sql_injection_block.php --list -time
a 123.231.48.246 2018-10-11 06:51:40
a 139.162.116.133 2018-10-16 11:25:01
a 43.241.252.89 2018-10-09 10:04:59
a 43.250.240.152 2018-10-10 14:31:09
a 43.250.242.203 2018-10-23 10:06:38
a 43.250.242.161 2018-12-04 05:00:26
a 43.250.242.107 2018-12-04 06:13:16
C:\xampp\htdocs\sql_injection_block>

```

Figure 19. Listing of black listed IP addresses with last suspicious attempt time

Source: Developed by the researchers based on the research study

Above mentioned "Listing of black listed IP addresses with last suspicious attempt time" (Figure 19) shows the Listing of black listed IP addresses that user requests coming from with their suspicious last attempted time in front of them.

In here, 123.231.48.246, 139.162.116.133, 43.241.252.89, 43.250.240.152, 43.250.242.203, 43.250.242.161, 43.250.242.107 were the blacklisted IP addresses. The blacklisted IP address 123.231.48.246 was recorded with last vulnerable activity date and time as 2018-10-11 at 06:51:40. The

blacklisted IP address 139.162.116.133 was recorded with last vulnerable activity date and time as 2018-10-16 at 11:25:01. The blacklisted IP address 43.241.252.89 was recorded with last vulnerable activity date and time as 2018-10-09 at 10:04:59. The blacklisted IP address 43.250.240.152 was recorded with last vulnerable activity date and time as 2018-10-10 at 14:31:09. The blacklisted IP address 43.250.242.203 was recorded with last vulnerable activity date and time as 2018-10-23 at 10:06:38. The blacklisted IP address 43.250.242.161 was recorded with last vulnerable activity date and time as 2018-12-04

at 05:00:26. The blacklisted IP address 43.250.242.107 was recorded with last vulnerable activity date and time as 2018-12-04 at 06:13:16. These details were added to the "suspicious\_IPs" file from "\$ipInfo" array. The new IP details were added to the "\$ipInfo" array with in "Apacheaccesslogparser.php" file. A PHP function called "parseFile" was included there and within that function new IP details were added to the "suspicious\_IPs" file.

#### D. Listing of Black Listed IP Addresses with Suspicious Attempt Count and Last Suspicious Attempt Time

The result of listing black listed IP addresses with last activity time and count of suspicious activities are shown in below (Figure 20). That results were obtained using "--list--count --time" command in the console.

```

C:\xampp\htdocs\sql_injection_block>php sql_injection_block.php --list -count -time
a 123.231.48.246 225 0 2018-10-11 06:51:40
a 139.162.116.133 11 0 2018-10-16 11:25:01
a 43.241.252.89 254 0 2018-10-09 10:04:59
a 43.250.240.152 260 0 2018-10-10 14:31:09
a 43.250.242.203 140 0 2018-10-23 10:06:38
a 43.250.242.161 76 0 2018-12-04 05:00:26
a 43.250.242.107 1136 0 2018-12-04 06:13:16
C:\xampp\htdocs\sql_injection_block>

```

Figure 20. Listing of black listed IP addresses with suspicious attempt count and last suspicious attempt time

Source: Developed by the researchers based on the research study

Above mentioned "Listing of black listed IP addresses with suspicious attempt count and last suspicious attempt time" in the "Figure 19" shows the Listing of blacklisted IP addresses that user requests coming from with their suspicious last attempted time and suspicious attempt count in front of them. In here 123.231.48.246, 139.162.116.133, 43.241.252.89, 43.250.240.152, 43.250.242.203, 43.250.242.161, 43.250.242.107 were the blacklisted IP addresses. The blacklisted IP address 123.231.48.246 was recorded with last vulnerable activity date and time as 2018-10-11 at 06:51:40 and count of vulnerable activities as 225. The blacklisted IP address 139.162.116.133 was recorded with last vulnerable activity date and time as 2018-10-16 at 11:25:01 and count of

vulnerable activities as 11. The blacklisted IP address 43.241.252.89 was recorded with last vulnerable activity date and time as 2018-10-09 at 10:04:59 and count of vulnerable activities as 254. The blacklisted IP address 43.250.240.152 was recorded with last vulnerable activity date and time as 2018-10-10 at 14:31:09 and count of vulnerable activities as 260. The blacklisted IP address 43.250.242.203 was recorded with last vulnerable activity date and time as 2018-10-23 at 10:06:38 and count of vulnerable activities as 140. The blacklisted IP address 43.250.242.161 was recorded with last vulnerable activity date and time as 2018-12-04 at 05:00:26 and count of vulnerable activities as 76. The blacklisted IP address 43.250.242.107 was recorded with last vulnerable activity date and time as 2018-12-04 at 06:13:16 and count of vulnerable activities as 1136. After analysing Apache access.log files these blacklisted IP address and other details were stored in the “suspicious\_IPs” file and when issuing command “--list --count --time”, then these details were taken from “suspicious\_IPs” file.

#### E. Apache Access Log File Analysis

The results of parsing Apache access.log file analysis is displayed below (Figure 21). That results were obtained using “--parse-apache-log -path = <path to the Apache access.log file>” command in the console. In here “suspicious IP addresses before processing: 76” means, before parsing Apache access.log file for processing which was previously stored suspicious IP addresses count in the “suspicious\_IPs” file is 76. When single suspicious activity encountered from an IP address, then that IP address was taken as suspicious IP address. Further, it was become as blacklisted IP address when exceeding the predefined suspicious activity count.

```

C:\xampp\htdocs\sql_injection_block>php sql_injection_block.php --parse-apache-log --path=C:\xampp\apache\logs\access.log
Suspicious IP addresses before processing: 76
Blacklisted IP addresses before processing: 11
Pattern match count: 7785
Suspicious IP addresses after processing: 77
Blacklisted IP addresses after processing: 11
a :1
a 116.196.128.180
a 77.157.50.152
a 60.62.206.60
a 37.144.93.17
a 43.250.240.152
a 187.173.205.190
a 123.231.48.246
a 93.179.68.40
a 43.241.252.89
a 43.250.242.203
C:\xampp\htdocs\sql_injection_block>

```

Figure 21. Apache access log file analysis

Source: Developed by the researchers based on the research study

Above mentioned “Apache access log file analysis” in the “Figure 21” shows the Listing of blacklisted IP addresses that user requests coming from with suspicious IP addresses count before processing, Blacklisted IP addresses count before processing, Total vulnerable pattern match count, suspicious IP addresses count after processing, Blacklisted IP addresses count after processing.

In here “Blacklisted IP addresses before processing was 11” means, before parsing Apache access.log file for processing previously stored blacklisted IP addresses count in the “suspicious\_IPs” file is 11. In here total vulnerable pattern match count was 7785. Here “suspicious IP addresses after processing: 77” means, after parsing Apache access.log file for processing total stored suspicious IP addresses count in the “suspicious\_IPs” file is 77 and new one suspicious IP address added to the “suspicious\_IPs” file after parsing the Apache access.log file for processing. Here “Blacklisted IP addresses after processing was 11” means, after parsing Apache access.log file for processing total stored blacklisted IP addresses count in the “suspicious\_IPs” file was 11. It means no new blacklisted IP address added to the “suspicious\_IPs” file.

#### F. Removing Blacklisted IP Address

The results of removing blacklisted IP addresses is shown below (Figure 22). That results were obtained using “--remove = <IP address>” command in the console. After removing blacklisted IP address, then it was stored in the “suspicious\_IPs” file.

```

C:\xampp\htdocs\sql_injection_block>php sql_injection_block.php --remove=43.250.242.203
Removing IP address from data file.
Suspicious activity count: 84
Last activity: 2018-10-23 09:38:34
IP address data updated! Please wait to reload IP data and update access files.
a :1
a 116.196.128.180
a 77.157.50.152
a 60.62.206.60
a 37.144.93.17
a 43.250.240.152
a 187.173.205.190
a 123.231.48.246
a 93.179.68.40
a 43.241.252.89

Successfully .htaccess file updated.
C:\xampp\htdocs\sql_injection_block>

```

Figure 22. Removing blacklisted IP address

Source: Developed by the researchers based on the research study

Figure 22 shows removing blacklisted IP addresses and after removing that IP address all suspicious activity count of that IP address, last activity time of that IP address. All blacklisted IP addresses listed here after removing the specified IP address. When removing of some IP address from the blacklisted IP address list, then it was not appeared in the blacklisted IP address list and that IP address was able to access the web server continuously without any hindrance. Then IP details of “suspicious\_IPs” file was updated and stored in the “suspicious\_IPs” file, then later too can be analysed and will be able to get backup copies. The command “--remove = < IP address >” was used to remove IP address from the blacklisted IP address list. Removing blacklisted IP address will do from handling “.htaccess” file. In here “.htaccess” was used to block vulnerable hosts adding “Deny from <ipaddress>” code inside it and this code will be added to each and every vulnerable blacklisted IP address to block the server access. Then it will be given “403 Forbidden” error to vulnerable host preventing access to the server. After removing the black listed IP address from the black listed list then “Deny from <ipaddress>” entry will be removed from the “.htaccess” file for the relevant removed IP address.

*G. Test an Evaluation of Final Host IP Address Blocking*

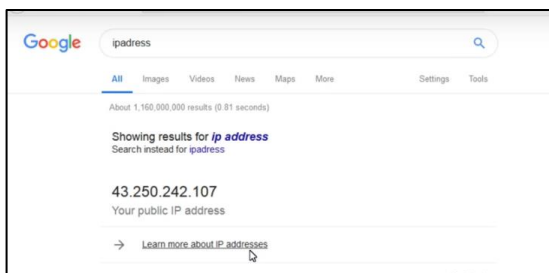


Figure 23. Host public IP address

Source: Developed by the researchers based on the research study

Above Figure 23 shows the tested vulnerable host public IP address (43.250.242.107).

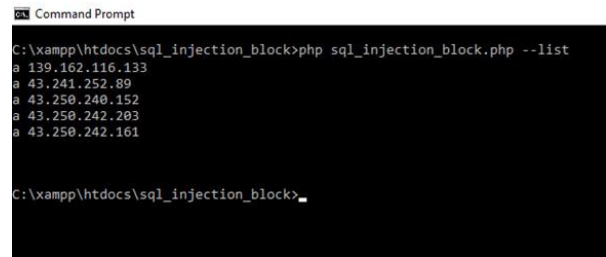


Figure 24. Blacklisted IP addresses

Source: Developed by the researchers based on the research study

Above Figure 20 shows the black listed vulnerable host public IP addresses. Above Figure 24 shows public IP address (43.250.242.107) wasn't belong to the black listed IP addresses after removing public IP address (43.250.242.107) from black listed IP addresses list of Figure 20

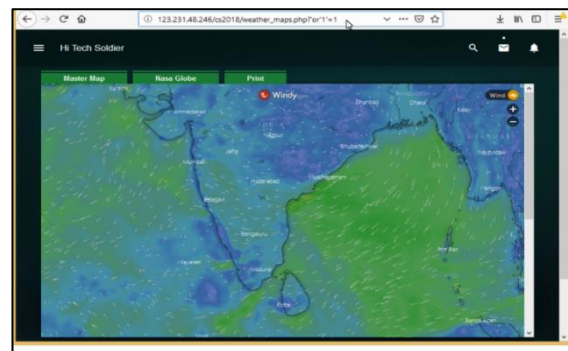


Figure 25. Trying to access web Server with vulnerable codes

Source: Developed by the researchers based on the research study

Above Figure 25 shows vulnerable host (public IP address (43.250.242.107)) was trying to access web server (public IP address (43.250.242.107)) with vulnerable user inputs “or'1'=1” continuously and after the exceeding of maximum count of vulnerable accesses IP address, 43.250.242.107 added to black listed IP address list.

```

Command Prompt
C:\xampp\htdocs\sql_injection_block>php sql_injection_block.php --list
a 139.162.116.133
a 43.241.252.89
a 43.250.240.152
a 43.250.242.203
a 43.250.242.161
a 43.250.242.107

C:\xampp\htdocs\sql_injection_block>

```

Figure 26. Trying to access web Server with vulnerable codes

Source: Developed by the researchers based on the research study

Above Figure 26 shows the IP address, 43.250.242.107 added to the black listed IP address list.

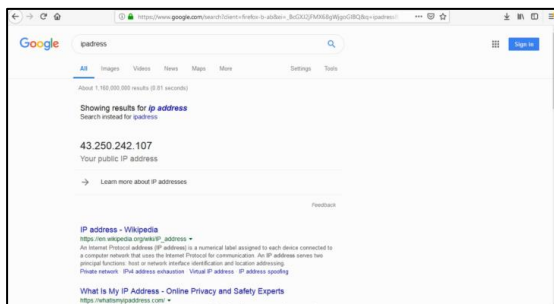


Figure 27. Trying to access web Server after vulnerable host black listed

Source: Developed by the researchers based on the research study

Above Figure 27 shows web results when trying to access web server after vulnerable host (IP address 43.250.242.107) got blacklisted with legitimate URL.

## V. DISCUSSION AND CONCLUSION

The proposed solution for SQL injection prevention facilitates for the continuous monitoring of suspicious activities. Conferring to this proposed solution, there is no requirement for the user to concern about monitoring or else IP address blocking activities in web applications. Further, the proposed solution automatically blocks the vulnerable hosts using its IP address. Moreover, the proposed solution facilitates for listing of blocked IP addresses if the user needs to remove some IP address from the black listed IP address list. As well as, the user

could be able to customize the blocked IP address list according to his will. Further, this proposed solution facilitates the user to view the last activity time of the suspicious IP addresses with the suspicious activity count, then the user will be able to compare each of suspicious IP addresses. In view of that, all the suspicious activities will be stored in a file including suspicious activity time, suspicious activity count, then the user will be able to later process or analyze such details further and such data backups also able to take. However, the proposed solution is designed mainly for “Windows” operating systems and have to install “XAMPP” or “WAMP” software, which is freely available in the Internet. Proposed solution is composed of a set of vulnerable user http request patterns & it is recommended to add more vulnerable user http request patterns. Then the user faithfulness to the proposed system will be increased. Further, it is recommended to use XAMPP version 7 or above. Finally, the proposed solution is recommended for “Windows 7” or above.

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# An Interactive E-Commerce Website for the Beauty Industry in Sri Lanka

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**Abstract**— The beauty industry has been gaining popularity for past few years, due to increasing social media trends in "self-care" with the use of beauty products. As a result, sales generated by the beauty industry spiked creating competition among vendors and sellers in the industry. With the COVID-19 pandemic, the traditional way of shopping for beauty products halted, creating a requirement to introduce customers with new methodologies to sell beauty products, which are similar in experience to traditional shopping. One such solution can be considered as e-commerce websites. E-commerce websites currently operating in Sri Lanka and are part of the beauty industry are dedicated to a singular brand or product line, not a marketplace with multiple brands. Also, considering the products sold, current e-commerce applications do not provide sufficient information regarding standards or ingredients used in the development of the product. This paper investigates an e-commerce solution to the beauty industry that allows customers to shop for safe beauty products that are suggested according to their personal preference by a variety of sellers.

**Keywords:** *e-commerce in beauty industry, e-commerce website, beauty industry*

## I. INTRODUCTION

E-commerce, according to (Andrew Bloomenthal, n.d.), is a business model that allows firms and individuals perform business transactions (buying and selling) over the Internet. In the modern society, possessing or being a part of an e-commerce website is considered a benefit to the business. ("The impact of E-commerce on Business Strategy: A Literature Review Approach" n.d.) says that, e-commerce has become the key means of modern "enterprise

competition" and is regarded as "complimentary tool" that supports the overall strategy and business performance.

As an ever-growing industry, e-commerce industry is growing 23% year-over-year (BigCommerce, 2021) with 12-24 Million existing sites around the globe ("68 Useful eCommerce Statistics You Must Know in 2021," 2019). In the year 2019, retail e-commerce sales globally added up to 3.53 Trillion USD, making online shopping one of the most popular activity online ("Global retail e-commerce market size 2014-2023," n.d.). The main reason for this is because of the advantages offered by e-commerce. E-commerce surpasses physical limitations the brick-and-mortar system offers, expanding the coverage and market base. It allows customers to find products, compare products, obtain more information on a certain product, ask follow-up questions and shop anytime convenient for them. Also, as sellers, owning a physical store is much costlier than owning an e-commerce site. Savings of hosting an e-commerce site over a physical store can be rewarded to customers as discounts, attracting more and more customers (Business and Khurana, n.d.).

In the year 2020, due to the COVID-19 crisis, people were driven towards limiting activities that involves physical interaction, which then later lead them to accomplishing their day-to-day tasks such as shopping, through online means. The report ("E-commerce in the time of COVID-19," n.d.), the demand in shift from brick-and-mortar retail to e-commerce has caused an accelerating expansion of e-commerce towards new businesses, products and customers. E-commerce transactions in most countries

deviated from luxury products to everyday necessities such as groceries and health care.

Considering the beauty industry, which includes health care products such as skincare, sun care, haircare, deodorants and fragrance. Products such as make-up and colour cosmetics, is also considered one of the popular niche markets on e-commerce under the beauty industry. According to (“E-commerce to dominate future of health and beauty sector | WARC,” n.d.), the online sales of the health and beauty sector is expected to rise from 16.5% to 23.3% globally. This projection implies that the demand for e-commerce is growing. Hence creating a need for better e-commerce application for the beauty industry.

The beauty industry in Sri Lanka is still at a nascent stage. With the influence of international personal care trends, people gain more awareness about their skin types and tends to be more oriented towards their outward appearance. According to an article by (Rohan, n.d.), personal care penetration is increasing rapidly within the country causing the “shelf heat” to triple every year. However, with the COVID-19 pandemic, the demand for colour cosmetics plummeted and the need for personal care items increased (“Beauty and Personal Care in Sri Lanka | Market Research Report | Euromonitor,” n.d.).

Beauty industry in Sri Lanka is unable to contribute to its maximum capacity to the country’s current need for beauty products, one of the reasons being, lack of online applications to market beauty products. During lockdown period in Sri Lanka, beauty products were sold through online supermarket applications and pharmacies which did not prioritize in providing product details such as ingredients used, purposes, etc. Also, it was identified that harmful products are being sold through existing online applications as well as in-stores. Existing applications do not have mechanisms to filter products that contain harmful ingredients added in beauty products.

The aim of this paper is to explore a possible solution, is a web-based e-commerce application dedicated to the sellers, manufacturers and buyers solely interested in beauty products. This e-commerce website will allow sellers to sell products such as Baby and Child-specific

Products, Bath and shower, Color cosmetics, Deodorants, Depilatories, Fragrances, Hair care, Men's grooming, Oral care, Sets/kits and Skin care. Each buyer user of the system will have a unique “feed” filled with product suggestions unique to their preferences. The order procedure will be straight-forward and easy for both users, buyer and seller. The website owner user will be able to manage the website with ease using the tools provided by the proposed system.

The rest of the paper is organized as follows; through the section 2 of the paper, an insight will be provided about popular e-commerce platforms related to the beauty industry both locally and globally. Further section 3 of the paper will elaborate the proposed solution and methodology used to overcome the defined problem in existing systems. Section 4 elaborates on how the proposed system impacts on the society. Finally, section 5 concludes the paper with a note on further improvements.

## II. LITERATURE REVIEW

In the past, beauty industry was only limited to physical stores, but with the development of e-commerce websites, social platforms and various other reasons, beauty and personal care market has experienced an immense growth. (“INSIGHT,” n.d.) lists out these reasons as:

*Rapid technological advancement:* technology has played a vital role in closing the gap between online and physical of marketing products. As an example, L’Oréal’s “Makeup Genius” application in the year 2014, not only opened doors for new sales, but it also gained popularity. This was because of its main feature, which is transforming mobile phone camera into a virtual mirror, allowing users to try-on shades of lipsticks and eyeshadow on users’ face.

*E-commerce:* making its way from online content to online shop, e-commerce now provides its users an experience that is close to “real life”. E-commerce not only allows users to shop for their favourite products any time of the day, but it also allows them to shop at the comfort of their homes and get products delivered to their doorstep.

(“INSIGHT,” n.d.) also elaborates that, though brand-based sites are popular, majority of online shoppers choose to shop through retailers such as amazon, etc. As an example, in the year 2015, L’Oréal reports that  $\frac{1}{4}$  of their online sales are

generated from their brand website, however, remain  $\frac{3}{4}$  is generated through online retailer sites such as amazon. Therefore, it can be acknowledged that online shoppers do use brand-base sites to purchase beauty items, however, much preferred choice is e-commerce websites which collaborates with multiple brands and sellers.

#### A. Global

According to ("Top Beauty And Cosmetics Websites in The World," n.d.), following are the top beauty and personal care e-commerce websites globally:

*Hot Pepper Beauty:* Beauty hot pepper is an e-commerce site for beauty operated or based in Japan but rated as no. 1 according to ("Beauty.hotpepper.jp Traffic, Ranking & Marketing Analytics," n.d.). This popular beauty e-commerce site can be considered to be the "marketplace" for booking local salons specialized in beauty, therapy and spa treatments through the website.

The website initially lured its customers through AdWords brand campaigns and offline advertising however, in order to reduce CPA (Cost Per Action), the website implemented DSA (Dynamic Search Ads) along with page feed as a solution. This helped the website gained immense popularity among the locals. ("hot-pepper-beauty-reduces-workload-by-90-percent-with-google-page-feeds.pdf," n.d.). Hot Pepper Beauty differs from other online booking websites because it has two main unique features. Since many customers stick to one salon they are used to, this application will be useless, to overcome this issue, search method has been changed from salon to searching by hairstyle. This allows users to explore different salons which offer unique and distinct hairstyles. Similarly, the website has expanded this feature for nail parlours, eye beauty, relaxations, etc. Second main feature is the "salonboard". This is a cloud-based management system which facilitates salons that allows 24-hour reservation and all-in-one management for reservations made through phone, online or via website. This feature aids salons in organizing their customers, giving promotion services, register functions and various tools for aggregation and analysis. These features ultimately resulted in site's unbeatable popularity among locals, saving labour and making online marketing more efficient. ("One of Recruit's leading services supporting dining and beauty in Japan," n.d.)

*Sephora:* Raking 2<sup>nd</sup> in the beauty and cosmetics e-commerce category, Sephora is based in Paris. Website acquaints nearly 3000 brands along with beauty products under their private label including cosmetics, skincare, body, fragrance, etc. ("Sephora.com Traffic, Ranking & Marketing Analytics," n.d.)

Few features that aided Sephora gain popularity can be considered as, the beauty insider community, beauty quizzes and Sephora's virtual artist ("About Us," n.d.). The Beauty Inside Community is a membership program given to members who spends a specific price limit on Sephora. Second special feature, which is beauty Quizzes, helps customers to find what they are looking for in an efficient manner.

According to (Stanovick, 2018), these Quizzes aids in finding perfect Foundation colour, skin-care regiment, but mostly popular for its quiz to find the best fragrance or the required make-up brush. Sephora's Makeup Artist is one of the prominent features loved by many customers, this is because, this application allows users to virtually try-on cosmetic products offered at Sephora. In addition, the customer can "mix and match" and apply many layers of eyeshadow and access the overall result before purchasing the product.

*Ulta Beauty:* Ulta Beauty is an American-based beauty chain which sells beauty products such as cosmetics, skincare, fragrances, nail products, etc. from various beauty brands ("Ulta.com Traffic, Ranking & Marketing Analytics," n.d.).

Few of Ulta Beauty's main features that draw customer attention include valuable content, harnessing data analytics for more effective marketing and direct personalized emails to customers (Chua, 2019). Ulta Beauty owns an online beauty magazine "Ulta Beauty Mix" to lure customers in offering beauty tips and article. Further the customer will be able to easily purchase the item by clicking the image of the product on the article. Ulta Beauty harnesses the data collected by the loyalty program to make smarter marketing decisions depending on the buying decisions made by their customers. Ulta Beauty's personalized emails contains 21 ad tiles in it with content based on recipient preferences and behavior.

#### B. Local



Due to the technological advancement and recent evolvement of internet-based businesses in small and largescale; it is quite visible that the beauty industry has initialized its path via online platform in Sri Lanka. With regard to online beauty cosmetics sites, most would state that it would mainly concern about women and would be aquite gender-based target market. However, the most liked and talked online site in Sri Lanka is raula.lk (“raula,” n.d.), which is based on men. This company introduced a beard oil brand to local male population through their website, which gave them this popularity among other competitors. Therefore, it is evident that the need of an online based beauty cosmetic site is not only for women but for all genders because simply who doesn’t like to be pretty.

Furthermore, (“Ramani Fernando Salons,” n.d.) are seen to be promoting their beauty related industries via the online platform in order to attract customers to their saloons. This has now become a trend within Sri Lanka to advertise the customers about the bridal and beauty related services through online platform; doing so they often promote their products and brands.

“(Cosmetics.lk | Premium Beauty Cosmetics in Sri Lanka,” n.d.) by CosmeticsBeautyMantra could be identified as one of the best online platforms to purchase beauty related gift packs in Sri Lanka. This introduced the path for other sellers to introduce gift packs and healthcare packages through online beauty cosmetic sites.

However, it is still visible that each online based beauty cosmetic industry has its own unique features to provide services to e-based customers.

In conclusion, it is evident that e-commerce marketplaces are much popular than brand based websites. Also, it is noticed that e-commerce websites that provide unique features such as personalised suggestions, virtual artist, interactive virtual magazines, etc. Have a tendency of being preferred over other websites. Sri Lanka currently lacks e-commerce applications to be in par with the moving beauty care trend as well as providing the basic need to shop for non-harmful, personally-suggested beauty products, all in one platform. Therefore, there is a need for such application based in Sri Lanka.

### III. METHODOLOGY

A web-based e-commerce application dedicated to the sellers, manufacturers and buyers interested in solely in beauty products can be

considered a suitable solution. This e-commerce website will allow sellers to sell products such as Baby and Child-specific Products, Bath and shower, Colour cosmetics, Deodorants, Depilatories, Fragrances, Hair care, Men's grooming, Oral care, Sets/kits and Skin care (“Beauty and Personal Care in Sri Lanka | Market Research Report | Euromonitor,” n.d.). The system will comprise of three main users, namely, buyer user, seller user and website owner user.

The basic overall architecture of the system is depicted in the Figure 1.

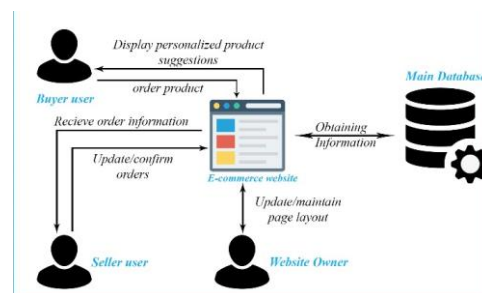


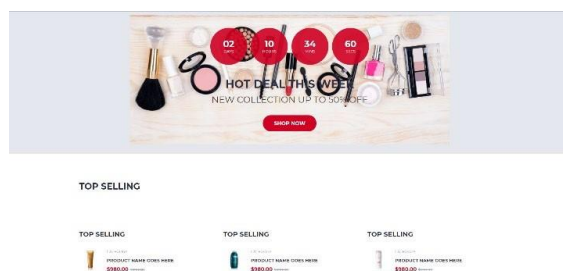
Figure 1 – Overall basic architecture of the system

Source: Author

Technologies used in the construction of this application are HTML, CSS and JavaScript to obtain the basic layout of the e-commerce application and its interactivity.

OpenCV and python are used in the implementation of the Image Processing module to obtain user face colour information. And, MySQL is used as the database connector.

Figure 2 depicts a prototype of the Buyer user interface of the system



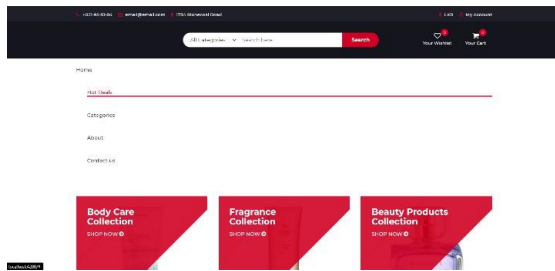


Figure 2 – Prototype of the proposed system

Source: Author

Functionalities of the system are as follows:

*Seller user perspective:*

*A. The process of ordering a product*

The buyer user of the system has the ability to browse various stores available in the e-commerce application and purchase products. The product purchasing procedure is simple and straightforward. The seller user, whose product is been purchased will receive a notification of the order.

*B. The process of managing orders*

After receiving the notification of the order, it will be stored as a “pending” order. The seller can either “accept” the pending order or “decline” the pending order. The notification regarding the acceptance/declination of the order will be sent the relevant buyer user.

In the case where the order is accepted, the status will the order will be updated to “to be shipped”. The website owner user will further update the status of the order to “shipped” when the order is handed over to the courier; “delivered” when the buyer user confirms that the order was received; And “return” if the buyer user fails to collect order or if the user is dissatisfied with the product. The statuses of the order will be notified to both buyer and seller user. *The process of managing products*

The seller user can add products to the e-commerce application and manage a “virtual shop”. The seller user is required to add specified product details and clear images to the system. The added product will be checked and approved by the website owner user. Once the product is approved, the seller user has the ability to update details of products such as stock,

images, discounts, etc. Also, the seller has the ability to remove a product from the shop.

*Website-owner user perspective:*

*A. The process of filtering products with harmful ingredients*

The website owner user acts as the administrator of the system. It is within the website owner’s authority to manage the appearance of the e-commerce application and approve/disapprove products sold on the application. The website owner user will update the system with keywords of harmful ingredients to flag the products with harmful ingredients in them. Through this input as well as other factors such as sufficient details regarding products, clear images, etc. may also influence website owner user’s decision to approve/disapprove products.

*B. The process of updating order status*

The website owner user has the authority to oversee the process of delivery. All accepted orders by seller users will be forwarded to the website owner user. When the order is handed to the warehouse, the website owner user will manually update the system that the specific order was “shipped”. It is solely within buyer user’s authority to enter manually to the system whether the order was received. After the buyer user confirms, the system will be updated to “delivered”. If the order does not reach the buyer user within the given timespan, the order status will be manually updated by the website owner user to “return” and the products will be redirected to the specific seller. Also, if the buyer user initiates a “return request”, the system will be updated by the buyer user to “return”.

*Buyer user perspective:*

*A. The process of providing personalized product suggestions*

The buyer user has the ability to undertake quizzes to view personalized product suggestions mainly on four categories, namely:

*Skin care preferences:* the user can include information regarding their skin type, allergies, etc. and gain product suggestions that fit the specified criteria.

*Hair product preferences:* the user can include information regarding their hair product preferences such as dry hair, dandruff, etc. and gain product suggestions that fit the specified criteria.

*Cosmetics preferences:* the user can upload an image of themselves such that the system will suggest products such as make-up foundation, lipstick and eyeshadow colours that matches with user skin tone and colour.

*Fragrance preferences:* the user can select preferred fragrance notes (such as floral, fruity, etc.) and receive product suggestions that match the specified criteria.

### B. The process of face Colour Identification using ImageProcessing

This module will be considered as a part of the quiz undertaken by the buyer user to analyse user cosmetic preference. The process of colour identification shown in Figure 3.



Figure 3 – Face colour Identification using ImageProcessing

Source: Author

*Image Acquisition:* The buyer user uploads an image to the system in jpg format to extract the mean skin colour of user face.

*Image Pre-processing:* Through the pre-processing stage, the image will be enhanced to differentiate prominent feature prior segmentation. Following actions will be performed:

- Removal of noise: Linear filter will be used to remove excessive blurriness and noise of the uploaded.
- Image convolution: The sharpness of the image will be increased to made the boundaries prominent.

*Image segmentation:* In this module, the pre-processed image will be segmented into background and different parts of user face. The

mean colour of the user face (specifically the cheek areas) will be extracted from the segmented image.

*Colour Categorization:* Extracted mean colour of the image will be further categorized into the closest predefined beige colour category and will be further used in suggesting cosmetic products that match the specific colour category. Python and OpenCV will be used to implement this module.

### III. DISCUSSION

With the use of the proposed solution, beauty industry in Sri Lanka will obtain an e-commerce application that is not only limited to one seller or a specific group of sellers, but a collection of sellers with products of various genres. Since this system follow a joint model of both B2C business model where the Business directly sells products to Consumers and C2C model where a sole Consumer sell products to another Consumer; both small businesses and large-scale businesses related to the beauty industry can sell products, providing job opportunities.

Since the world is moving towards the trend of using non-harmful and organic products, this application is projected towards popularity. As this application ensure that harmful products are not sold, customers will be satisfied.

Providing personalized product suggestions yields around 10-15% conversion rates and around 20% customer satisfaction rates according to ("21 Ecommerce Personalization Examples That Won't Break at Scale," n.d.). This is because this feature is important is keeping the customer in the loop of returning to the site again and again. With the usage of quizzes in this application, the buyer user will receive suggestions that is relevant to him/her only, motivating them to purchase products in a hassle-free manner.

Therefore, it is evident that the proposed solution will increase the sales generated by the beauty industry in Sri Lanka by providing a safe consumable product which will ultimately aid in the improvement of the country's economy.

### IV. CONCLUSION & FURTHER WORK

This paper elaborates on a solution that can improve the sales of the beauty industry in Sri Lanka, namely, an interactive e-commerce application solely dedicated to the beauty industry. This application comprises of three users namely, buyer user, seller user and website owner user. The system allows buyer users to purchase products sold on the e-commerce site by the seller user. The website owner user act as the administrator of the system, hence in charge of controlling quality of products sold on the site, filtering harmful products. The application provides personalized product suggestions to each buyer user depending on their preferences in skin, hair, fragrance and cosmetics. Personalization for cosmetics is obtained using an image processing module which will extract user face color information from an uploaded photograph and suggest products accordingly

As for further improvements, the system can be expanded such that all manual inputs such as website owner user updating product status, etc. is automated. In addition, this system can be presented to intended users, namely, seller, buyer and website-owner; and obtain feedback. Based on the feedback obtained, the system can be further developed to make it more effective for each pertaining user. Further, mechanisms such as virtual mirrors and other AR applications can be added to the system to provide customers an in-house shopping experience. Also, as blockchain technology in e-commerce is a trending topic, blockchain can be implemented in this system will allow users to securely store digital assets such as order information, users' personal information such as skin allergies, etc. Also, blockchain will aid in reducing managing costs, ensure fast transactions, secure the application from cyber threats and many more.

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# A Personalized Food Recommendation Application using a Hybrid Collaborative Filtering Approach

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**Abstract-** With the increase of workloads, the usage of recommendation platforms for purchasing meals has increased. The diet patterns of individuals are influenced by a multitude of factors including age, health conditions, pregnancy, culture, religion, and location. Existing applications recommend restaurants to the user depending on the user's ratings and locations. However, these apps do not consider personal traits of a user during the recommendation process, so they cannot provide effective suggestions that match the user. None of the existing apps recommend individual food items that suit the user's preference. This research aims to provide a smart solution to this common issue encountered during online food purchases. Through the development of a personalized food recommendation system, the time spent on selecting food items can be decreased. This model will be implemented in 2 sections- a mobile application that allows the users to order food items based on the recommendations, and a web platform that can be used by restaurant owners to maintain their restaurant's profile. The customized recommendation process is implemented by using a hybrid collaborative filtering model, by addressing the data sparsity and scalability issues associated with the content-based and traditional collaborative filtering approaches.

**Keywords:** *personalized, food recommendation, hybrid collaborative filtering*

## I. INTRODUCTION

Food, being a fundamental human need, provides energy for humans to steer through the day and supplies the vital nutrients that are essential for growth. It is of utmost importance that people take a balanced diet that matches their preferences, nutritional needs and their physiological conditions. People seek for more convenient ways to perform their regular

activities, such as dining out instead of preparing their meals at home, to keep up with the increasing workloads. This led to an increase in the number of restaurants and fast-food places in the 21<sup>st</sup> century. This is backed up by statistical evidence, which states that the predicted increase in the number of restaurants that provide limited services is 8%, during the year 2021 (Moon *et al.*, 2015). With the advent of automation technologies, online ordering platforms have become increasingly popular (Saad, 2020). Most modern restaurants will provide the facility to order food online via their website. A major underlying issue encountered would be the inconvenience of choosing food items over a wide range of restaurants, which would be time intensive. Apart from this, these systems are not constantly updated. Thus, food recommendation technologies were introduced to allow cross comparison of meals between multiple websites. Existing recommendation apps like Uber Eats, PickMe Food and OpenTable recommend restaurants to the user, and allow users to compare restaurants using a single platform. Based on the location of the user and the restaurant, restaurants will be recommended and the list of food items available will be displayed. These systems generally use location filters. This will allow the users to pick meals that suit their preference. The recommendations are made based on users' ratings; higher the ratings, more likely it is for the restaurant to be recommended. Due to the added convenience, the usage of online ordering systems to order food has increased by 300%, since 2014. By the year 2020, third party food purchasing applications were predicted to become a \$38 billion-dollar industry (Trang Tran *et al.*, 2018).

### A. Factors affecting the food preference

Anatomical, social, economic and environmental differences between individuals have created a variation in their food preferences. Around 119

cuisines have been identified around the world, which includes Korean, Chinese, Italian and Sri Lankan cuisines. According to popularity scoring surveys, Italian food received a popularity score of 84% and Chinese food received a score of 78%. Local ingredients which suit the palate of local citizens, might not suit the taste of individuals from other countries, which will prevent them from purchasing food items containing these exotic ingredients.

Moreover, with the increasing number of ethical issues, more people have resorted to vegetarian and vegan diets. Apart from this, some people have dietary restrictions due to innate physiological conditions.

Gluten intolerance, lactose intolerance and allergies are a few among them. Variations in age will also lead to changes in the dietary patterns of humans. Progressive deterioration of the human body will alter the requirement of nutrients (Bartkiene *et al.*, 2019), which will make older individuals increase the protein content in the meals. Pregnancy would also be another factor affecting the nutritional needs of an individual, since the mother will intake more nutrients for the healthy growth of the baby.

Another crucial factor that should be taken into consideration while choosing a meal would be the presence of non-communicable diseases. Genetic and environmental changes can result in conditions like cardiovascular diseases, hypertension, diabetes mellitus and cancer. It is evident that these diseases can be controlled by a dietary change; a 30% reduction in the intake of sodium has proven to mitigate the number of diabetic patients (Ge, Ricci and Massimo, 2015). These diseases have a direct link with the imbalance in diets, thus people suffering from non-communicable diseases will take carefully controlled diets in contrast to other individuals. Apart from this, economic, geographical and cultural differences affect the food preferences as well. Food items which are prepared using expensive and rare ingredients cannot usually be afforded by poverty-stricken individuals. If the restaurant is distal to a user's current location, they will be reluctant to order food from it, due to the added cost and delivery time. Religions like Buddhism will encourage its followers to adopt plant-based diets and Muslims generally prefer Halal food items, leading to variations in food patterns between different religious groups.

Combinations of two or more of the aforementioned factors will affect the dietary patterns of an individual. Thus, it can be concluded that no two individuals have an identical choice of food, although similarities can be found between the choices of individuals who share common genetic traits and environmental conditions.

#### *B. Drawbacks of the existing systems*

To provide effective recommendations to the user, their attributes must be carefully studied, to ensure that the food items recommended match the user's preference. However, none of the existing applications take traits of the users into consideration. Thus, none of the existing recommendation systems can provide personalized food recommendations to the user. Instead they will be provided with generalized predictions, based on the highest user ratings and location filters. (*Food Discovery with Uber Eats: Using Graph Learning to Power Recommendations | Uber Engineering Blog*, no date) If key factors like age, health conditions and gender are excluded from the recommendation process, the user's preferences cannot be identified, and this will yield unsatisfactory results. A major problem encountered when ordering food items online would be that a method of cross comparison, for a particular food item, across multiple sites is not yet available. The main purpose of a recommendation system would be to add ease and comfort by reducing the time invested in selecting a food item. This cannot be fully achieved by the existing recommendation apps, since they do not provide a platform to compare an individual item, though they allow comparison of restaurants. Apart from this, recommending food items based on the user ratings would mean that the unrated restaurants will not be included in the selection process, and they are less likely to be recommended. This would affect certain small businesses, which have received low ratings though they provide high quality meals that complements an individual's taste.

#### *C. Current recommendation approaches*

The most popular recommendation systems that currently exist are YouTube, Uber Eats, Netflix and Amazon. Most of the applications will make suggestions based on the past behavior of the user. Using various machine learning techniques and AI algorithms, these systems will make predictions based on the behavioral patterns of a

user. Effective recommendation systems employ filtering techniques to filter and classify the vast amount of data that is received continuously. The major machine learning algorithms in a recommendation system can be classified based on the filtering approaches used, which are content-based filtering, collaborative filtering and hybrid filtering techniques (Salehi, 2013). Collaborative filtering does not require the items and users to be individually known and prevents overspecialization of a user's profile. Based on a similarity index, suggestions will be made to the user. The ratings provided by a user for different food items can infer the similarity between these items. For an active user, the predictions are provided by ratings calculated on this weighted average of similar users. (Kumar and Fan, 2015) This will provide effective recommendations for food combinations that will suit the user's preference.

#### *D. Proposed solution*

The aim of this proposed initiative is to resolve the issues that are faced by people who order food online. This app will provide personalized food recommendations by analyzing the end user's food patterns. This will take factors like the age, gender, religion and general health issues into consideration. To identify these factors, a preliminary survey was conducted. This system will be established as two sections: a mobile application that can be used by the user to place an order and a web platform which will allow the restaurant owners to update their menus. The mobile application is trained to provide customized recommendations to the user by deploying a hybrid collaborative filtering approach. The user's interest can be predicted, conditioned to the rating data of users with common interest as the target user. The recommendations are made, and the user will purchase food items from the set of alternatives. Food items which are compatible with the one that was purchased will also be recommended; for instance, if multiple users who bought a burger also bought fries, the current user who bought a burger will be notified about this. This will allow the users to purchase meals with compatible food combinations. Once the purchase is made, the respective restaurants will be notified through their web application. This vendor platform allows the owners to add new food items and modify their prices on their

profile. They will be allowed to monitor their customer base to identify their preferences. This will be a highly useful tool for all customers and vendors, since this system provides the user with ideal meal recommendations that suit their attributes. No resources will be wasted on providing ill-fitting recommendations. This can be used to alleviate non-transmissible diseases including CVDs and will provide maximum satisfaction to the user.

## **II. METHODOLOGY**

### *A. Preliminary studies*

To ensure the effectiveness and feasibility of this research, the target customer base and their traits were initially identified. This was deduced based on the data collected by a Google form. 300 data samples were collected by random individuals to list the attributes that will vary across them, including the frequency of using recommendation applications for food purchases, age groups of the users, common dietary restrictions (vegan, vegetarian, halal, gluten free), preferred tastes (sweet, sour, spicy, salty bitter), and health information that leads to varying food patterns. The common application users were identified to be within the age group of 15 to 30. The data collected also demonstrated that most people dined outside instead of cooking at home. Preliminary studies lead to the conclusion that parameters like age, country, location, and health condition affects the food patterns of an individual. Out of these variables, health conditions had a significant effect on the diet compared to other factors. The feasibility of this app was predicted to be high since 84.8% of the participants consumed meals from outside and 94.3% of the participants were in favor of a personalized food recommendation app. The following results depict some factors that were taken into consideration in order to develop the application.

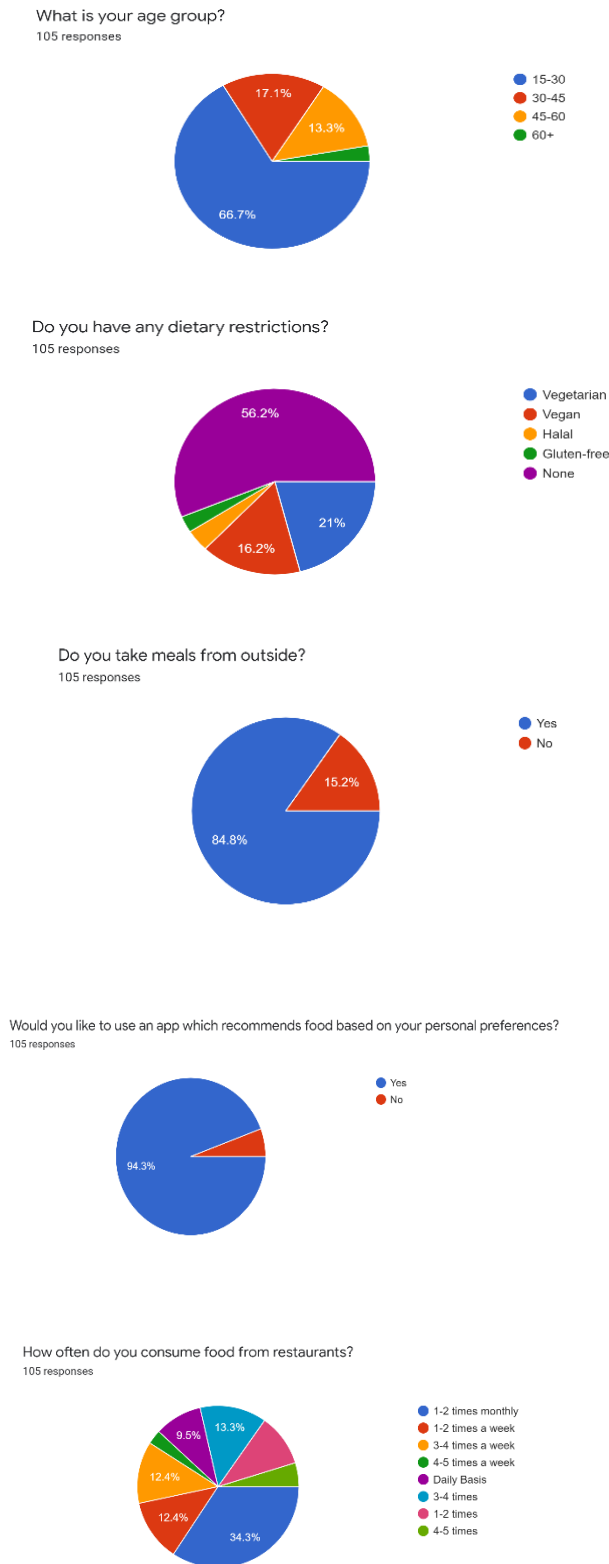


Figure 1. Selected results of the preliminary survey

### B. Hybrid collaborative filtering

This research will follow a collaborative filtering approach due to its effectiveness and ease. Collaborative filtering technique generally follows two approaches- user based and item

based. Due to the data sparsity, scalability and cold start complications associated with the traditional CF approaches, a novel approach was employed to develop this system. An approach merging the user and item clusters, called hybrid collaborative filtering approach, detects the similarity between the average users and the active user and locates the immediate neighboring clusters of the active user. (Hu and Lu, 2006) To resolve the data sparsity issue, the incomplete cells in the user matrix are filled by deducing that similar users will rate items similarly, thus will require a similar result. The unrated food items are rated based on the ratings provided by similar users. (Safran and Che, 2017) The scalability issue was resolved by clustering users with similar traits. This reduces the number of users considered during the prediction process. Following this, the item clusters are used to make accurate recommendations, using the closest neighboring cluster.

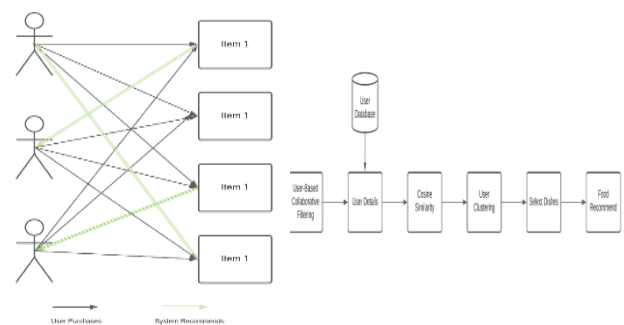


Figure 2. User-based CF

### C. System Design and Architecture

The proposed system consists of two ends, namely the mobile and the web platforms. The authorized parties (system administrators and restaurant owners) will be allowed to feed in data to the database. The system administrator has different privileges when using the web platform, compared to the restaurant owners. This includes adding and deleting stores to the system, handling the complaints of customers and managing the users. The restaurant owners are allowed to add new food items to the system and monitor their sales. On the other end, users can use the mobile application to log into the system in order to obtain their personalized food recommendations. The web and the mobile

platforms are connected to a single database, hosted by the cloud. This links the two systems.

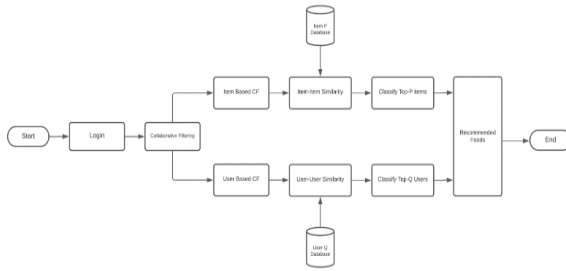


Figure 3. The system design

The mobile and the web platform are built using the same technologies- ReactJS, NodeJS and MySQL. ReactJS, which is a commonly used front-end library currently, is used to build interactive, attractive, dynamic and high-performance user interfaces with many functionalities. The UI will be fragmented into a collection of reusable sub components, each having unique attributes and functions. (ShravanG, 2020) In this project the front end of the system (the mobile application and the website) was developed using ReactJS front end library. The backend functionalities of the system were developed using NodeJS. This will also be a JavaScript based open-source platform. (Chhetri, no date) The database for the system was implemented by the MySQL database service, which is an open-source database management platform, built using SQL. Large number of data entries to the system will be effectively managed by the relational database.

The user is required to register using the mobile application initially. During the registration process, the system requests the user to input personal data, including the name, age, email address, telephone number, food preferences (vegetarian, vegan, non-vegetarian, halal, high or low salt diets, etc.), location and health conditions. After the registration is successfully completed, the system requests the user to set up credentials including the username and a password. Once the user logs in to the system using the respective username and password, the system will automatically identify the user by matching the user credentials with the database. Once the authentication process is complete, the user will be allowed to access the system.

Since the model is trained with continuous input of data, the initial shortage of data will lead to inaccurate predictions. To overcome this cold

start issue, the initial recommendations are made based on the data that was input to the system during the registration. The initial recommendations will be based on the user's age, food preference, gender, location and the health conditions. This application requires the geo location of the device to filter proximal restaurants and include them in the recommendations. If the location cannot be accessed by the system, it will use the most recent location stored on the database. When a user logs into the system for the first time, their preference can also be predicted based on the history of other users. This information is also included in the initial recommendation process to obtain the best possible outcome. The only limitation posed when employing this technique to make predictions is that 3% of the users will receive recommendations that will not suit their preferences.

After the user has successfully purchased a food item, the system records the user's preferences. Following 4 to 10 purchases, the system starts to make accurate predictions. The accuracy of the system is fully dependent on the number of purchases made by the user. Each record will be uploaded to the database, which will then make predictions based on the data stored. The hybrid collaborative filtering algorithm will then be applied by the system to generate similar users and items from the database. A deep learning neural network was used to implement the hybrid CF model. An item-item model and a user-user model serve as inputs, which is used to build the layers of the neural network. A dummy data set was fed into the model in order to train it and the output layer was built. This will allow the app to recommend frequently purchased food combinations by similar users to the active user. The user is also allowed to rate the item on a scale of 1 to 5 stars. The ratings, along with the number of times that the items are added to the cart, will also be used to provide an accurate recommendation.



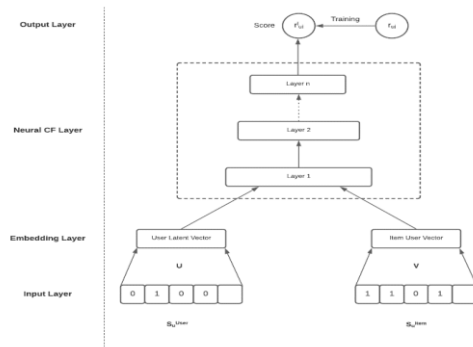


Figure 4. The hybrid collaborative filtering model

Based on the likes and the dislikes of the users, predictions will be made by the system. If the user wants to select a food item apart from the recommended items in the list, they are provided with a search functionality. Once the item is selected, the user will be allowed to view the ingredients involved in making the dish, its price, related food items and purchase it.

### III. RESULTS

During the registration process, the user will be asked to enter personal details and the food preferences, by checking off the boxes, as displayed below. This will be a two-step process as the personal information and login credentials must be established.

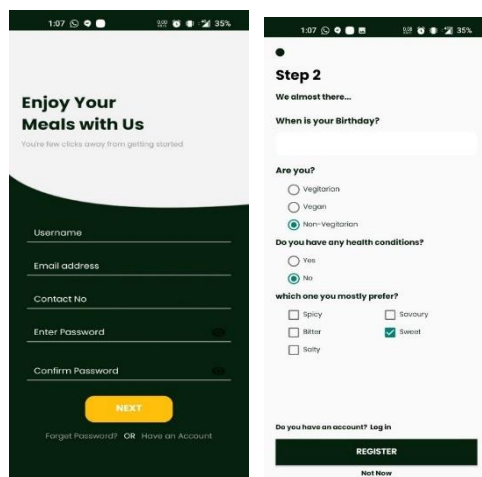


Figure 5. Registration and login interface

Once the user logs in to the mobile phone application, a request will be sent to the server. The server accepts the request and performs the necessary validation operations. After the operations are successfully executed, the processed data is sent back to the mobile

application. Any issues with the connectivity will be notified by an error message in the app.

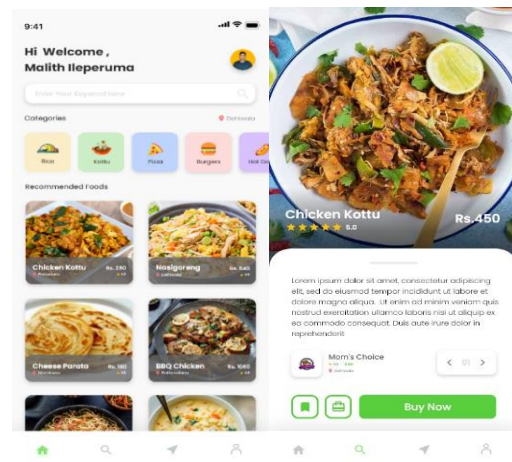


Figure 6. Recommended products

This application has three potential stakeholders-the end user, restaurant owner and the system administrator. The system administrator is responsible for updating new items to the system, as shown in the following image.

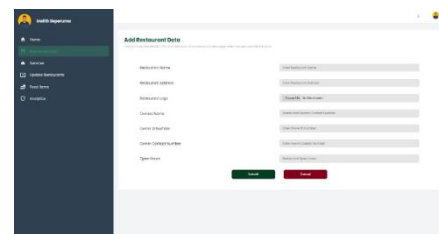


Figure 7. Web platform for the administrator

Restaurant owners will manage the web application end of the system, through which new dishes are added. The ingredients available in the food items and their prices will be added through this. The vendors can view, update and delete items from their menu as well. This web platform will allow the restaurant owners to monitor the sales and the status of their items.

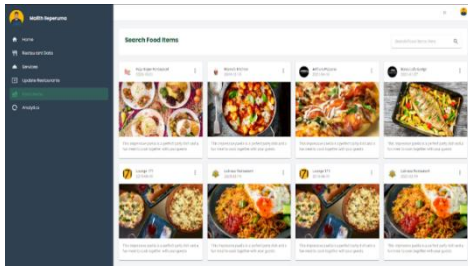


Figure 8. Web platform for the restaurant owners

#### IV. DISCUSSION AND CONCLUSION

This project exemplifies the ease of using the hybrid collaborative filtering technique over other filtering approaches. This also resolves the common issues that users commonly face while purchasing food online. To reduce the time spent on selecting food, this system provides a smart and realistic solution, where the recommendations are customized according to the user's preference.

Using the data from preliminary studies, it was concluded that 83.8% of the users are below the age of 35. Thus, the application interfaces were designed and developed to increase the usability and to attract members of the above age group. In the first stage of the development, training datasets were collected. A prototype was developed, using which raw data was collected. This was used to create a dataset which trained the collaborative filtering model. The model was trained with different datasets and parameters to achieve the best possible output. During the initial training sessions, new layers were added with different parameter combinations to compare the training and validation accuracies. By breaking the product development into cycles, a fast and hassle-free development was ensured.

With an increasing number of purchases the accuracy of the system increases. Thus, more personalized recommendations will be made to the user. A common issue that is encountered would be that the users' preferences are subjected to constant change. Making predictions based on their preferences would not be valid for a single trial. This will be an iterative process that has to be performed regularly. The application's database is hosted in a cloud and all the data of the users will be stored in it. Thus, cellular network is a mandatory requirement for the application to connect with the database hosted

by the cloud, in order to function properly. To access this system, a device that supports the functionalities of this application is a necessity. This is a limitation posed since this restricts individuals who do not have the income to afford, or the knowledge to operate a smartphone/PC. Technical literacy is another crucial factor to be considered, since the fundamental knowledge to read the predictions and handle the transactions should be present in the user. This will be a disadvantage for old people and those who lack technical knowledge. To overcome this issue a tutorial will be integrated with the system in the future, to educate the users about the features of the application.

In the future, this system will be advanced by incorporating a profit prediction system, which can be used by the restaurant owners to predict their sales monthly and in different quarters of the year. This will be highly beneficial for the business and the economy, since necessary modifications can be made in order to compensate for any possible losses. To enable users from different countries and ethnicities to use this application, this will be developed into a multilingual system in the future. This system will also be integrated with other models to enhance the accuracy of the recommendation during the initial stages. This user-friendly system will indeed minimize the time spent on selecting food items and will provide customized food recommendations that will suit each user.

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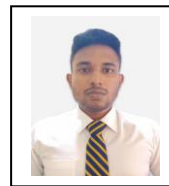
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# Knowledge Management Systems in the Agricultural Context to Face Resilience in the New Normal

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**Abstract**— The COVID-19 pandemic has given a forceful full stop to all daily routines, while shutting down workplaces, entertainments and meetings among others. Amidst the revolution of the Coronavirus, the active parts of the world are only the essential services such as health, food production and supply. The continuation of the pandemic has created a New Normal with lapses in the production lines evoking the value of cultivation and their need to engage in self-productions. Therefore, farmers and the public have attempted at taking steps to cultivate at their best as they do have to survive. Though the start-up was a success, issues arise with the continuation of their cultivation due to the lack of precise knowledge and experience. Primarily, the issue arises with the lack of know-how knowledge for cultivation. Therefore, this research provides a critical analysis of how knowledge management systems can support sustainable progress in cultivation. This paper attempts to define the meaning of knowledge management and knowledge management systems in national and international perspectives to guide the unguided public in critical New Normal conditions.

**Keywords:** *knowledge management systems, knowledge management, agriculture and cultivation*

## I. INTRODUCTION

Knowledge management concepts and knowledge management systems are globally applied in many industries to secure the know-how and other knowledge and experiences for the future and to accomplish their goals faster and more effectively by delivering the right knowledge to the right person (Lwoga, 2009).

The paper targets analyzing the procedures to apply the knowledge management concepts on knowledge management systems to secure the

prestigious art of Sri Lankan agriculture. It aims to highlight the benefits of securing agriculture knowledge and know-how through knowledge management systems to be used now and then in new normal or critical economic conditions to safeguard the life systems.

The Covid-19 pandemic has created a new normal where each life has been adopted to a silent growth with self-isolation, and the busy patterns of buying and consuming have been limited with the uplifted restrictions to the free movements. Many of the private sector entrepreneurs have been affected by this new pandemic normal. Therefore, many of the public has moved to the most demanded business in the new normal, cultivation, either to sell or to consume for their life survival. It is that the pandemic's new normal has created an increasing and enthusiastic pattern in public to engage in agricultural and cultivation activities knowing the value of it.

The attention to agriculture to ensure the needs of consumers at both the home basis and country basis has become an essential factor during the pandemic. It is that most of the Sri Lankans who had led busy life patterns with junk food patterns had to shift into home-prepared foods due to the shutdown of the country and with the existing limitations and movement restrictions to defeat the spread of COVID -19. Therefore, this shutdown of the country has created much time for the people to utilize that for agricultural purposes to produce foods for their daily consumptions. Though the people have enthusiastically engaged in agricultural purposes, sometimes the lack of knowledge and experience as of farmers with them may not give them the productive results of harvest as expected. Agriculture is a vast process that

extends with a lot of traditional ways, experiences, and with the practice of the farmers, they have on their hands and especially with the tacit and implicit knowledge that the traditional farmers are rich with. A man who cultivates intending to achieve financial benefits through cultivation to secure his lifestem in the new normal should at least have all the basic knowledge about all the prerequisites and the steps and conditions to follow with.

#### *A. Research Problem*

Though the trend has started to move towards the cultivation during the pandemic season, the lack of knowledge and the inability to acquire required knowledge from agricultural institutes and government agricultural departments with the prevailing pandemic's new normal conditions, the enthusiasts have moved a little backward, and many have become failed due to the lack of guidance, and lack of experiences and know-how.

In Sri Lanka, most of the government and semi-government websites are well rich with content regarding agricultural issues and anyone can acquire the theories and steps by reading those contents. But, if the prevailing systems are mostly content-based rather than providing know-how and indigenous knowledge or real-time or more practical solutions, the knowledge management and sharing may not be productive as it is only a set of words and steps with just a content management system than a knowledge management system that can accelerate people to do cultivation.

#### *B. Aim*

The research aims to analyze the options that could be taken to guide the unguided general public to engage in cultivation accurately with the use of knowledge management concepts and knowledge management systems to achieve sustainability in cultivation by any person who has or has not tacit and implicit knowledge even during such an arduous and shutdown period like, COVID - 19. Therefore, this paper aims to analyze the aforesaid concept to develop a knowledge management system embedded with both implicit and explicit knowledge suitable for the Sri Lankan context.

#### *C. Objective*

The objective of this paper is to identify the ways and means of utilizing the knowledge management concepts to develop knowledge

management systems to provide knowledge service for the unknown. Secondly, the general public to make them achieve success through the acquisition of needed knowledge at the right time in cultivational targets during a new normal condition with an unending pandemic suffering where they cannot acquire knowledge through physical means and support. Furthermore, the objective is to secure tacit knowledge, implicit knowledge and precious experiences in a systematic and value-added manner to obtain and learn by any person who needs know-how about the farmers' secrets and proper guidance to the cultivation through virtual means that is accessible by any time of the period efficiently and effectively.

## **II. LITERATURE REVIEW**

Many concepts and research ideas have been carried out by world researchers based on the application of knowledge management strategies to sustain agriculture utilizing knowledge management systems. Moreover, literature about how countries and certain villages have adopted the support of knowledge management systems to overcome certain types of critical situations is synthesized below.

According to the ideas of Soc et al (2003) the knowledge management approaches can harness isolated information, experiences, skills, and know-how for sustainable socio- economic development. Furthermore, in the same manner, systematic knowledge management methods and tools can apply to store and disseminate the valuable know-how and the experiences of farmers can make the unaware audiences engage in cultivation and agricultural activities in a better productive way. Thus, it enables to achieve an agriculturally sustainable country even in pandemic situations as the correct information is available for any and could be guided utilizing knowledge management tools.

Amarendra (2017) has reviewed that, "Knowledge management in agriculture is relatively a new idea. Knowledge management in agriculture requires a lot of ability building". Further, Arun Kumar et al (2014) have agreed and commented the same, "Knowledge Management in agriculture is relatively a new concept. The mammoth task of driving the knowledge sharing process in agriculture



requires a lot of capacity-building exercises.” As quoted, that application of knowledge management tools to capture, store and share know-how needs a lot of effort. It is stated as “knowledge harvesting and sharing through a write shop process – Knowledge Management for Agricultural and Rural Development (KM4ARD),” n.d. has emphasized a model named, ‘Knowledge Harvesting’ which uses a variety of approaches like relating a story, interview, coaching, writing, and documenting to transform implicit knowledge into explicit knowledge easily so that information can disseminate to a large audience.

Amarendra (2017) has highlighted, even the agricultural organizations have realized the “importance of managing both explicit and implicit knowledge for the dissemination of knowledge as well as to fulfill the Ranganathan’s concept right information to the right user at the right time.” Further, the paper emphasized that knowledge management is a key component and as well a systematic discipline of policies, processes, and activities which lead an organization towards empowerment while optimizing effectiveness, innovation, and quality. As proposed by Amarendra (2017) to capture knowledge and embed those into knowledge management system need the participation of stakeholders who are related to agriculture through the “the attainment of efficient knowledge management in agriculture includes the farmers, farmer organizations, policymakers, extension agent, and scientist.”.

Moreover, Soulignac et al (2012) have also agreed and commented similarly that; “the development of a collaborative knowledge space relies on a capacity to appropriate the experience of others. The actors also have to share the same objectives.” Further, Soulignac et al (2012) have highlighted that, to sustain agriculture, it needs vast knowledge because “it has a systemic logic and therefore requires a strong knowledge base.” Therefore, for that, they proposed to “develop a knowledge management IT-based system.” As quoted by Soulignac et al (2012), “in sustainable agriculture, besides, the thematic knowledge appropriation of knowledge by the farmers is fundamental,” and according to the critical point of view, to achieve maximum productivity through agriculture, the implicit knowledge and expert experiences over the

years, within a farmer is an essential thing. Among the concept projects, Soulignac et al (2012) have proposed that an “Organization, Information, Decision, Knowledge” (OIDK) model dedicated to large-scale organic farming,” where knowledge is integrated with subsystems to deliver agricultural knowledge as the output. The system manages the inflow of information about Fuel; weather data; organic fertilizer; state of the crops; the level of bio-aggressors, natural products, seeds. According to them, “the knowledge capital is embedded in the system in the modes such as know-how, soft skills, and the other knowledge is feed into information systems which includes the agents who inform the farmer. It comprises all the strategic and tactical information supplied by these actors, which become information consumed by the farmer. The information system also lists the information produced by the farm. This information is later utilized in decision-making (ACTA, 2007). Furthermore, Soulignac et al (2012) has discussed a model named, MASK, Concept which is based on recognizing the excellent skills of the chosen farmers classify knowledge according to the agricultural mechanization model for organic wheat production and the system intakes the way professional farmers reason and their soft skills and know-how as the system inputs.

Moreover, in the paper, Part (2010) also has assessed “applying knowledge management models in managing and integrating indigenous and exogenous knowledge for improved farming activities in Tanzania...”. According to that, in Tanzania, mostly the explicit knowledge by researchers, laboratories and universities are preserved in information systems and make access by farmers through an intermediate person who has technical facilities. Also, it highlights the preserving of explicit knowledge of researchers and universities are not sufficient to sustain in agriculture as “farmers’ knowledge has been responsible for improving agricultural productivity and ensuring food security for centuries in Tanzania.” Therefore, the paper points out that “success in agricultural activities depends on the capability of farmers and agricultural information actors to leverage local knowledge and embody it with exogenous knowledge to produce value from these knowledge resources. Since Indigenous Knowledge is essential for agricultural

development, it must be managed and preserved in the same systematic way as external knowledge”, as the knowledge and local practices that are preserved in people’s minds may be eroded by failing memories and death or not held in the heads of a few. Further, the paper Part (2010) thoroughly emphasizes that Knowledge management practices can give a better solution for that by converting tacit knowledge into a more explicit form by enhancing tacit knowledge flow through human interaction. As well Lwoga, Ngulube, & Stilwell (2010) signify the “urgent need to acquire, document and preserve indigenous knowledge so that it can be available for agricultural developmental initiatives before much of it is completely lost.”

Moreover, according to the rice knowledge management portal discussed by Arun Kumar et al (2014), the portal helps to share the knowledge and information regarding rice cultivation “context in the local languages to the ever “Information-Hungry” farmers.” The system consists of a separate section for the farmers called “Farmers Domain” to place questions and then solutions are provided via online modes and through SMS. Furthermore, that portal is not only built for the use of farmers but also other stakeholders such as extension professionals, researchers, traders, NGOs, policymakers, who can search and gather information related to rice farming. So, that information may not be limited to fewer.

Further, Zecca & Rastorgueva (2017) has emphasized that sustainability of knowledge management is the success for providing sufficient information is enabling to use of that knowledge to improve individual performance and to apply accurately in decision making. According to the viewpoints of Zecca & Rastorgueva (2017), “improving availability of information; enhancing a decision-making activity on different levels and providing relevant information for all production stages.”

In addition, “knowledge harvesting and sharing through a write shop process – Knowledge Management for Agricultural and Rural Development (KM4ARD),” n.d. has discussed a system which was “developed by the International Institute of Rural Reconstruction (IIRR) during a workshop to produce a kit for

“Regenerative Agriculture Technology” in the Philippines. It is defined as “a participatory way of packaging knowledge over a short period.” It helps document tacit “experiential” knowledge turning it to explicit, by making it understandable and thus, more easily usable.”

Furthermore, the article, “knowledge sharing through social media creates a voice for Pacific farmers and smallholders – Knowledge Management for Agricultural and Rural Development (KM4ARD),” n.d. highlights the use of digital media to store and share farmers’ problems to a common collaborative platform about their selling, product prices, tacit and know-how with the hashtags enabled tracking of conversations.

Further, “developing a taxonomy for agriculture and rural development – Knowledge Management for Agricultural and Rural Development (KM4ARD),” n.d. portrays the need for the knowledge generated from experience and a system of taxonomy where people can retrieve it easily as per their need.

Boateng (2006) signified the importance of mixing both implicit and explicit knowledge in equal portions to return productive decision making. According to Boateng (2006), “an effective knowledge management strategy for agricultural extension practice must aspire to bring the communities of extension experts and farmers together in all the knowledge management phases – from knowledge creation to utilization.” Further, the author points out that roles and actual meaning of both tacit and explicit knowledge should be understandable to both communities and the concept of externalization through socialization is vital. It can be accelerated utilizing the model, “Nonaka and Takeuchi” which bridges the knowledge divide between the two communities, farmers and experts (Hoe, 2006).

Besides the aforesaid, according to Ngulube (2002) the inadequate management of information, most of the indigenous information accumulated by colonial district officers and early missionaries cannot be located in many archival institutions in Africa. Similarly, the inability and the failure to keep the knowledge management system to acquire hidden know-

how of rural farmers have made other general public far from achieving true harvest and

### III. ANALYSIS

The analytical overview of the knowledge management systems that have been utilized globally to achieve proper knowledge sharing and management in the context of agriculture and cultivation are synthesized below. Further, few websites were utilized by the Sri Lankan government, i.e., [www.goviya.lk](http://www.goviya.lk), [Govianna](http://Govianna), [www.agrimin.gov.lk](http://www.agrimin.gov.lk), [www.doa.gov.lk](http://www.doa.gov.lk) were analyzed to validate the knowledge management concepts within the existing systems in Sri Lankan agricultural sector (Baddegama, 2020).

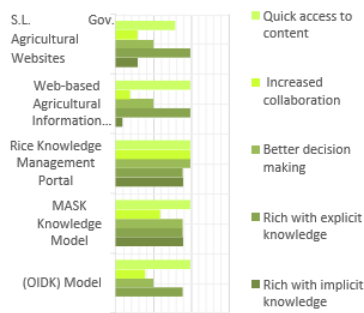


Figure 1: Analysis of Literature Summary

A web-based agricultural information system was proposed for Sri Lankan agricultural sector. This application provides content management through a web application and composed of explicit information, i.e., crops and inter-crops, their production and export details, crop and inter-crop diseases, land availability, soil suitability, fertilizers related to four major crop types, i.e., Rubber, Coconut, Tea and Rice (Fernando, 1998). The data inputs to the system are provided through institutes, namely: “Rubber Research Institute, Agalawatta; Tea Research Institute, Thalawakale. Further, it is highlighted that application will eliminate the barriers to agricultural information, which is rarer and may add more value to the information and may be benefited many researchers and other parties who are searching for agriculture-related information (Fernando, 1998).

### IV. METHODOLOGY

A qualitative and qualitative approach was applied to critically analyze the applicability and

the idea of utilizing knowledge management tools and concepts in the field of agriculture.

Initially, a comprehensive analysis of secondary data collected regarding knowledge management systems, concepts, and models presented globally in works of literature, i.e., international journals, publications, conference papers, government reports, and websites are observed and evaluated considering essentials for a tacit and explicit knowledge.

Secondly, interview sessions were organized with agricultural officers and authorities to clarify the prevailing perceptions and the systems in the Sri Lankan agricultural field and analyzed to evaluate the applicability and the need for implementing knowledge management tools to acquire store and share indigenous tacit knowledge and experiences of rural farmers, to make accessible by the public who are away from those.

The applicability, benefits, and limitations of knowledge management systems in the agricultural sector were evaluated and the analysis of that information collected through the interview sessions is emphasized below.

### Knowledge Management in the Field of Agriculture

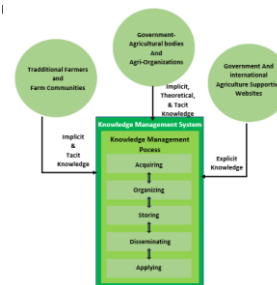


Figure 2. Analysis Results

### V. PROPOSED DESIGN

The proper knowledge management tools should be implemented to overcome the challenges that the public faces in the attempt to cultivate. Therefore, knowledge management systems could be plugged in as a means of guidance and knowledge providers to avoid the general public stepping backward for cultivation. A system can be designed to store and deliver the right information about traditional indigenous knowledge and farmers’ experiences to use by any person who needs guidance and information in a quickly accessible way.

As the means of data input to the system, the data acquired from the development officers, “Govi-Jana Sewa” officers, farmers, field workers can be identified. Moreover, the data inputs can be done through the systems such as the E- farmer ERP (Pradeep.R.M.M, 2020), government websites; (SriLanKorDAA), (International Crop Research Institute for the Semi-Arid Tropics (ICRISAT)).

The system can store data about the traditional indigenous methods and knowledge applied in cultivation; knowledge about soil combination, land selection, an essential type of treatments and their measurements of application depending on the crop type, phases to follow to plant crops from seed selection till the watering and other general guidelines and practices of rural farmers, etc. So that the general public can search and acquire knowledge which they are lacks with depending on each of their need. Further, the system can be embedded with an online collaborative platform where users can place their queries into the system to get customized and practical answers in real-time.

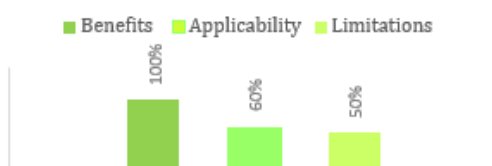


Figure 3. The Conceptual Design

## VI. DISCUSSION

According to the information synthesized above concerning the literature analysis, the world has accepted the need for preserving indigenous knowledge and experiences of farmers they had for years. Further, the linking of both know-how of the farmers and the proved scientific methods of experts and other researchers could lead to sustainability through cultivation, especially during a pandemic period as social distancing has blocked the acquisition of knowledge in real-time interactions. Therefore, the systematic management of knowledge, utilizing knowledge management tools and concepts can enlighten and transform a person who does not know what farming is into a skilled farmer.

Mainly, during the pandemic new normal, where everyone is practicing social distancing, the people who are eager to enhance their farming and cultivation lands to become sustainable through that can be supported with the

implementation of a knowledge management system. It is, the system will provide quick access to indigenous know-how of rural farmers for any searcher with just a single click. In addition, the shutdown of services rendering by agricultural offices and officers can be replaced by the implementation of a knowledge management system where the general public can place the queries and be afforded quick solutions through the system's embedded knowledge of explicit and implicit knowledge.

## VII. CONCLUSION

This paper provides an analytical overview on the concept of developing a knowledge management system to store, disseminate and apply the tacit, explicit and implicit knowledge and experiences of rural farmers and explicit and theoretical knowledge of researchers and institutes to a one-stop accessible system, where the general public can acquire the knowledge, they need for today and the future.

The accurate knowledge management will ensure sustainability through cultivation as the knowledge will not be buried even the decades got over as the hidden tactics of know-how and the experiences of the ancestral farmers are still alive with the technology-enabled knowledge management systems and concepts.

In a new normal condition, where we all have learned the vitality of cultivation, knowledge management systems will stand against the information dissemination barriers and provide benefits for cultivation engagers.

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# Toothcare: A Toothbrush Quality Identifying App Using Machine Learning and Image Processing

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**Abstract** - Toothbrushes of varied qualities, designs and standards are globally available, yet majority of them do not conform to international standards. There is no proper guidance or awareness given for the people with this regard. So, generally people do not know to choose the suitable toothbrushes they need, when they require to replace the used toothbrush, and whether the existing toothbrush is suitable for use. Therefore, the Toothbrush Standard Monitoring App provides a solution for all the above mentioned issues. This app is capable to scan the user’s toothbrush and identify its condition. Machine learning and one of image processing techniques, image classification are mainly used for development of the app. Android Studio, Java programming language and firebase are used as development platform, backend development language and database platform respectively. The main purpose of implementing this app is to improve the dental health of human beings with the help of modern technology, and this will be the very first such solution implemented, addressing the above-mentioned health and social issues. This app functions in order to make people aware about the quality of toothbrushes and the conditions, hence reducing dental health issues and acknowledging people regarding the time period when they need to replace the existing brush with a new one. Accordingly, the app suggests certified toothbrushes following the user’s data, monitoring the quality and damaged capacity of the toothbrush using image processing and informs the user whether the toothbrush can further be used or needs to be replaced. For this process, a TensorFlow Lite model with 83.48% of accuracy has been developed.

**Keywords:** *image classification, machine learning, image processing, Tensor Flow Lite*

## I INTRODUCTION

There are many types of toothbrushes in the market with different qualities, designs & standards but all those toothbrush models are not suitable for everyone according to their dental structure and age. So, the populace does not know what kind of toothbrush they need. Toothbrush Standard Monitoring App gives a solution for that issue by suggesting suitable toothbrushes according to user’s dental structure and user input data when registering to the app. Many do not have an idea when they should replace their toothbrush. For the record, an average person should replace their toothbrush every three-four months, but in most cases, it does not valid and it depends on user’s habits and toothbrush condition. (Ganss et al., 2009) So, Toothbrush Standard Monitoring App has a solution for that issue too. App is capable of scanning user’s toothbrush several times between three to four months and predict the average time period that user need to replace toothbrush or user can directly check whether existing toothbrush is suitable for use or should replace by scanning it. (Leeuwen et al., 2019)



Figure 1 – Different bristle conditions  
Source - Wiley Online Library

Another issue is the population does not know whether the current toothbrush is suitable for their dental structure and age group. Toothbrush Standard Monitoring App is the solution for that. App gives the users an option to scan their toothbrush for check that it is suitable for the user. (Solanki, 2011)

Above mention issues are mainly affecting human's dental health and Toothbrush Standard Monitoring App is a better solution for those issues.

The mobile app uses mobile phone's inbuilt camera as an input media to the system for scanning toothbrushes. Machine learning and Image processing technologies are used to identify the scanned toothbrush and predict the time period for replace toothbrush. TensorFlow Lite is a machine learning platform that uses on android devices. This platform is used for developing machine learning and image processing features on the application. Android studio, java programming language and firebase are used to develop the application UI, backend and database.

Toothbrush Standard Monitoring System's main aim is to improve dental health of our society.

## II. RELATED WORKS

introduced many new products and technologies. Hence machine learning and image processing concepts are emerging concepts now a days. "An Approach for Object Detection in Android Device" by Savitha G, Venugopal P S, Dr. Sarojadevi and Dr. Niranjana Chiplunkar paper presents about object detection on android devices. For object detection, morphological opening and closing filters are used in sequence. For the drawing contours of the detected objects, contour-based learning techniques are implemented. Objects are extracted in the process and stored for further analysis in an array. All these algorithms are implemented using OpenCV functions. (Savitha et al., 2014)

Rattapoom Waranusast, Pongsakorn Intayod, Donlaya Makhod researches about using image processing and machine learning on android devices for Egg Size Classification. Chicken eggs, used as an ingredient in almost every food culture worldwide, are a popular ingredient in human food. In many food recipes, judging the size, and therefore weight, of an egg is often important. Authors develop a mobile application

for classify egg's size using an image displayed on an android device. They used a known size coin as reference object. Radius of the coin and eggs dimension are automatically detected and calculated by image processing algorithms. Egg sizes are categorized using a support vector machine (SVM) classifier based on their characteristics computed from the calculated measurements. The experimental results show that the measurement errors were low at 3.1% in egg measurements and the overall size classification accuracy was 80.4%. (Waranusast, Intayod and Makhod, 2016)

"Lightweight Mobile Object Recognition" paper presents Client-server framework where many methods of image restoration and approaches to image segmentation can be checked with the help of a network connected Android device as the most stable lightweight descriptor found in tests, a modified version of the CEDD (Color and Edge Directive Descriptor) and manual or salience-based object selection is also included. With the updated descriptor and distinct object segmentation, the main purpose of the research is to illustrate the possibilities of lightweight object recognition. (Czuni et al., 2014)

Andres Campoverde and Gabriel Barros presented "Detection and Classification of Urban Actors Through TensorFlow with an Android Device". They had developed a mobile app for identify urban actors using TensorFlow Lite and TensorFlow mobile models. The authors confirm advances in artificial intelligence because it is now possible to use Neural Networks for detection and classification within a device with limited hardware. Here the performance of Deep Neural Networks is compared (DNN). Their default model is a Single Shot Detector (SSD), which has been retrained, and the frameworks are TensorFlow mobile and TensorFlow light, respectively. The default model has 80 different object classes, while their re-trained model has only 6 different classes based on urban actors (car, bus, truck, bicycle, motorcycle, person). Their main purpose is to use an Android cell phone to create an object tracker for urban transportation. (Campoverde and Barros, 2020)

Ankita Saxena, Deepak Kumar Jain and Ananya Singhal worked on a hand gesture recognition application that uses android mobile platform.

The key features used are the hand centroid, the presence of the thumb and the number of peaks in the gesture of the hand. The algorithm is based on shape-based characteristics, taking into consideration that, except in some cases, the shape of the human hand is the same for all human beings. Artificial neural network among back propagation algorithms is the recognition approach used in this paper. This methodology can be very easily adapted to a real-time framework. Frames are sent to the server and edge detection of the video is performed after image were captured using android device inbuilt camera. Statistical analysis or artificial intelligence techniques are used to interpret these gestures. (Saxena, Jain and Singhal, 2014)

Sapan Thakker and Prof. Harsh Kapadia presents “Innovative approach towards design, developing, and implementation of image processing-based application using embedded vision platform”. The image processing-based algorithm can be implemented on Android devices by using the OpenCV library. It is possible to build OpenCV with an Android embedded vision-based system, which can be replaced by a machine vision-based system. The embedded vision device based on Android reduces the system size and also offers a cost-effective solution for industries. Basic operations such as color transformations, edge detection, morphological operation etc. are carried out by the android application introduced in this paper. (Thakker and Kapadia, 2015)

“Android-Based Object Recognition for the Visually Impaired” paper presents about an Android-based object detection application that developed to help the blind better understand their surroundings. This application is based on the extraction of the local characteristics of the object of interest, which are then compared to the corresponding characteristics of the objects saved in the previously generated knowledge base. Using image processing technology, local characteristics are checked against more than one method of classification and the findings are analyzed. This system is evaluated using a dataset specially developed for this purpose when the application is deployed on an android device. The dataset used includes over 600 images of twelve objects under different

distortions and shifts in viewing conditions. (Saeed, Salem and Khamis, 2013)

Seyed Mohammad Alizadeh and Ali Mahloojifar present how to identify skin cancer named Melanoma early, using image processing technology. The authors proposed an application for early detection of melanoma using Android Studio applications, Java programming language, and OpenCV library image processing methods and pattern recognition algorithms. The Android smartphone was used to perform all the detection measures. A computer was also used for better performance in the classification stage, in addition to the smartphone. This software is user-friendly and, on average, the measured precision, sensitivity and specificity are 95%, 98% and 92.19%. (Alizadeh and Mahloojifar, 2018)

DONG Ranran and others present an image matting system that uses the Android platform. Digital Image Matting refers to cutting out the part of a natural digital image that you are interested in while retaining the full edges. The aim of this paper is to add a convenient type of human-computer interaction and high process speed to the design and implementation of an Android image matting application. Second, on the basis of the Android graphics API and Android touch API, we get the user's interactive inputs. Then, to process images, we use a new matting algorithm based on the improved Grab-cut and targeted Filter. If the consumer is not pleased with the matting result, some scribbles may be applied as additional constraints to the result. Then, the matting result will again be processed by the matting algorithm suggested. Image segmentation technology is used in this application for cut the image that user is interested. (Dong et al., 2015)

“The aim in this paper is to utilize the advancement in mobile technologies to foster knowledge on plant species around us.” In this paper it is proposed to create an application to classify plant species on android operating system. To detect the edges of the leaf from a plain white background, we use contour-based edge detection, and centroid classification is also done. The feature vector obtained should be independent of any contour scaling, rotation or translation. In the past, Fourier descriptor was

commonly used by these types of applications to compare object shapes and object textures, now we use Maximally Stable External Regions (MSER) detector and FD's represent the external shape. (Deepak and Vinoth, 2014)

Kanghun Jeong and Hyeonjoon Moon worked object detection on smartphone platforms. They suggested a method for real-time object recognition in smartphone environments. The proposed framework for object recognition consists of two main modules: extraction of features and recognition of objects. Feature detectors such as Scale Invariant Feature Transform (SIFT) and Speeded Up Robust Feature (SURF) are good techniques that deliver high-quality functionality, but they are too computationally intensive for any complexity to use in real-time applications. Smartphone platforms have limited resources relative to PC platforms, so computation-intensive SIFT and SURF descriptors in such resource-limited environments are less available. The FAST corner detector is utilized in this paper, which provides faster feature computation by extracting only corner information. The number of corners identified by the FAST corner detector varies, so to change the extracted corners to the same number, normalization is applied. Training for the efficient recognition of objects is carried out on the basis of normalized corner information, support vector machine (SVM) and back propagation neural network (BPNN). The suggested object recognition method based on the FAST corner detector yields increased speed and low performance degradation on smartphones compared to traditional SIFT and SURF algorithms. (Jeong and Moon, 2011)

Akhmad Qashlim and others researched about image segmentation using OpenCV Library. This research describes the use of mobile technologies to help fisheries. Specifically, authors developed an Android application that uses an internet-connected camera to detect and then convert RGB image artifacts to HSV and gray scale. The digital tool that provides fish detection results in the form of length, width, and weight used to decide the price of fish will be addressed in this paper using Android-based mobile technology using image processing methods. This application was developed to generate binary images using features provided by the

OpenCV library. To build the user interface, the contour-active method was used to divide and separate image objects from the context, while the clever edge method was used to enhance the outline appearance of objects, three key challenges highlighted during application design, including C++ QT. On the Android platform, both approaches are introduced and use mobile cameras as an identification tool. (Qashlim et al., 2020)

### III METHODOLOGY

Toothcare app is an all-new app for mainly identifying toothbrush condition. Also, the app consists of another two main features. Suggest a suitable toothbrush for users and notify the time period that user has to change their existing toothbrush. The app is developed using android studio and it's compatible with android API level 25 and above.

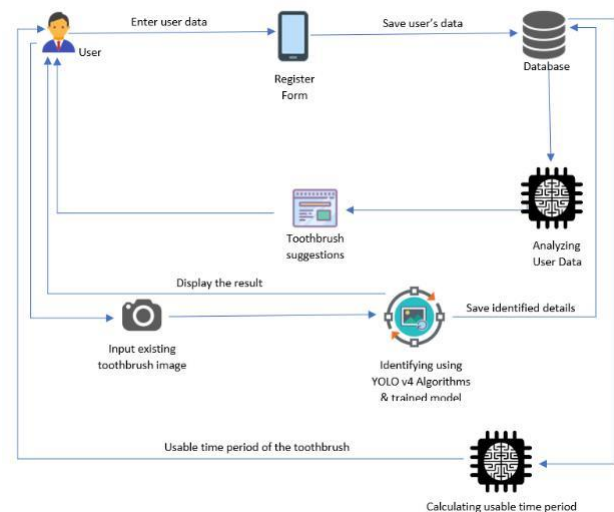


Figure 2 – Application Work Flow

Source – Toothcare Documentation

Firestore is used as the database and Python and TensorFlow are used for model development. Figure 2 depicts the basic process of toothbrush quality identifying app.

#### A. Toothcare App



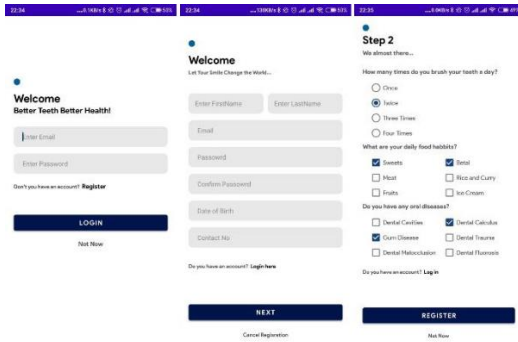


Figure 3 – Login and Registration Interfaces

Source – Toothcare App

Here in figure 3 presents login and registration interfaces. User needs his email and password to login to this app. In the registration process user needs to enter some private data and these data are used for the functionality of this app.



Figure 4 - Home Screen Interface

Source – Toothcare App

In the home screen we can access to the main features of the app and also, we can access profile details, notifications and settings. The app gives ability to edit user data and upload a profile picture for the user account. And in the settings section user have permission to on or off notifications that we generate to notify the user about time period that user need to replace the toothbrush. In the notification section the app displays all the past and current notifications.

In the home screen three main features are displayed. When the user opens “Explore Toothbrushes” it displays the suitable toothbrushes for the user. The other button is “Scan

Your Toothbrush” here user have two options “New Toothbrush” and “Previously Scanned Toothbrush”. user have to select whether it’s a previously scanned toothbrush through the app or a new toothbrush that needs to scan for the first time. The third button in the home screen is “Toothbrush Usage” from here user can view all their previous usage data, how much time they used previous toothbrushes and how much time they scanned those toothbrushes.

## B. Identify Toothbrush Condition

The main feature is identifying the quality and condition of the toothbrush. Image processing model is used for identifying the toothbrush condition and quality. The model is developed using image classification technique. Here we use TensorFlow, keras, cv2, NumPy, matplotlib and pickle libraries for develop this model. We use grayscale images to train our model because the colour of the toothbrush doesn’t need for identify the quality and condition and we can reduce the processing power by not using colour images. We classify the input image into two classes, suitable for use and not suitable for use. To train this model we used a dataset that includes 900 images, 450 images for each class. We are using Convolutional Neural Network algorithm to train the model. It uses 2D convolutional layers to process the images. To train this model we used 25 epochs, 32 images for a batch and validation split as 0.1. The model accuracy was 83.48%.

The input image classified through the model and outputs the result if the toothbrush is usable or not. After deciding the toothbrush is usable or not these usable or not usable percentage is saved in the database with the date. These saved data will be used for predicting the toothbrush usable time period. Anaconda Navigator was used to access and manage libraries and Jupyter Notebook was used as the model development IDE.

## C. Suggesting Suitable Toothbrushes

Another feature is suggesting suitable toothbrushes for the user. When registering to the app we are requesting some personal data from the user. Age, Food habits, Frequency of brushing teeth for a day and previous dental diseases are the data we request. By using these data, we categorize users into four categories.

Age, food habits, previous dental diseases are the main parameters considered when categorizing users. According to these categorise we suggest users what toothbrush is most suitable for them, whether it's a kid's toothbrush, adult soft, medium or hard toothbrush.

#### D. Notifying the User

Another main feature is notifying the user when the existing toothbrush needs to replace. For this feature we used existing toothbrush's usable time period and brushing frequency for a day as parameters. From these parameters we categorize users into several time periods starting from

three weeks to three months. We save each and every toothbrush's scan date and current toothbrush quality percentage for calculate usable time period of a toothbrush. Then we can use previous toothbrush usable time periods for predict more accurate date.

This notification procedure has 2 stages. First stage is notifying user to buy a new toothbrush when the existing toothbrush can only use 7 more days. Second stage is to notify user to replace the damaged toothbrush that is not suitable to use. This notification will occur until user scan the new toothbrush using Toothcare app.

### IV. RESULT & DISCUSSION

Toothcare is a toothbrush quality identifying app that uses machine learning and image processing libraries and algorithms for identifying toothbrush quality and condition. Here we use a TensorFlow Lite CNN model that uses TensorFlow, Keras, cv2, NumPy, matplotlib and pickle libraries. We use a manually created dataset that includes 900 images, 450 each two classes. When training the model, we ran 25 epochs including 32 images for a batch and validation split as 0.1. Finally, the model reaches 83.48%. of accuracy.

We tested the model accuracy manually by identifying whether the toothbrush is usable or not with the help of dental doctors and by scanning the toothbrush through the app. From

this testing procedure we got 84% of overall accuracy by testing 50 toothbrushes.

To test the user experience and feedback, the app was presented for some users randomly to conduct the testing process. Also, a questionnaires were provided to these participants to get the feedback of the app whether it needs to improve features or satisfying users. Testers were briefed about the functionality of the app after that tester start to test all the features that include in Toothcare. According to testers' feedback the features are all useful features. And the app UI also attractive and simple. The simplicity of UI is a must when we considering the userbase of the app. Toothcare has no age limit from child to older persons should have ability to use the app. That requirement was successfully achieved in Toothcare. And according to the questionnaire most of the testers don't have an idea when to change their existing toothbrush and what is the most suitable toothbrush for them. Not knowing these can cause serious oral diseases. Toothcare provide the solution for those too. And another problem that testers had was forgetting to replace their existing toothbrush because most of them forgot to buy a new toothbrush and some forgot to replace it.

The notification feature was useful when considering above problem. We remind users to buy a new toothbrush and replace it when existing one is not suitable for use. And users can view their previous usage history through the app. It also a useful feature for uses who wish to trach their toothbrush usage and app usage.

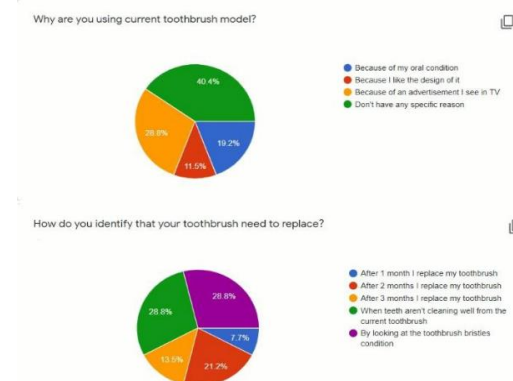


Figure 5 Survey Results  
Source – Google Form

Through this testing procedure it confirms that the Toothcare app is a useful app for every human being who use a toothbrush and it is easy to use because of simple UI design.

## V. CONCLUSION AND FURTHER WORKS

This app can be used by all the humans who brush their teeth. There are no age limits for using this app. A human starts to brush teeth when 6 months old. So, parents can make a profile for their children and monitor their toothbrush condition through Toothcare. Users only have to scan toothbrush that they use and Toothcare will decide whether it's usable or not and when should user change the existing toothbrush.

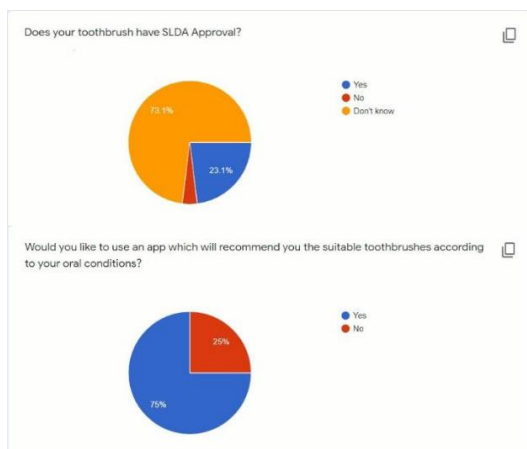


Figure 6 – Survey Results  
Source – Google Form

According to the survey done by using 150 participants 73% don't know whether their toothbrush is under SLDA standards. 80% don't have a specific reason about why they use current toothbrush model. 71% don't have an idea when they should change their current toothbrush. Further, 75% like to use a app that can manage their toothbrush usage and recommend them suitable toothbrushes. According to these survey data we can conclude that Toothcare will be a useful app for society to maintain their oral health and prevent from oral diseases that cause by using damaged toothbrushes.

Further this app will be developed for iOS & Huawei platforms too. Also, Toothcare will introduce for toothbrush manufacturing companies for advertise the advantages of brushing teeth properly and manufactures can also introduce & educate about their

toothbrushes through Toothcare. Also, in the future we are planning to improve Toothcare as an online store where users can purchase products related to oral care.

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# Air Quality Prediction Using Machine Learning

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**Abstract** - The main basis of human survival is Air. The Air Quality Index is the value that qualitatively describes the condition of air quality. The greater the Air Quality Index, the more threatening risk to human health and environment. In Sri Lanka, poor air quality is a huge concern, especially in cities like Colombo and Kandy. Accurate Air Quality prediction will minimize health issues that can occur due to air pollution. This research has attempted to identify the best-suited machine learning algorithm-based approach to predict accurate air quality based on PM2.5 concentration in Colombo. In order to identify the most influenced air pollution concentrations for the air quality prediction purpose, correlation analysis was conducted. In this research, PM2.5 was predicted in Colombo city using 4 related air pollution concentrations including SO<sub>2</sub> concentration, NO<sub>2</sub> concentration, PM2.5 concentration & PM10 concentration. In order to get higher prediction accuracy, the gathered dataset was pre-processed by prediction beforehand. The prediction model trained and tested using machine learning algorithms such as KNN, Multiple Linear Regression, Support Vector Machines, and Random Forest. Multiple Regression was identified as the most suited prediction model which was able to gain 94% higher accuracy.

**Keywords:** *air quality, concentration, correlations, machine learning, pollution*

## I. INTRODUCTION

Air Quality is a massive luxury to have & unfortunately most people who live on the earth won't have that luxury. According to the World Health Organization, most people live in poor air quality areas. In recent years, Colombo air quality getting poor & poor year-wise. Most times in rush hours Colombo air quality exceeds level four

category of the air quality index. Unfortunately, most people who live in the Colombo area don't aware about what is the air quality around them (Mahanta et al., 2019).

In this Research paper, we explore predicting air quality using algorithms of machine learning. Machine learning algorithms are implemented & evaluated for accuracy. The research presented to improve air quality index prediction methods & air quality knowledge in Colombo. The air quality index value in Colombo is average at an unhealthy level, especially in rush hours. With reliable predictions of air quality index levels, people can get precautionary measures, such as minimizing outdoor activities, to minimize the consequences of air pollution. This introduction chapter provides an overview of the air quality index & the motivation for this project, followed by background details about air quality in Colombo & the research goal (Castelli et al., 2020). The availability of clean air to breathe has been of very importance & luxury to have. As air is important for all the living beings on the planet, it is human responsibility to protect the air quality. Industrialization & the increase of vehicles has led the earth into air pollution & an environmental curse. Air pollution basically refers to the high contamination of the air by large quantities of very harmful chemicals, gas & dust substances. Mostly air pollution occurs due to the use of energy & emissions from production, where emissions from vehicles & industries are main contributors to the cause. Air pollution is a threat to human survival due to the impact on human health & the environment. Mostly Urban cities like Colombo normally have the worst air pollution compared to the rural areas due to large human actions within a small area of land. Clear correlations between ambient air pollution & effects on human health have been



identified, which includes both long-term & short-term effects on human health issues as well as their living environment. Increase in heart diseases & reduced lung functioning, direct impact on public with asthma & many other types of pneumonia & once air inhaled, the particular matters like PM<sub>2.5</sub> & PM<sub>10</sub> may very hard to be self-purified by the human immune system (Zhong, Yu and Zhu, 2019).

Air pollution can be considered as one of the most critical factors that affect human survival. Every year air pollution is responsible for millions of deaths worldwide. Not only for human health but also for the environment, air pollution brings negative effects including acid rain, global warming, etc. According to many public perception studies, the main problem is the lack of awareness about the air pollution causes & effects. Therefore, with the increase of air pollution, it has become an important endeavor to predict & aware the people about the effect of air pollution levels on human health & the environment (Nandasena, Wickremasinghe and Sathiakumar, 2010). Predicting the air quality index can avoid the worst effects on human health issues & the environment. Find out the best way to predict air quality index from using various techniques and methods, training the data set to get the most accurate prediction necessary to the success of this research. The main basis of human survival is Air. The air quality index or short firmly AQI is the value that describes qualitatively the condition of air quality. The greater the air quality index the more threatening risk to human health & the environment. The key factors that mainly cause the AQI are NO<sub>2</sub>, SO<sub>2</sub>, O<sub>3</sub>, CO, PM<sub>2.5</sub>, & PM<sub>10</sub>. In this research, a past air pollution concentration dataset has gathered from the Central Environment Authority which consists of hourly concentrations of different air pollution parameters & weather parameters such as Solar Radiation, Relative Humidity, Average Temperature, Wind direction, Wind speed, O<sub>3</sub>, CO, NO<sub>2</sub>, SO<sub>2</sub>, PM<sub>2.5</sub> & PM<sub>10</sub>. A number of data preprocessing methods have used to ensure the accuracy of the predicted outcome. A Cross-Validation has done for the preprocessed dataset, by partitioning the data set as 80% for model training & 20% for testing. Several machine learning algorithms have been used as a

prediction model such as Multiple Linear Regression, Support Vector Machine, K Nearest Neighbors & Random Forest. Based on the accuracy & performance, the most suitable model for air quality prediction is identified.

This research paper is ordered as follows. The second part consists of the Literature Review for this research. The methodology used in this research & Results has been identified as demonstrating in the third & fourth parts respectively. Finally, the last part consists of the conclusion of this research.

## II. LITERATURE REVIEW

There are many air quality index predicting systems available. Few of those provide a common indication of human health diseases according to the level of PM<sub>2.5</sub> particles in the air. With the lack of an exact framework within the area of research air quality index prediction, with various problem identifications, locations, & datasets in the research studies, a literature review is conducted to identify an overview of the air quality literature. The research area varies in different techniques & methods, but also, the available datasets are more often different due to the traffic, climate, & environment of the selected geographical area together with the selected air pollutants to predict. For some cities, the poor air quality due to mainly PM-related air pollutants causes, while in other cities the poor air quality might mainly come from NO<sub>x</sub>, SO<sub>x</sub>, or CO<sub>x</sub>. Because of these limitations, the literature review is an attempt to get a good understanding of the research scope & find relevant research that doing the same task as in this research. This chapter defines a set of the latest relevant air quality studies for this thesis. Here is a review about exiting air quality index predicting systems. Which method is more suitable to predict air pollution is also an important factor. The deep learning method for air quality prediction is one approach most commonly used in existing systems (Xayasouk and Lee, 2018). As an example, Korean air pollution prediction systems use the Stacked Autoencoders prediction model for training & learning datasets. The predicted output shows the overall performance of the air quality prediction using Machine Learning algorithms. Machine learning approach is the most popular technique when

predicting the air pollution. Machine learning techniques able to train a model using big data and algorithms (Iskandaryan, Ramos and Trilles, 2020). Data trained by using regression models and regularizations like nuclear norm regularization and standard Frobenius regularization. One of the experiments had already shown that consecutive regularization and parameter formulation achieve far better performance than existing regularizations and standard regression models. Another technique that can be used to predict air pollution is using a neural network. Accurate predictions of Air quality index is possible with the simple neural network and further modifications of the model achievable using different experimental setups and different input parameters (Sampath, 2019).

Another research paper, machine learning prediction model for AQ prediction for urban cities. In this paper, the Author mentions Air pollution vastly remains a huge challenge for people & governments all around the globe. Air pollution can cause noticeable effects to human health as well as on the environment resulting in global warming, acid rain, skin cancer, and heart problems to the public. This research study addresses the issues of predicting Air Quality, with the focus to minimize air pollution in cities before air pollution gets impacts human health and the environment, using two Machine Learning algorithms, SVM, & Neural Networks(NN). The Machine Learning (ML) model is supposed to predict the AQI. Predicted results will show an increase in the Air Quality prediction outcomes accuracy & recommend that the machine learning approach can be suitable in predicting other city's air quality as well (Bellinger, 2017). This research paper proposed a system using a Machine Learning approach for AQI prediction for big cities. The machine learning model is evaluated with the New Delhi Air pollution data mainly due to the fact that poorness of New Delhi's air quality. Using the Support Vector Machines and Neural Networks, Air Quality Index is predicted accurately by using two machine learning models with 91.62% higher accuracy for the Neural Networks model & 97.3% accuracy for the SVM model. Six of the SVM algorithm functions were identified to predict Air Quality Index accuracy, & finally, it was identified that the "Gaussian Support Vector

Machines" gives the highest accuracy value of 97.3%(Mahalingam et al., 2019).

According to the research work of Timothy & Dela Cruz for predicting the Air Quality Index requires decisive & perfect readings & more complex calculations, therefore it is not recommended portable predicting devices. The main aim of the research is to identify another way of characterizing & monitoring to obtain solutions to minimize the effects of poor air quality. Five predictive machine learning models have developed, K-nearest neighbors, support vector machine, random forest, neural network, and Naïve Bayesian classifier. Results of the paper clearly mention that the research team obtains accuracies of 97.78%, 98.67%, 94.22%, 99.56%, and 98.67% for the five machine learning models respectively, clearly having the model of a neural network(NN) be the perfect accuracy model (Amado and Dela Cruz, 2018)

Table 1. Summary of the Literature Review

Author	Application	Technique	Remark
Sara Silva & others	Air quality prediction for smart cities	•Support vector regression	•Predict PM 2.5 levels variability. •Model is suitable for predict hourly air pollution. •Obtain an accuracy of 94.1%
Usha Mahalingam & others	Air Quality prediction	•Neural Networks •Support vector machine	•Accuracy of 91.62% for neural network •Accuracy of 97.3% for support vector machine
Min Lee & others	Air pollution prediction	•Deep Learning	•predict against PM 2.5, PM 10 particulars. •Accuracy based on PM 10 is very low. •Accuracy based on PM 2.5 is very high.
Timothy M.	Air quality	• Naive Bayesian	•Highest accuracy was obtained

Amado & others	monitoring models development	classifier • KNN • SVM • Neural network • Random forest	through Neural Networks. • Sometimes Neural Networks leads to slower responses.
Chen Zhao & others	Air Quality Index Prediction	• Linear regression	• Prediction based on one-year data of PM10, PM2.5, etc. • There is a deviation between predicted results and actual data.
Esmail Ahmadi	Air pollution prediction	• Data Mining • Decision Tree	• Used Clementine software for data clustering. • Data sample include climate data of 53 years
Niraj Tailor & others	Predict Air Quality in Urban cities Using Regression techniques for analysis	• Linear regression • Neural Networks • Lasso regression • Elastic Net regression • Ridge regression • Extra Trees • XGBoost • Decision Forest • Boosted tree • KNN	• 84.68% accuracy for Linear regression • 82.52% accuracy for Neural networks • 84.77% accuracy for Lasso regression • 84.772% accuracy for ElasticNet • 84.89% accuracy for Decision Forest • 85.31% accuracy for Extra Trees • 83.89% accuracy for Boosted Tree • 84.56% accuracy for XGBoost • 69.48% accuracy for KNN • 84.68% accuracy for Ridge regression

			• Prediction based on Weather & AQI datasets.
Colin Bellinger & others	A systematic review of Machine Learning & data mining for Air Pollution	• Machine Learning Algorithms • Data Mining • Big Data	• Refer 400 research papers & reduce to 47 after the inclusion/exclusion criteria's • Divided papers into 3 categories • End of the survey that highest accuracy levels always obtain in Machine Learning Algorithms.

According to the literature review, a few drawbacks exist in the available air quality prediction approaches, such as the problems that can occur when collecting datasets. Inaccuracy & amount of null values have affected the predicted output low accuracies of the existing air quality prediction systems in Sri Lanka. Another factor that affects accuracy reductions in the data preprocessing. Considering all these factors, most of the existing systems in Sri Lanka have been failed to obtain a correct prediction. Considering these problems with foreign countries they are able to achieve these drawbacks & gain high accuracies. Also, air quality prediction systems based on machine learning have faced the issue of selecting the most suitable algorithm. Most used machine learning algorithms are not the appropriate algorithms for the target research area.

### III. METHODOLOGY

The proposed structure of predicting the air quality index includes sequence of steps. Those sequence of steps include Gather data, preprocess the dataset, analysis the dataset, use suitable machine learning algorithms & finally find out the best suitable machine learning algorithm & analyze the result.

#### A. Data Gathering & Pre-processing

In Data Gathering & Pre-processing phase for the first part, past dataset of air pollution parameters hourly concentration data in Colombo is gathered from Central Environment Authority & National Building research organization. Dataset Consists of hourly concentration of air pollution parameters like PM2.5, PM10, NO2, SO2, CO & humidity from 2019 January to 2021 February. To get higher accuracy & ensure the quality of the predicted values, the gathered dataset is pre-processed using preprocess technique.

#### B. Data Analysis

In order to find out the correlations between air pollution parameters & identify the distribution of the dataset & identify the nature of the dataset correlation matrices & distribution graphs are used. For the data analysis R studio IDE is used. Using correlation matrices & distribution graphs can be used to identify the most affectable parameter for PM2.5.

#### C. Testing

Under the cross validation technique, the Train Test Split method is the most common method which is used for the already pre-process data, by splitting dataset into two sets as 80% for training the prediction model & 20% for the testing the predicted results.

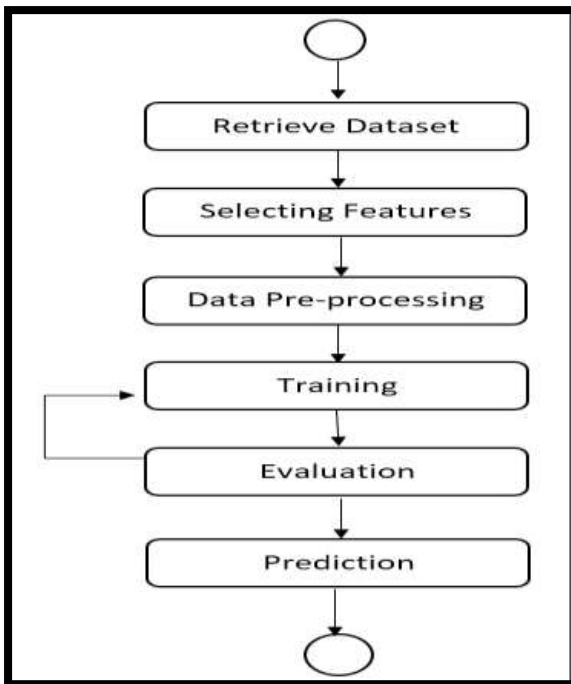


Figure 1. Overall Architecture

#### D. Training Model

- Multiple Linear Regression
- K Nearest Neighbors
- Random Forest
- Support Vector Machine

Machine Learning algorithms are used to train the dataset. For each of these cases default parameters are used. For the implementation, python based scikit learn, Pandas libraries are used & pycharm IDE also used.

#### E. Model Evaluation

After finishing the model training phase, model is used to predict PM2.5 value based on pre-processed dataset. Based on the accuracy most suitable machine learning algorithm is selected.

### IV. RESULTS

In this research study, the gathered dataset includes nearly 15000 data records & 12 Air pollution concentrations & weather attributes, such as Solar Radiation, Relative Humidity, Average Temperature, Wind direction, Wind speed, O3, CO, NO2, SO2, PM2.5 & PM10. According to the Figure 2 correlation matrix chart, the correlation matrix has computed using through R, between PM2.5 & PM10 have the highest correlation among than each & other. According to the correlation matrix PM10, SO2, NO2 & CO has the highest correlation with the PM2.5 with compared to other air pollution & weather attributes. Therefore, to train the prediction model we considered PM2.5, PM10, NO2, SO2 & CO parameters.

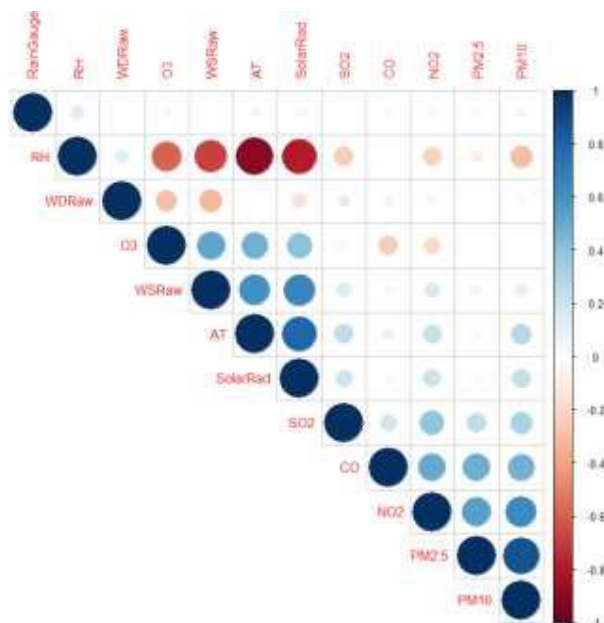


Figure 2. Correlogram

Out of all those Air pollution concentrations & weather parameters, four air pollution parameters were selected from the gathered dataset after a complete correlation analysis. They are NO2 concentration, SO2 concentration, PM2.5 concentration & PM10 concentration.

	AT	RH	SolarRad	RainGauge	WSRaw	WDRaw	O3	CO	NO2	SO2	PM2.5	PM10
AT	1.00	-0.90	0.79	-0.07	0.60	0.01	0.48	0.08	0.22	0.25	0.06	0.27
RH	-0.90	1.00	-0.79	0.12	-0.68	0.13	-0.59	-0.01	-0.23	-0.24	-0.10	-0.31
SolarRad	0.79	-0.79	1.00	-0.05	0.66	0.15	0.40	0.03	0.21	0.19	0.05	0.23
RainGauge	-0.07	0.12	-0.05	1.00	-0.01	0.02	-0.04	0.04	0.05	0.00	-0.05	-0.07
WSRaw	0.60	-0.68	0.66	-0.01	1.00	-0.33	0.52	-0.05	0.16	0.14	-0.07	0.10
WDRaw	0.01	0.13	-0.15	0.02	-0.33	1.00	-0.30	0.07	0.07	0.10	0.02	0.05
O3	0.48	-0.59	0.40	-0.04	0.52	-0.30	1.00	-0.24	-0.19	-0.03	0.01	0.01
CO	0.08	-0.01	0.03	0.04	-0.05	0.07	-0.24	1.00	0.50	0.19	0.48	0.48
NO2	0.22	-0.23	0.21	0.05	0.16	0.07	-0.19	0.50	1.00	0.40	0.54	0.63
SO2	0.25	-0.24	0.19	0.00	0.14	0.10	-0.03	0.19	0.40	1.00	0.24	0.32
PM2.5	0.04	-0.10	0.05	-0.05	-0.07	0.02	0.01	0.48	0.54	0.24	1.00	0.86
PM10	0.27	-0.31	0.23	-0.07	0.10	0.05	0.01	0.48	0.63	0.32	0.86	1.00

Figure 3. Correlation Matrix Char

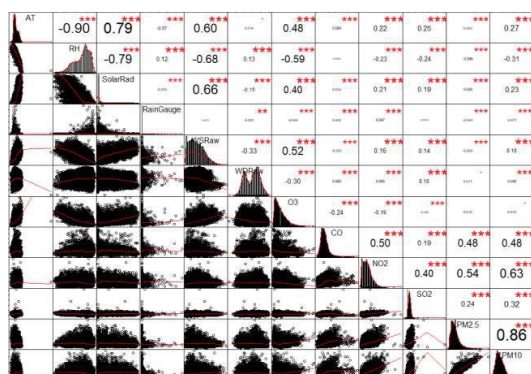


Figure 4. Correlation Matrix

As represented in Figure 3 and Figure 4, correlations between PM2.5 & some weather & air pollution concentration parameters are weak other than PM10, NO2, SO2 & CO. To get a higher correlation value, computed the correlations among PM2.5 & multiple air pollution concentration as represented in Figure 5. The

correlation among PM2.5 & the combination of PM10, CO, NO2, SO2 is 0.8644 which is an excellent value.

Table 2. Summary of Multiple Correlation

	PM2.5
PM10 + NO2	0.8635649
PM10 + NO2 + CO	0.8623043
PM10 + NO2 + CO + SO2	0.8644263
PM10 + NO2 + SO2	0.8642185

### A. Multiple Regression

	precision	recall	f1-score	support
0.0	0.20	0.02	0.03	53
1.0	0.96	0.98	0.97	3377
2.0	0.62	0.59	0.60	210
3.0	1.00	0.13	0.24	15
accuracy			0.94	3655
macro avg	0.69	0.43	0.46	3655
weighted avg	0.93	0.94	0.93	3655

Figure 5. Linear Regression Classification

According to the represented matrix in Figure 6 & the classification chart in figure x, the predicted accuracy of the output is 94% which is a great accuracy. The predicted accuracy of the regression model is always influenced by the nature of the gathered dataset, for this dataset & prediction process multiple regression is suited nicely.

### B. Support Vector Machines

	precision	recall	f1-score	support
accuracy			0.30	3655
macro avg	0.03	0.03	0.02	3655
weighted avg	0.14	0.30	0.17	3655

Figure 6. SVM Classification

As represented in the classification chart in Figure 7 the Support Vector Machine model has achieved 30% accuracy. This SVM model has got a very low accuracy when compared with the regression model. The reason behind achieving much low accuracy is Support Vector Machines handle inputs with polynomial features, for this prediction work SVM might not be suited.

### C. Random Forest



	precision	recall	f1-score	support
accuracy			0.31	3655
macro avg	0.07	0.07	0.07	3655
weighted avg	0.27	0.31	0.28	3655

Figure 7. Random Forest Classification

Random Forest algorithm was also considered for this approach. Random Forest supervised learning algorithm can be used as both classification problems and regression problems as well as Random Forest is not difficult in calculating the relative importance of every feature that consists of the prediction. As represented in the report in Figure 8. Random Forest model has achieved 31% accuracy. This 31% accuracy is also very low when compared with the Multiple Regression model accuracy.

#### D.KNN

	precision	recall	f1-score	support
accuracy			0.30	3655
macro avg	0.05	0.04	0.04	3655
weighted avg	0.23	0.30	0.26	3655

Figure 8. KNN Classification

KNN is another model which has used to predict air quality index in many research studies. As represented in the report in Figure 9, the KNN prediction model has achieved 30% accuracy when  $k=5$ . Since some air pollution parameters are very weak, it is very difficult to gain a higher accuracy from this prediction model.

## V. DISCUSSION

In this research, we have achieved 30% accuracy for KNN & SVM models, 31% accuracy in Random Forest & 94% accuracy for the Regression model. According to Table1, many existing foreign studies obtain higher accuracies in using KNN, SVM & Random Forest algorithms. The main reason that has affected to the low accuracies obtained by these three machine learning algorithms is the incompleteness of training dataset. Missing values and noisy features that exist with the dataset affect the accuracy of the results. Different data pre-processing techniques have been followed in order to increase the quality of the training dataset.

Since the Multiple Regression model gives the highest

overall best accuracy compared to the SVM, Random Forest & KNN models, the Multiple Regression model can be identified as the best-suited model for this prediction process.

Table 3. Summary table of the Model Evaluation

Model	Accuracy
Multiple Regression	94%
Support Vector Machines	30%
Random Forest	31%
KNN	30%

## VI. CONCLUSION

The main basis of human survival depends on Air. The air quality index or short firmly AQI is the value that describes qualitatively the condition of air quality. The greater the air quality index the more threatening risk to human health & the environment. Air Pollution always caused by due to human actions. In Sri Lanka, poor air quality is a huge concern especially in cities like Colombo & Kandy. Accurate Air Quality prediction will minimize the health issues that can occur due to air pollution. This research has attempted to identify the best-suited machine learning algorithm-based approach to predict accurate air quality based on PM2.5 concentrations in Colombo. In order to identify the most influenced air pollution concentrations for the air quality prediction purpose. In this research, PM2.5 was predicted in Colombo city using 4 related air pollution concentrations including SO2 concentration, NO2 concentration, PM2.5 concentration & PM10 concentration. In order to get higher prediction accuracy, the gathered dataset was pre-processed by prediction beforehand. For the prediction model, cross-validated data according to 80 to 20. The prediction model trained & tested using machine learning algorithms such as KNN, Multiple Linear Regression, Support Vector Machines, & Random Forest. For the model evaluation, Multiple Regression was identified as the most suited prediction model which was able to gain 94% of higher accuracy.

## VII. FUTURE WORK

For future work, expected to gather more datasets from air quality monitoring stations in Sri Lanka & apply more suitable pre-processing

methods for the dataset. Since some machine learning models have low accuracy levels, the research team plans to build a deep learning prediction model for this approach on the prediction of air quality.

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## An Optimum Train Selection and Management Platform

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**Abstract** -Sri Lanka, as a developing country faces rapid urbanization, which leads to high mobility requirements. Due to increased traffic congestions during peak hours, people tend to select the railway system as their mode of transportation. As a considerable amount of people choose railway as their preferred platform in their daily routine, it is highly crucial to maintain an efficient and timely railway system. Unfortunately, the Sri Lankan Railway system is not known for its efficiency. As a result, considerable number of daily users of the system are affected in their daily routines. Increasing the efficiency of underlying infrastructure has been going on for decades, yet it has not been a solution for the inefficiency of the railway system itself. Hence, the only logical approach to address this issue is to introduce a common platform, which the users and Railway department can communicate, while maintaining a stand-alone system which can select optimum trains for the users. The objective of this research is to discuss the necessity of the proposed solution, ultimately providing a solution to the inefficiency of the railway system of Sri Lanka. The proposed platform will comprise of two parts; A web application for the railway department and an Android-based mobile Application for railway users. The web application will be powered by a ESP8266 and NRF-24 based hardware modules with a firebase Backend. A mobile application will gather required inputs via the hardware modules to provide users with an optimum train to travel at any given time of the day towards the required destination. System will be running using dynamic data acquired from the train stations with a dynamic train schedule. Users will have the opportunity to get notified about train delays, unavailability and breakdowns. The aim of this research is to provide a common communication platform to railway department

and public, ultimately making railway platforms more efficient.

**Keywords:** *railway transportation, Arduino, long-distance communication, public transportation, android applications*

### I. INTRODUCTION

Railway system was introduced to Sri Lanka in 19th century by British to bring the harvest from inland to the port located in Colombo. For few decades this was used as the main mode of transportation for both passengers and cargo. Introduction of road based public transportation led to drastic downfall of the railway transportation. Since then, Railway department has been trying to increase its revenue and to provide more efficient service towards the users.

Each year a considerable portion of employees, students and tourists use trains as their main transportation mode. Sri Lanka Railway department operates approximately 396 trains. This includes 67 Long distance trains, 16 Intercity trains. These trains carry around 3.72 million passengers daily ("Welcome to Sri Lanka Railways," n.d.) .As these figures depict, railway system plays a major role in the transportation sector of Sri Lanka. Increasing efficiency in such system will benefit major areas of the society.

Currently, Sri Lanka Railway system is overseen by Ministry of Transport. It is operated under three main operation regions namely, Colombo operation Region, Nawalapitiya operation region and Anuradhapura operation region. Colombo Region consists of 4 railway lines, Coastal line, Main line, Kelani valley line and Puttalam line. Among these railway lines, coastal line accommodates most of the passengers who are seeking to get to Colombo urban areas.

Due to numerous reasons trains experience delays. A Research by Vromans et al. has

introduced few measures to measure the punctuality/reliability of the trains (Vromans et al., 2006).

- Punctuality of trains at starting, ending and mid points
- Transfer punctuality
- Average train delays
- Average passenger delays
- Amount of cancelled trains

As these factors suggest punctuality is a complex measurement which has a considerable number of variables affecting it. Each variable has a considerable impact on the reliability of trains. A Delay at a transfer of trains will lead to a greater number of passengers getting in to the train, leading it to passenger delays at each station. These kinds of situations occur at a considerable rate in Sri Lanka.

According to research done by Pubudu Damsara and others focusing on the coastal railway line of Sri Lanka, it's noticeable that more than 92% of the trains are experiencing a delay during peak hours (Damsara, n.d.). A train delay at the starting station will result in a chain delay which will affect till the end of the train route. Since delay at one station will affect the arrival time of the next station. Due to this staggering number of delays observed during the peak hours of the country most of the workers and students who use railway as their mode of transportation disrupt their daily schedules. Hence people tend to use other modes of transportation to get to their destination during peak hours. This leads to unnecessary number of vehicles being pushed in to the urban areas during the peak hours, creating more congestions.

Time	Train Nos.	From/To	No. of delays (%)
5.00-5.30	8302	IDA/FOT	73%
5.30-6.00	8304	ALT/FOT	68%
6.00-6.30	8309	ALT/FOT	89%
	8309.1	ALT/FOT	94%
6.30-7.00	8311	GLE/MDA	90%
7.00-7.30	8310	PND/MDA	91%
7.30-8.00	8313	PND/FOT	96%
	8316	PND/MDA	93%
	8320	GLE/MDA	82%
	8321	GLE/MDA	83%
	8327	GLE/MDA	100%
8.00-8.30	8324	ALT/MDA	100%
	8326	KTS/FOT	100%
	8324.1	ALT/MDA	92%
	8328	PND/FOT	100%
	8325	MRT/MDA	97%
8.30-9.00	8331	MRT/MDA	95%
	8333	KTS/FOT	100%
	8334	KTS/FOT	100%
	8334.1	KTS/FOT	100%
	8330	RML/MDA	98%
9.00-9.30	8335	PND/MDA	94%
9.30-10.00	8341	MRT/MDA	98%

Figure 1: Train delays during peak hours

People who depend on the railway system is overwhelmed as most of the trains are not being arrived at stations according to schedules. This leads to peoples' daily routines being disruptive completely. Workers might be late to work, students will be late to school and numerous people might lose their appointments and schedules.

Ensuring having an efficient railway system will benefit the society in numerous ways. Starting from traffic congestions during peak hours to employees' productivity. By making sure railway system is efficient, people will be attracted to using public railways rather than their own personal vehicles. Reducing traffic congestions will benefit every sector of the society.

## II. LITERATURE REVIEW

Researchers have developed various techniques and products which can be used to monitor and track the trains. These systems are developed in a way which they communicate with a central server, providing data towards the government body. It's noticeable that systems are not developed in a user centered manner. Most of the existing systems are developed to ensure the data collected are centralized and authorities can make the necessary decisions after analyzing data collected through the systems. As a result, users of the railway system are not benefited directly, rather in an indirect manner. Systems have been deployed using a variety of technologies including Global System for Mobile Communications (GSM), Global Positioning System (GPS) and Ethernet.

This section of the study focuses on identifying existing systems and their perspectives on the problem. It can be later analyzed through the efficiency, productivity and the technologies they have used to deploy their systems. By identifying these existing systems' literature, we can dive into more insights and approaches which can be inherited or removed by comparing their performances.

### A. Existing Systems

Stated below are some of the of the systems which were researched and developed by researchers. Each system has its own pros and



cons depending on the hardware, platform and other technologies used to deploy the system.

Train tracking and monitoring system was developed by Poornima Mashesh and others. Trains are equipped with a GPS module ensuring a high accuracy and transfers GPS data towards a central system using a GSM module (Mahesh et al., n.d.). Realtime data availability makes sure that the train controller can take accurate decisions. Using positioning data with train speed, controllers can identify possible safety issues which might occur and react to them before any issue occurs within the railway and trains. Multisensory system was used to inform the monitoring system about any existence of obstacles. Obstacle monitoring system was built using infrared and ultrasonic sensors. Proposed system is aimed at building a management structure based on performance evaluation using the monitoring data. System is able to generate time-distance graphs which can be used to plan train movements. It functions as a monitoring and warning system as well. Warning system is equipped to send alerts to train drivers on possible collisions and derailments.

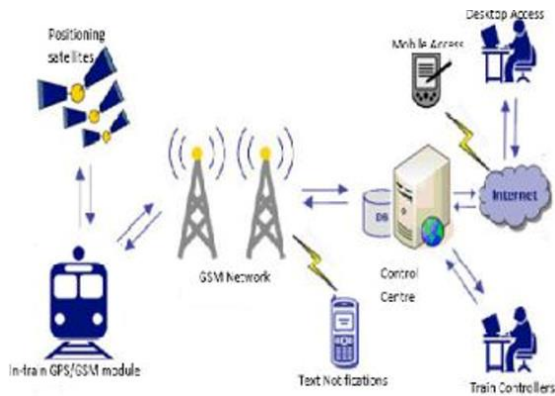


Figure 2: High Level Architecture

GPS and Ethernet based Realtime train tracking system was developed by R.Immanuel Rajkumar and others. (Rajkumar et al., 2013) System was focused on ensuring the safety of the train while alerting the driver about any shortcomings in the system. The system reports to a central controller which provides the ability to the controller to provide necessary instructions to the train driver. System communication was made available using 3 modes namely, periodic, query based and event driven. First mode periodically reads the sensor data and location

data and reports it to central command. Query driven mode is used to receive data matching a certain criteria and event driven mode is triggered when a pre-defined event is triggered by the sensors. System is comprised of 5 main components, Arduino Microcontroller, Ethernet shield, GPS Shield, Router and USB dongle and Sensors (Alcohol sensor, Force sensing resistor - FSR) . System was able to provide real-time data to a Web Interface which was deployed at the central command displaying Train position, train speed and driver health status.

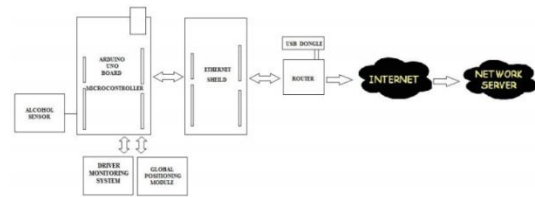


Figure 3: System Block Diagram

A Realtime train track tracking system is introduced by Shreya Mathur and others.(Mathur, n.d.) In their research they have focused on providing a solution for the existing problem of railway track maintenance. Openlayer-2 is used to implement the dynamic map of the rail tracks and to show outline and vector information from any required source. Researchers has developed a simple algorithm to find inspected tracks and uninspected tracks. In the proposed system, user will enter values towards 2km from his current location. That data is compared to values stored in a central railway database and it will notify in green if the track is inspected, otherwise in red, requiring inspection of the track. As the researchers point out, the cost of automating track identification is cost effective than the manual method of inspecting each track. Proposed system provides detailed information about tracks and it can be used for future references in upcoming developments and inspections.

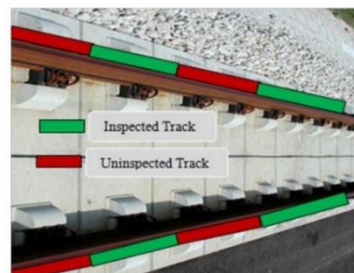


Figure 4: Representation of track slots



### III. METHODOLOGY

#### A. Data Gathering

To gather required data, interviews, questionnaires, yearly statistics and documentary reviews were used. The main purpose was to identify the correct objective and the critical drawbacks of the existing system. Finally to deliver a useful product with the sole purpose of making railway system more effective and efficient.

#### B. Data Analysis

Collected data was analyzed to identify the critical problems and requirements. For analyzing purposes, the collected data was represented through visual means such as charts. And through this it was concluded the exact requirements and critical issues which the system needs to address. This helped authors to provide required features towards the system.

#### C. Approach

Main users of this system are categorized into two parts, namely train users and administrators. Inputs to the system will be administered using the Hardware modules deployed in trains, stations and notification handling will be done by System administrators; Railway department. In order to increase the reach of the user-base android platform was selected.

#### D. Technology Adapted

Web application will be implemented using HTML, CSS, JavaScript, Firebase and Google Cloud Platform. These technologies and platforms were selected after analyzing the requirements of the system. Technologies were selected in a criteria which provides the best performance while being cost effective.

Proposed system will be consist of three parts, hardware modules, a mobile application and a web application. Development will be done locally and hosted in Google cloud platform. REST-APIs will be hosted on Heroku, a Pipeline service provider. Since communication between system modules were critical Google Push notification system was introduced to provide minimum latency to the system. High Priority messaging was used within google push notification system to ensure all notifications to

be delivered to users almost instantly (“About FCM messages,” n.d.).

#### E. Proposed Design

The proposed system comprises of hardware and software modules. The hardware of the proposed system comprises of the following components.

- ESP12-F WiFi module
- nRF24L01+ Transceiver module
- Arduino Nano

Hardware modules of the system are connected as follows. Two modules, one module equipped in the train to communicate towards the module in the station and one module equipped in train stations to receive data from the train and sync with the cloud database. The system block diagram is as follows. Web Application and the mobile application will be responding according to data received from the hardware modules deployed in the train stations. Collected data via the hardware modules in stations will be synced throughout the System via Google Cloud platform.

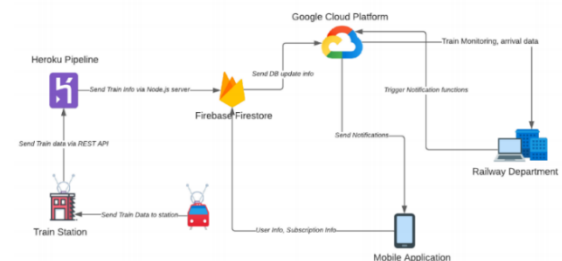


Figure 5: Proposed System Block Diagram

### IV. IMPLEMENTATION

Web Application plays the role of notifying train unavailability, breakdowns, updating and modifying train schedules and sending alerts to mobile application. Web application can be used to generate performance graphs regarding the trains’ individual performance. Mobile Application is presented to users which they can use to find the optimum and most efficient train to travel to their destination. Upon selecting the destination station, user will be provided with an optimum train to travel from his/her location. Following parameters are considered when calculating and selecting the optimum train,

- User Location

- Current Time
- Mode of transportation towards train station
- Destination Station
- Train Delays, unavailability
- Train arrival time to destination

Parameters are run through a tailor-made algorithm to detect the optimum train for the user to travel, even with any delays or unavailability of existing trains. When a train arrives at a certain station, modules at station and on the train will communicate with each other. The data received from the train module will be synced to the cloud database via the module installed at the train station. It will dynamically update the train schedules rather than prevailing static schedules. Basic information regarding hardware modules are as follows.

#### A. ESP 12-F WiFi module

ESP 12-F is developed by AI-Thinker team with a core processor ESP8266, with clock speeds of 80MHz, 160MHz and supports Real-time operating system (RTOS). This model supports standard IEEE802.11 b/g/n, complete TCP/IP protocol stack with 2.4GHz -2.5GHz frequency range (“esp8266-module-family [ESP8266 Support WIKI],” n.d.). ESP 12-F provides the ability to embed the WiFi-Capabilities in the proposed system, which will be used to sync data with the cloud. ESP-12F supports SPI/SDIO or I2C/UART interface for the communication with computer for data exchange or configuration tasks. ESP-12F can act as a standalone system at the lowest cost and minimal space requirement which makes it the best candidate for this system.

#### B. nRF24L01+ Transceiver module

nRF24L01+ module is operating in 2.4GHz frequency using GFSK modulation for data transmission. Even though Operating voltage stands at 1.9-3.6V, logic pins are 5V tolerant making the transceiver compatible with ESP-12F. nRF24L01+ uses Enhanced ShockBurst packet structure (“In-Depth,” 2018). Which ensures the acknowledgements to be received with each packet on arrival. Due to availability of Automatic Packet Handling, it ensures re-transmittance of

packets which does not arrive within Auto Retransmit Delay (ARD) ensuring packet loss at a minimum. Range of nRF24L01 can be increased using PA LNA Wireless transceiver module with External Antenna, which will be deployed with this project to ensure the highest transmission range with minimum packet loss. Range variates from 500m – 1000m depending on structural architecture of the buildings, which falls within perfect range of this project.

#### C. Arduino Nano

Arduino nano is powered with ATmega 328 with 32KB memory. It’s equipped with 14 digital pins which operate at 5V and specialized function pins which acts as Serial I/O (RX-TX), External interrupts, PWM and SPI. Arduino nano supports UART TTL serial communication (“Arduino - ArduinoBoardNano,” n.d.). RX – TX ports in the Arduino nano will be used to ensure communication of nRF24L01+ module which will be equipped in the trains. Arduino nano runs with 5V external power supply to pin 27 or via Mini-B USB Connection, which in this project will be using a regulated external power supply.

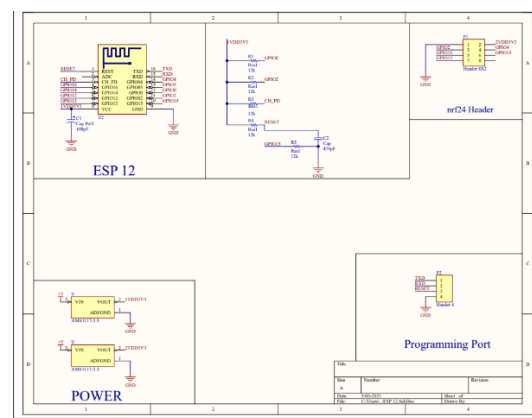


Figure 6: System Circuit Design

Data received through the Hardware modules will be synced with the Firebase Firestore database via a Heroku pipeline which is used to deploy representational state transfer (REST API) to collect incoming data from the ESP-12F. Upon arrival of a train to a train station, train id, train station and time is passed via the hardware module towards the Firestore database. This process takes up to ±10ms with an average WiFi connection. Upon updating of Firestore database, Web Application administrators can view data and trigger notifications towards mobile application if deemed necessary. Furthermore, if

train schedules need adjustments or train unavailability are notified to the Railway department, web administrator can broadcast notifications towards users. Users can find the optimum train to travel by selecting their destination station and the mode of transportation towards the railway station. Algorithm will calculate the optimum train to travel, alongside the optimum nearest railway station.

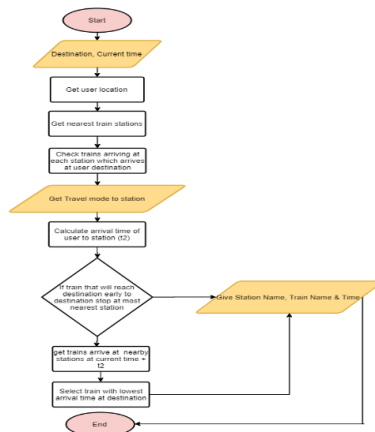


Figure 7: Train Selection criteria

Train delays and unavailability are automatically taken into consideration when the algorithm is processing user inputs, hence user will have a better understanding of the estimated arrival at his/her destination. If the arrival time is not up to users' satisfaction they can select another mode of transportation, rather disrupting their daily schedules due to train delays. Users can view the dynamically updating train schedules and train unavailability beforehand and plan their activities accordingly. Tourists can easily find their trains, and visit their destinations without any hassle.

## V. DISCUSSION

Train delays and unavailability in developing countries such as Sri Lanka is a common sight. Even though a majority of the society is impacted by this issue a viable solution to reduce delays or completely eradicate them has not been provided. The remaining logical solution is giving power to the people who use the Railway system to adjust their activities accordingly. Therefore, a common communication platform, equipped with features to find the optimum train to travel towards user destination; will in fact make an impact on people who are using the public

railway system. People will not have to deal with uncertainty of train delays or unavailability and start planning without visiting a railway station.

Arduino based hardware modules provide the cheapest and most reliable solution of synchronizing train data with the server while the whole system being at low cost and low maintenance rather than a typical GPS system, which monthly costs would occur and require maintenance. nRF24L01+ will ensure the communication between trains and the station without any delays or disturbance due to enhancement with PA LNA Wireless transceiver module to extend the range and bandwidth. Data update process merely take 10ms which ensures that the end-users get the updated data almost instantly. Dynamic train schedules will help the public to check on train delays and plan their activities accordingly.

This platform will be ensuring communication between railway department and public instantaneous while the public can get their optimized train selected with the mobile application itself.

## VI. CONCLUSION AND FUTURE WORK

Main purpose of this research is to propose a solution to battle the train delays which people experience on a daily basis. Even though this has been going on for years, no official body has taken action to remedy the situation, leading the public to experience delays wasting their valuable time.

This article suggests a Introduction of a platform which they can communicate, as well as find their optimum train to a selected destination will give public a great relief and encouragement to use public railway transportation system.

This system has further development avenues depending on the public engagement on the system itself. Experiencing a high number of users in the system would make the system to be moved in to a cloud platform with scalable resources, such as Amazon Web Services, providing users with less latency. Increasing of accuracy of the system can be done by adding GPS based tracking to each train which will be subjected to more implementation cost and monthly maintenance cost as well. Drawbacks of the current system include the inability to track

the trains in Realtime, rather by station-to-station basis.

From the research gathered during this project, we can conclude that implementing this system will benefit each avenue of the society indirectly while reducing the time wastage of people using public railway system.

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# Feasible Solution to Manage Donations Intended for Community Service Responsibility (CSR) Projects

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**Abstract** - The motive of this mobile application is to donate money and funds to trusted CSR projects. Searching for a trusted CSR project is the main problem that decreases the interest of the donors and prevents people from making donations. So, this application will help to solve the problem by including a list of trusted CSR projects which are admin-approved. Also, the application contains separate user profiles for CSR projects and donors. There is a function for counting how much funds the CSR project takes, and how many donations a single donor donates since he/she has registered to the application. One of the main features of this application is that donors can donate any amount of rupees ranging from Rs.1 to a maximum at the donor's discretion. In addition, the donor can choose any CSR project of his/her desire and can maintain a separate private profile. This research intends to mention how helpful this application is for those who are willing to donate, and the methodology uses quantitative and qualitative-based survey, experiments and interviews. The goal of this research is to mention that it is a platform that people can help each other within a minute's time and build up an easier process than a conventional donation.

**Keywords:** *donor, CSR projects, platform, funds, fundraising*

## I. INTRODUCTION

Community Service Responsibility (CSR) Project refers to an unpaid task or a work which conducted by a group of people or a single person toward helping their community without any kind of Commutation. Difficulties of communities expect to cover by these projects and then CSR projects occur to find voluntary groups or individual volunteers to be participants of these projects. Community service, a well-known term in community programming, has its definition: "the voluntary action of an individual or group of

individuals without pay." For example, donate funds to schools for building up their education, helping patients to survive their lives by contributing to finding the money needs to cure diseases, and fulfill the day-to-day needs of kind of orphanages like children's homes, elder homes, etc. The overall giving grew as a percentage of approximately 4.1%, online giving increased by 12.1% over the past year. In addition, 45% of donors worldwide are enrolled in at least any monthly giving program.

These kinds of donations help all demographics without considering gender, age, or income but find a proper trustworthy platform is the hardest thing in this hierarchy. Therefore, the interest in donating is unintentionally missed by donors, and the need of finding a trustworthy platform is arising for everyone willing to donate. Any mobile application or a web-based site can take responsibility for the track of donation or help donors to ensure where their funds were transferred. This web-based application can support such projects for collecting funds from donors and distribute them among poor children, orphans, or any related trusted CSR projects. CSR project's president represents the person who needs help and once the desired fund is received, it is given to that person or institute who needs the help. One of the main features of this application is that donors can donate any amount of rupees from Rs.1 to the maximum at the donor's discretion. In addition, a donor can choose any CSR project on his desire and can maintain a separate private profile. Also, donors are able to use this web application for paying platforms, and then the rest of the money can be donated for a CSR project. Another profile is used by a CSR project to check how much donations does the project receive and these kinds of features are used to increase the interest of

donors to donate. The advantage of this process is a small amount of money can be donated and that fund has huge value to convert results success for the CSR project. The Application approves a CSR project only after doing some survey of that project and confirms it as a trustworthy project. The team of that CSR project can continue it through this site. Therefore, donors can use this application as a trustworthy platform for their donations. The main objective of this is to invent a more effective method for online donations and research on technologies that can be used for this application as well as a website. Eventually, researching to prove that the online donation method is effective for all donors and CSR projects.

The research aims to solve problem analysis to formulate and design practical and effective software solutions for the problems. It also focuses on the practice of checking and reviewing the system to find flaws for future development, since the system can solve research problems well. These objectives are nodes for designing software solutions to the problems discovered by this study. Objectives are to Identify the available methods that are used for managing donors and the problems come across, Pinpoint the technologies available, Layout the software solution to address research problems with available technology at present.

## II. LITERATURE REVIEW

Fund Raising and Donation Application System: CSR projects are depending on funds and donations which people donate but it is a difficult task that is to tend people to donate. This research has described the funds that need to continue a business project or a business creation. They mentioned that there are many ways to get help from the people towards their project by helping in the cost and to reach more internet users they decide the best solution is to create a donation system or online fundraising system by utilizing internet technology and information technology. In addition, by using this application, users can create an account for their project and gain donors' attraction towards this project by using this application or site. This crowdfunding website consists of three major categories for the easiest of the user and social projects, creative projects, and events.

Base on this above application and site there are some issues to study by that research. The main problem that arises is how can this application or website collect funds, how to build this crowdfunding application as a useful app for all those communities who wish to use and how this application displays categories of crowdfunding. The research methodologies used for this research are as follows: Method Library (Library), the method they used to collect data is library studies by studying articles and reading, for research materials this researcher used scientific journals or other sources. The second method is observation methods and collecting data via doing observation directly in the field. The third method is the interview method and it is a method that asking a direct question from resource and take direct answers systematically. Helps donors to donate a small amount of money is one of the main aims of this research paper and can take that idea to the developing project. Also, this research paper focus to list trusted CSR project list for those who are willing to donate and that point is so important to the developing project. (Muliawati, 2019).

Educate Youth: Android app for fund donation is built to help students who need the help of donors to continue their studies. This app provides two interfaces for users to create a student account and a donor account. Students can register on an educational fund program and maintain a profile to gain donor funds through the app. In addition, the donor also maintains his profile for donating to these kinds of projects.

This is an android application and it connects two users of students and donors in the same platform and the best part of this system is that student can ask help when he/she needs at any time in anywhere. Students can send a request to the donor and then the donor can view those requests and accept it if he/she likes to donate. Also, donors from different states can donate to students in other states and that's the special thing in this application. In this application, there are two different ways of contributing to a donation. Donors can donate directly to a specific student or donate to different students to spread their donations randomly. Eventually, the special thing about this application is that only authenticated students can do with this, and here

is the point that is suitable for developing a project. Therefore, before the CSR project can gain donations, the project needs to take the approval of the admin by submitting required trusted documents. (Hovale, 2019).

Helping hand is a mobile application that is used for donating money, funds, blood, and helping to the orphanages and elders' homes. They include a list of non-profit recognized qualified non-profit organizations after searching. This point is helped to add this function to the developing project and then listing only the trusted CSR projects which were approved by the admin. Therefore, they introduce this application as a solution for this matter by adding a list of qualified nonprofit organizations in their application. In addition, they used messages, emails, notifications, and push messages by saying a new non-profit organization was added. This is also an important function for the developing project. Therefore, by adding this function to the project, donors can receive a push notification by saying the donor's new project is added. So, donors can ask questions on this organization and contribute to the donation if he interests and this application connect both non-profit organization and Donor needs to register in this system before start donating or to search a non-profit organization and the aim of this application is supply money or blood when in an emergency.

Also, there are so many details about the nonprofit organization to which donor wants to contribute. But the application uses some authorized features like they allow to view private data only for the authorized users and they keep every record of the users. So, by adding this function to the developing project, donors are able to request and receive previous records of donations. This mobile application support both android and iOS and it contains donors, admins, non-profit organizations, money, database, and patients. Another feature of this application is all orphanages and elder's homes locations are tracked so it is easy to find a nearby location. (Elapanti, 2018)

Afu is a mobile application developed by china to help people in their country and increase the interest in charity programs and make space for those who are willing to participate in those

programs. Also, this mobile application presents a solution to build trust among the people who wish to donate and help poor people in their day-to-day life. Therefore, by referring to this research paper, can take an idea on how to add trusted projects only and manage donation system. Afu application is relieved people to solve all kinds of problems in normal traditional charity donation patterns.

They find some faults in these traditional charity programs and some of those faults are lack of trust, poor information communication, poor people cannot fulfill their daily needs, transparency, charity is a not thing that people can use anywhere at any time and help those people who need support. Eventually, they build a platform as a service for poor people who can express their needs online, and then donors can find a charity program as they wish. The mobile application helps both donors and beneficiaries to express their ideas throughout the process and then supply what beneficiaries expect. In addition, the main purpose of this application is to build trust among these two parties. Therefore, admin must guide that information and confirm those charity programs are real and they are doing this process in two steps. Firstly, the audience has to trust that information and the higher trusted program can gain more donations. Secondly, it is released to the network and donors can contribute to this program. Most important thing is that after confirming this is a trusted program, the interest in donating has been doubled. Eventually, by referring to this research paper, can take an idea of this is the way of developing an application by adding trusted CSR projects only. (Ahmed, 2014).

### III. METHODOLOGY

The proposed system is based on the web application to increase the portability and availability of the system and for any user to use this easily.

- Angular is used for building the front end of the application using HTML5, CSS bootstrap frameworks, and Typescript. Angular is a TypeScript-based open-source web application framework led by the Angular Team at Google and by a community of individuals and corporations. Angular is a complete rewrite from the same team that built AngularJS.

- Java is used for developing a mobile application using android studio and IDE is this android studio. Java following object-oriented programming.
- Firebase is used to build the database environment for the project. Using this database web application and mobile application connects and through any of this application can register and login through any application.

This methodology will be based on main three parties.

1. Donor
2. CSR Project(owner)
3. Admin

Admin, Donor, CSR project(owner) can use this web application and on the other side mobile application is only for the donors.

Before implementing this software, the main function is to use the same database for both mobile applications and web applications. In addition, then one donor who created his donor account by using the web application able to log in using a mobile application and the same credentials. In here to store the user credentials in a separate form, use tree-structured, and then user details do not mix. Any Donor who wants to take a report of previous records can take it easy. This research paper describes what features are added to the users for their use.

#### IV. ANALYSIS AND DESIGN

The mobile application is needed to be collect details of how previous donations applications and sites are going on before starting to develop. The main purpose of this is to determine the application goals and figure the issues out there after developing an application by reviewing those online donation applications and websites. Before doing this research quantitative and qualitative data are required to enlarge the quality of the application and mainly to achieve the application goals. The data can be categorized into primary data and secondary data. Therefore, the Primary data of the research identified by using techniques of gathering data and other all methods are used for gathering secondary data. Also, the project used to direct a quantitative

analysis for collecting data and to achieve all expected project goals.

##### A. Interviews

Simple interviews are used to collecting ideas and data on what the application is needed and can users satisfy by using the functionality of this application. Some of the interviewers have used these kinds of applications before and they mentioned errors and shortcomings in those applications and websites. In addition, interviewers who used the conventional donation method, bring up new features that they expected. As an example, they said they want user-friendly interfaces and some of the interviewers have huge credibility issues.

##### B. Experiments

reviewing previous applications and websites for collecting other data and check it out the errors in those applications and websites. After installing some applications there are various kinds of Charitable projects like CSR projects here. But to gain donations it doesn't need to wait until the admin approved that project as a trusted project. Furthermore, those applications do have not any function to measure how many of the donations donors did since registered. A single student is also able to make an account on behalf of them to receive donations and because of this, any kind of racketeers can create an account and funds can be smuggled.

##### C. Survey

the project used a simple google form by adding simple ten questions to follow the survey-based method to gather data. This google form has targeted the ideas of the people on donating through an online mobile application, whether they have an interest in donating, their experience about those online donation applications, and their idea on some features that the application was developed. This fundraising mobile application developed some features like includes a list of trusted CSR projects which admin approved, the application contains separate user profiles for CSR projects and donors.

In addition, there is a function for count how much funds the CSR project takes and how many donations a single donor donate since registered

to the application. Also to increase the interest of donation, the application adds a feature like anyone can transfer their changes after buying goods from shops/supermarkets to the favourite CSR project of the donor. The online Fundraising application contains some modern interfaces and databases and going to develop an application by using android studio and already decided to develop an android application as the result of the survey.

Table 1- Analysis Table

	Sample size	Answers	percentage
Interviews	50	48	96%
Experiments	15	15	100%
Surveys	120	100	83.3%

Source: Author

Analysis of the system is done by using a survey of a google form and share the form among the people. This is the best way to gather information to analyze the current system and 100 responses used for this survey. In addition, it helps to add special functions to the system and get rid of the errors, and the following questions are included in the questionnaire.

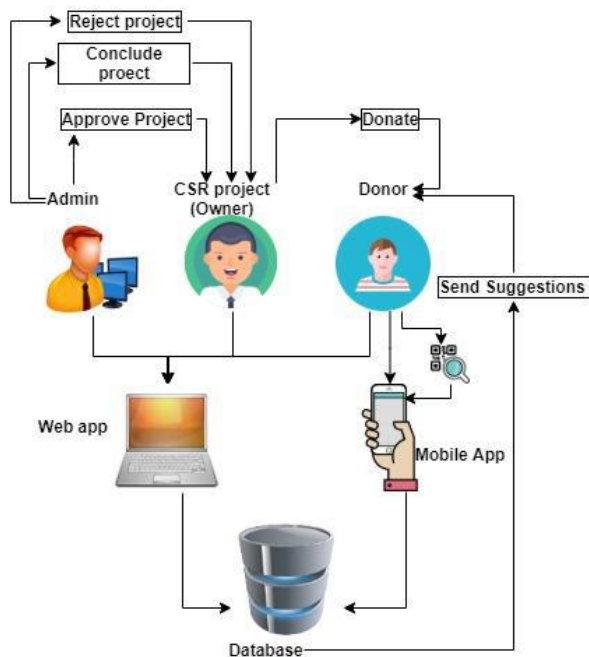


Figure 1- Methodology

Source: Author

## V. IMPLEMENTATION

Both applications can send a notification when a donor's favourite CSR project is created. This process will happen as mentioned. First, the application does a back-end program to take a percentage of the categories of the CSR projects which donors donated before. As an example, since donors registered to the application, donors mostly donate CSR projects which relevant for the child. As the same donor donates to some projects relevant to educations, relevant sports, and animals.

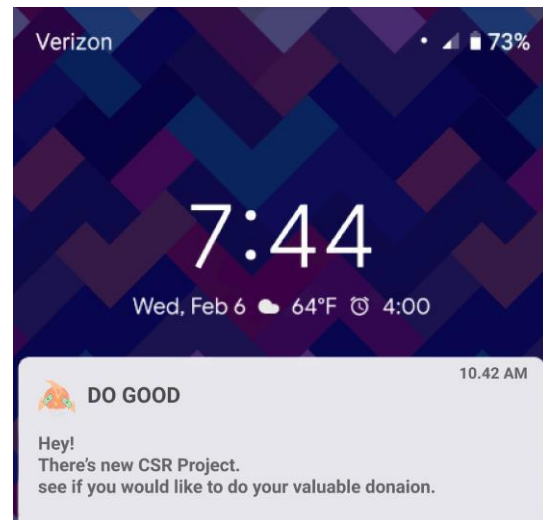


Figure 2- Notification screenshot

Source: Author

Then backend of the application takes all the previous reports of the donor and takes a report of the donor's favouritisms. After all, another CSR project(owner) creates a CSR project relevant to the children. So then immediately application sends a notification by saying there is another new CSR project relevant to your preference. As the below figure 2 donors receive a simple notification and can directly go to the relevant CSR project by clicking the notification.

Also, applications are mostly focused on the users by using user-friendly functions. Therefore, any mobile app user who has this mobile application can search directly using the search bar or there's a QR scanner for the same task. Any CSR project owner can share a QR code relevant to the CSR project in any place. As an example, if the CSR project owner takes a printout of the QR code and keeps it near to the cashier of the shop, then the user of the mobile application can scan



this QR code and browse the relevant CSR project.



Figure 3- Search bar  
Source: Author

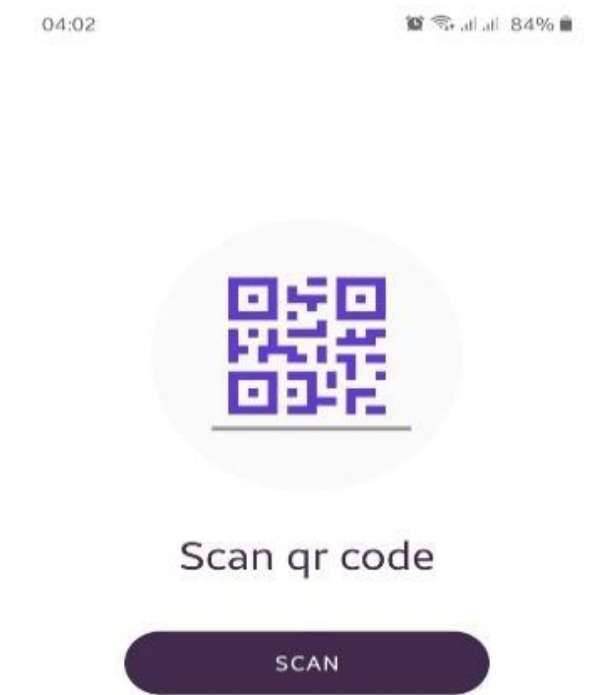


Figure 4- QR scan page  
Source: Author

This QR scanning is the same as the process of the barcode reader at the supermarket. Also, this image is a kind of machine scannable picture which mostly scans using a smartphone. The process of this scanning happens as, when focusing on this image, can see there are a number of squares and dots and every single of this represent some information. Eventually, these scanners convert this into a human language which human can be understood.

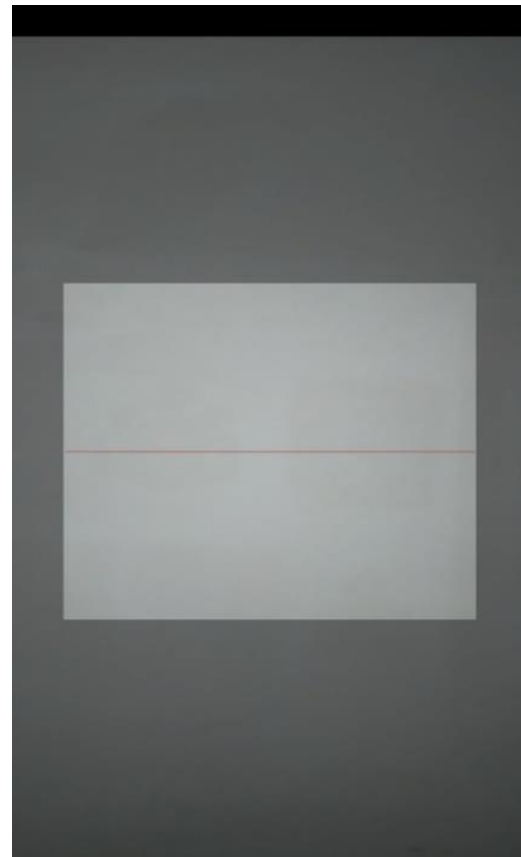


Figure 5- QR Scanner  
Source: Author



Figure 6- Search result  
Source: Author

To motivate the donor, these applications are added a feature for donors to take a report of

previous donations. This process happens through both web application and mobile application. Then donors receive simple PDF format documents with their previous records adding the name of the CSR projects, How much donations per each project.

## VI. REVOLUTION

The main purpose of this research paper is to Manage donations by accepting only the trusted CSR projects and maintain the donor's trust. In addition, the application is able to send push notifications for each user by saying the donor's favourite category of CSR project was added. As an example by analyzing previous records, the application gathers all the information of the donor's previous donations projects, and when the same kind of project is added application sends this notification. Eventually, the donor can request a previous donation report using the application and the main aim of this feature is to motivate the donor to do more donations.

## VII. CONCLUSION AND FURTHER WORKS

In the conclusion, Donors can give a break from a conventional donation because of this online mobile fundraising application. Throughout the research paper mentioned the way that how fundraising mobile application helpful for donors to find trusted CSR projects for their donations. The project develops web and mobile applications to help people who need a hand and those people who are willing to donate. User interfaces of the fundraising mobile application are done by using flutter and it is an open-source user interface software development kit used to develop android or any other OS mobile applications. Java and Angular are the languages used to code all the features and firebase used to manage the database. As further development developer tries to develop this application for iOS also. According to the questionnaires users are expecting a trusted platform to do their donations and expect to add some value to their donations by the feature of the application. Eventually, interviews and installing the same kind of donation apps help to avoid errors occurring in previous donation applications.

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# Smart Ticketing and Seat Reservation System for Sri Lankan Railway

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**Abstract** - This system is formulated to overcome the significant flaws in the present scenario and the consequences of traveller ticket buying and seat reservations, which frequently lead to mistakes and long queues. Long queues are a massive issue in the current railway system. The proposed system provides proper solutions for train passengers to make their daily travels easy, and most local and foreign travellers use trains to move to their travel destination. Nevertheless, there are some issues with the current train seat reservation system. The proposed system will be able to give a solution for these issues. The proposed method is an online application that allows travellers to buy ticket seat reservations from their mobile phones. The unique feature of the new proposed self-seat reservation system is that travellers can reserve any number of seats according to their preference. Moreover, in this research paper, we have discussed some solutions for people who cannot use smart phones, and who do not have the technical knowledge to use smartphones and modern technologies. A system dashboard is a separate application of a system used for management system works, reservation and database.

**Keywords:** *smart reservation, e-ticketing, train ticketing, e-transportation*

## I. INTRODUCTION

The railway is one of the most important modes of transportation and plays a vital role in the transport industry. With such a vast customer base, purchasing train tickets has been a preeminent problem. Every day there are long queues in front of the ticket counters at the busiest train station. It is a waste of time, and most local and foreign travellers have faced many difficulties with the current train seat reservation

system. There is no proper method to refer to train details before reserve. The difficulty of railway tickets might be solved through electronic commerce. Implementing a new online ticketing system is not the only technological advancement, but it will also improve railway services and, to a certain extent, resolve the challenging problem of railway ticketing.

"Smart Ticketing and Seat Reservation System" is a mobile application as well as a web application. It is for making an online reservation and ticket buying. To buy a ticket, the user should create an account and log in to the application. After that, a payment method should be set. As soon as payment is made, a QR code is generated. Passengers should scan QR codes to enter the train station before getting on to the train. After they get off the train same QR code should be scanned to inform the end of the ticket to the system. The system calculates ticket prices using start train station, end train station, and transitions. As well as someone wants to print a ticket at home, the system gives function for it. A computer can be used for it. A train seat reservation can be made by mobile application or web application. Users should pick a train and give the number of seats as well as train class. Then generate a reference number for every reservation. It is generated after making the payments. Quick Response code technology inputs passenger data correctly and quickly; people cannot stay much in front of the platform gate at the busiest moment. Therefore, QR technology help to make it efficient. The system will be implemented as a mobile application and web application. Sprint boot, Angular, Ionic, and MySQL technologies are used to develop the entire ticketing, reservation, and other applications. Some people have no computer literacy. As well as some do not use smartphones

or computers. Therefore, they are unable to use the system. Therefore, they will not be able to use the train service. It is trouble. Therefore, as a solution, a ticketing machine will be implemented with the ticket agent. Passengers can ask for a ticket from the agent, and the agent issues tickets. To manage the database as the admin, it can provide a dashboard. It is a separate component of the system, and railway employees can log in to this application.

## II. PROBLEM DEFINITION

The reservation system was done manually before the advent of modern technologies. This meant that someone planning a trip would have to waste much time standing in lines to buy their tickets. The manual reservation procedure was also subject to human mistakes, resulting in an outstanding level of frustration among tourists and local travellers. Long queues at ticket booths are caused partly because most stations do not have enough ticket counters to satisfy peak-hour demand. However, increasing the number of ticket counters to service during peak hours is not realistic. Another factor is the amount of time it takes for a single passenger to purchase a ticket. The person behind the counter is responsible for issuing the ticket, and this transaction will take longer to complete due to this. Tickets printing cost is also high.

Furthermore, it is not easy to catch any imposters who travel without using tickets. The difficulty can be solved by automating the system. However, when choosing how to automate the system, we must consider the Sri Lankan railway scenario. Because many train riders do not utilize debit cards, the debit card system is ineffective. The system we have proposed is a fully automated prepayment mechanism. The primary users can be categorized into different levels according to the usage of the system. They are daily basis travellers, non-daily basis travellers, seasonal travellers, people who can use smart devices, and people who do not know to use smart devices.

## III. RELATED WORKS

(Zongjiang, 2012) According to this research paper, the Researchers discuss guideline applicability and propose a method for evaluating rule effectiveness in rough sets.

Moreover, provide a way for obtaining the most effective rules. In comparison to the approach for obtaining the fascinating rules, this one is straightforward and objective. The rule of interactiveness must take into account prior knowledge of what types of information are fascinating. This technique significantly decreases the number of rules created while providing a measure of rule effectiveness.

Moreover, the researchers build and implement an online train ticketing system in this study: the data access layer, business logic layer, and business exterior layer composed up the whole system. Customer registration, cancellation, ticket inquiries, online booking, and online ticket refund are all implemented in the system. The focus of this system is a business process and database design, which are clearly and effectively developed through business process diagrams and database ER diagrams. Travellers will receive real-time ticket messages via the online railway ticketing system. The reservation efficiency has increased, manual booking flaws have decreased, and the administration of railway passenger transport and customer reservations has improved.

(Musa, n.d.) According to the research, online train reservation is one of the best innovations in the rail industry, and those service providers that have not yet accepted online reservation systems should forfeit. They may see extra expenses, maintenance expenses, and production costs as pitfalls. However, business is more than almost any other invasion, and it is a constant negotiating with the coming years and persistent assessment, an instinctual forecasting activity. The World Wide Web and the Internet have emerged, and transportation firms will take advantage of this chance to build online reservation systems and flourish in the future.

(Yadav et al., 2014) This concept envisions a significant shift in railway operations and passenger experience. TTEs are provided with hand-held devices to make passenger confirmation easier and faster. The tickets include a QR code on them, which is read by HHT devices. A passenger-specific URL is saved in a QR code; when the HHT device encodes this URL as part of the Scan procedure, it directs to the PRS server and retrieves the encoded data to verify

the traveller. The scan procedure refreshes the details of all passengers on board and informs the DSA server if a seat is reserved or empty. The check-out method allows travellers to stop their travel at any station and get their remaining money while having their vacant seat filled by a waitlisted traveller. The reservation portal allows users to book tickets for travellers. These technological improvements to the train increase transparency and minimize tout behaviour during the high season.

(B. et al., 2018) Smart trains have been introduced in developed countries leveraging the internet of things (IoT), which allows them to take advantage of the opportunities offered by the Industrial Internet of Things (IIOT). The survey in this article focuses on various communication methods within the IoT paradigm like Global System Mobile Communications-Railway, Long Term Evaluation, 5G, and Wireless Sensor Networks. The passenger ticket production and validation were detailed with the Unique Identification Authority of India database as part of the smart rail transportation vision of India 2022, and the testing results showed that the IoT system is more practical than the well-known approach. The results revealed that passengers could get tickets in fractions of a second, that the reservation chart included the travellers' names and photos, and that adequate customer reservations were preserved.

(Pothineni, n.d.) According to this research paper, anyone with a login can access the data. So, in addition to ticket buying, this application will also include ticket cancellation, ticket and train status, and live station info. The primary focus of this research is to provide a user-friendly interface for all clients that will assist them in whatever way they require in response to their questions. This program must be beneficial to all of the travellers that use trains and must fulfil their expectations.

#### IV.SYSTEM DESIGN

According to the issues detected above, the existing purchasing train ticket and train seat booking system should change with the new technology. However, the solution of online services made it easier to obtain many things at

any time and anywhere. The leading solution is 'Smart Ticketing and Seat Reservation System.' It provides an alternate and convenient method for train passengers to purchase tickets. An Online Ticketing and Reservation System allows a potential customer to book and pay for a service directly through the system. That means from the moment a customer decides they want to book a slot for service to choosing

- i. Date
- ii. Picking time and
- iii. Paying for the book
- iv. membership management,

everything is handled online (thus) through a simple operation. The customer can select the seat and make the payment. The customer can also cancel the ticket

Further Smart Ticketing and Seat Reservation system consist of two main parts. They are,

- i. Ticket Buying
- ii. Seat Reservation

In the process of ticket buying, the traveller will access the online Ticketing and Reservation System and open an account by registering themselves on the system. The process includes,

- i. First, enter their details (First Name, Last Name, Email, NIC, Mobile number, Password) for user registration purposes.
- ii. Verify the phone number by verification code.
- iii. After that customer can log into that system using NIC as user id and Password.

Travellers who do not have a (NIC) National Identify Card need to use mobile numbers as user-id when accessing the account. Once the passenger logs into the account, the account will automatically log in until the passenger logout from the account. That is, the system does not automatically log out. After that, the passenger must enter the payment method. That customer can use online payment cards issued by any bank in Sri Lanka. If there is a foreign traveller, they can make this payment through 'PayPal.' Thus, online ticket booking payments can be made using all Master/ Visa/ Amex cards. That system also offers secure online payment via its e-wallet



service. An E-wallet is a scheme under which users can deposit money in advance with that system. After that, the payment method details are entered, a QR code is generated, and it can be used at the entrance to any train station.

There are two ways to purchase train tickets under this scheme.

#### *A. First Method*

In that way, Tickets can be purchased using the QR code that includes the details here. Passenger can scan the QR code to QR code scanning machine that located at train station platform entrance. The passenger can enter through the flap gates to the platform. Then the ticket will open with the starting point. When the traveller reaches the destination and gets off the train station, the traveller must scan the QR code again. However, there is a problem here. When the passenger gets off the train and leaves the station, the ticket will not be completed if the code is not scanned because the destination railway station was not mentioned. Then the ticket charges cannot be done. As a solution to that, when the passenger first enters the station, after the scan the code. That system charges the total cost of travelling to the train station with a long destination from that place. However, the passenger gets off the train and scans the QR code again; the extra charge will be refunded.

Nevertheless, passengers leave the station and fail to scan QR codes, and they will not recover their extra charge. It is a unique point of the Smart Ticketing and Reservation System. Passengers can also get a card with a QR code at all train stations. The passenger can use it when they do not have their smartphone.

#### *B. Second Method*

In that situation, the passenger should know about the starting station and destination station before purchasing the ticket. This can be done at home, and payment should be made in the same manner as above. The train ticket is made after entering the start train station and the destination train station and train class. The passenger can print it at home. QR code is printed on the ticket, and a QR scanner checks validity at the train station. After, the passenger can enter the railway station. However, if the passenger cannot print the ticket, he/she can be printed the

ticket by a particular ticket-making machine at the railway station. However, passengers must have the reference number (given at the time of making the ticket). Passengers can make a ticket on that method. Passengers need to log in to their accounts and do so. After that ticket is printed, this can solve when the passenger does not have a phone or card containing a QR code.

The following central part of the Smart Ticketing and Seat Reservation System is the train seat reservation. The problem mentioned passengers do not have any method to see all train details before reserving a seat. It is very uncomfortable for local travellers as well as foreign travellers and regular passengers. Smart Ticketing and Seat Reservation System make proper solutions for this problem. In that situation, the passenger should log into their account. If there is no account, the passenger should do the same manner as above to register in the system, and a passenger should give a payment method if there is no existing method. The above method can be used. After that, all the railway lines of Sri Lanka can be seen. By choosing a railway line, passengers can see trains on that railway line available a seat reservation facility. Then all details are displayed about the selected train. They are train number, available classes, departure time from start station, arrival time to destination, the train station that train stops, train name, number of compartments, and attached pictures. Passengers can see inside the compartment by those pictures. It is a proper method to get an idea about seat format in the compartment, lavatory facilities, food and beverages, phone charging facilities, window facilities, and other facilities. As well as this part consists of other passenger services of Sri Lanka Railway like observation saloon. Then passengers can reserve seats in different classes. Sri Lanka passenger trains consist of three classes as first-class, second class, and third class. Seats are numbered, and available seat numbers are presented to the passenger. It means those seats had not been reserved. Passengers can reserve one or more seats. After reserved seats are locked, and another passenger is unable to reserve locked seats. This is the process of seat reservation. As well as anyone who wants to cancel a reservation, there is a function for doing it. However, refund money only eighty percent of

ticket value. Above all, functions are essential for the tourism industry because there is no method for foreign travellers to make their train journey properly. Not only for foreigners, but local travels can also make their journey correctly.

An application for managing server-side can be proposed to enhance further the project to manage the database as the admin. Railway employees can log in to this application and manage reservations and check validity. The system has a separate application called checker application for the validation of tickets. Since the Checking application, it saves a massive work of the ticket checkers for validation of tickets by moving from manual ticket checking process to digital ticket checking process. This has happened during the train journey.

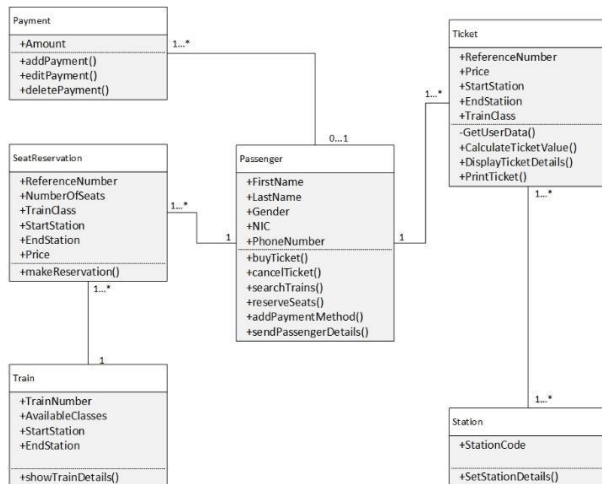


Figure 1. Class diagram of the system

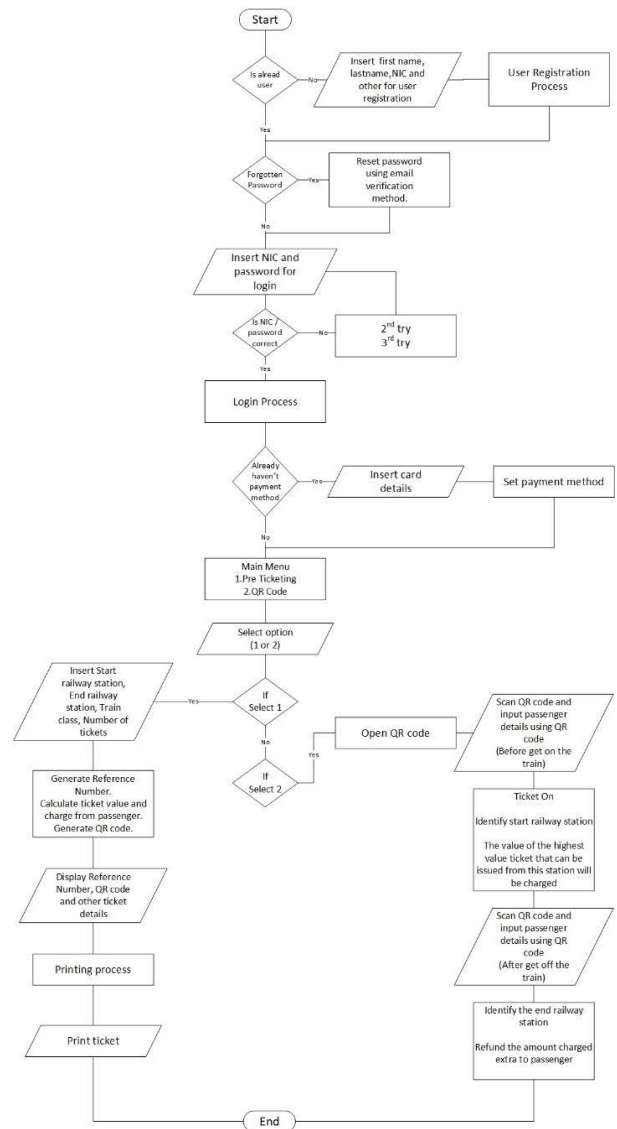


Figure 2. Flow chart

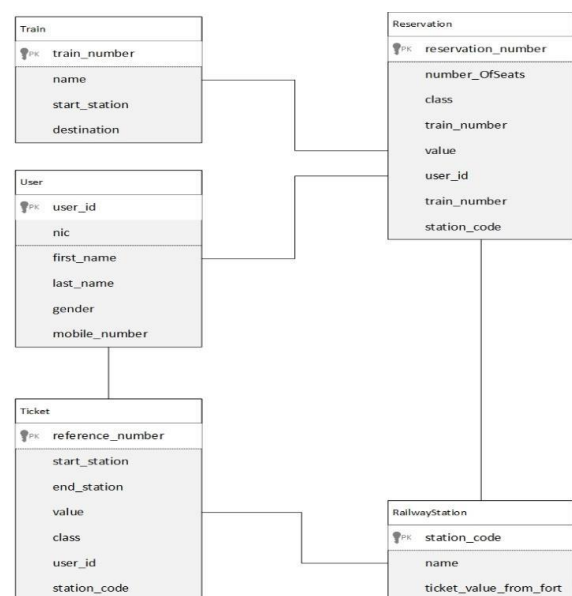


Figure 3. Database diagram

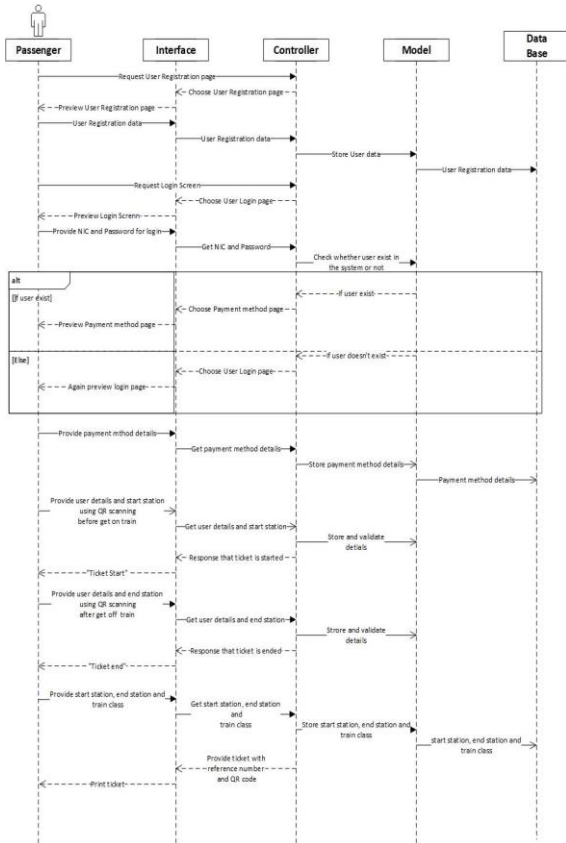


Figure 4. Sequence diagram of the system

## V. CONCLUSION

In this research paper, we have discussed some problems of the current manual railway system of Sri Lanka and proposed a Smart Ticketing and Seat Reservation System; the underperforming railway transportation in Sri Lanka is not still running on the self-seat reservation system. The Sri Lankan railway has been following the same traditional way of issuing tickets. According to that process, passengers need to visit the counters in railway stations, pay for the tickets, and get the tickets. The tickets currently issued by the Sri Lanka Railways are valid only from the date of issue and to the given destination only. Also, the current ticket reservation process of Sri Lanka Railways can be identified as a primary level system. Therefore, passengers cannot know about their seats and ticket prices and train details, train destinations. However, Travellers can reserve any amount of seats according to that new proposed system. It is a unique feature in that new proposed self-seat reservation system. When in a situation like, when a passenger is trying to book the window seat, the passenger will get the opportunity for it. Although that

system can provide many travel options, explanations about destination area to local travelers and tourist when they choose, that has posed changes for the tourism industry and travel services infrastructure.

Further, All these facilities are most important for ordinary train passengers and local and foreign tourists, which is a mobile application and a web application with the use of QR technology. The complete ticketing and reservation can be built using Sprint Boot, Angular, Ionic, and MySQL technologies. Furthermore, the research paper highlights the Several alternatives for those who are unable to use smartphones and people who are not having the technical expertise required to utilize smartphones and current technology.

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# Impact of Social Media-Related Cybercrimes and Preventive Precautions

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**Abstract** - The impact of social media on people's lives is enormous. Through social media, people can communicate and collaborate with anyone in the world and can entertain themselves. It is a good platform for entrepreneurs to promote their business too. As a result of the COVID-19 pandemic, people tend to work from home relying on computer systems, mobile devices and different social media platforms. The usage of social media platforms for communication, sharing information, business purposes and shopping increased to mitigate the impact of social distancing. Cybercrime will rapidly rise because of the widespread use of social media. The increase in volume, velocity, veracity and variety of data in social media networking are major concerns that may lead to privacy and security issues. Cybercrimes will create a massive impact on the security of people in future. To address this problem, the security of social media users should be improved using different techniques. This paper focuses on the usage of different social media platforms, types of social media-related cybercrimes, techniques, tips, recommendations and future precautions that can be used to prevent social media-related cybercrimes.

**Keywords:** *cybercrime, social media, cybersecurity*

## I. INTRODUCTION

Social media is a computer-based technology that enables people to interact with each other around the world and it helps to discover new things too. People can exchange data, pictures, videos through social media platforms. Among all the social media platforms Facebook, YouTube, WhatsApp, Messenger, Instagram, TikTok,

Twitter, LinkedIn, Telegram, etc. are at the top. There are around 4.33 billion social media users worldwide in 2021, which's more than 55% of the global population. The growth of social media users increased by 13.7% from 2020 to April 2021, which means 16.5 new users per single second (Kemp & Kepios, 2021). Facebook is the biggest social media platform that is using today, it has nearly 2.85 active users in the first quarter of 2021 (Tankovska, 2021). With the rapid increase in social media users, social media platform security should be a key focus. These platforms should take appropriate steps to combat hackers and safeguard users' sensitive information. Social media data leakage makes a huge effect on data of people, intellectual property, business operations, etc.

Cybercrime is a criminal activity carried out against computers or devices to damage them or to harm sensitive data of individuals. Cybercrimes such as committing frauds, trafficking pornography of children, stealing identities, trafficking intellectual property, etc. can happen through social media. With the huge increase in social media usage cybercrimes raised day by day. Hackers try to get access to social media accounts of people and attack the financial and personal information of people suspiciously. As a result of the Covid-19 pandemic, people all around the world were compelled to work from home, reliant on the internet. As a result of this situation, cybercrime will become a bigger problem in 2020 and 2021 (Monteith, et al., 2021). To avoid cybercrimes people can enhance the security of their social media accounts themselves as well as all the authorized parties such as the government, social media companies, and cybersecurity authorities



should take appropriate actions to reduce cybercrimes. This paper discusses the usage of different social media platforms, social media-related cybercrimes, a discussion on preventive measures against cybercrimes, and the conclusion.

## II. BACKGROUND STUDY

Social media has been on the rise because of the Covid-19 pandemic (Monteith, et al., 2021). In 2021, social media networks such as Facebook, YouTube, WhatsApp, etc. are at their peak, with billions of active users.

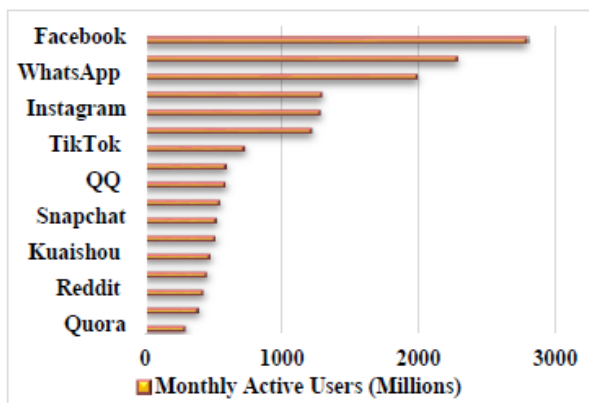


Figure 1. Different social media platform users of April 2021 Source: (Kemp & Kepios, 2021)

A study has revealed that a user visits more than 6 social media platforms each month and a user spends an average of 2.5 hours on social media per day. It also revealed that people spend about 15% of their lives on social media. In a typical day, people around the world spend over 10 billion hours on social media platforms, equating to 1.2 million years of human existence (Kemp & Kepios, 2021). Social media platform preferences are different from country to country. So, the main important thing is to concern about the privacy and security of people's data at a local level too by relevant authorities of the country.

Cybercrime has been identified as a major global threat (weforum.org, 2019). Cybercrime rate increases with the rapid use of social media platforms. Figure 2 shows how cybercrime complaints increased from 2016 to 2020 according to the data provided by the internet crime complaint center (Institute.org, 2020).

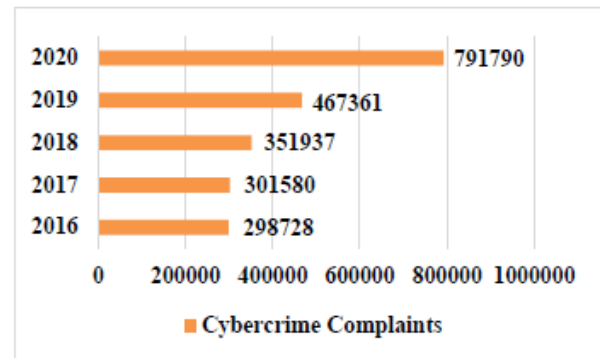


Figure 2. cybercrimes complaints (2016-2020) Source: (Institute.org, 2020)

As seen in Figure 2, cybercrimes increased considerably from 2019 to 2020. The main reason for this issue is the growing popularity of working from home because of the Covid-19 pandemic. Millions of people, including children, university students, employees, and others, were obliged to work from home because of this circumstance, and their use of social media platforms increased (Monteith, et al., 2021).

Main cybercrimes related to social media are Cyberstalking, Cyberbullying, Identity theft, Social engineering and phishing, Burglary using social networking, Malware (Malicious software), Cyber-casing, Cyber intrusion, and data breaches.

### A. Cyberstalking, Cyberbullying

Cyberstalking and cyberbullying mean a crime where an attacker harasses a man/ woman using any social media platform or any other medium. Cyberstalking may include threats, cryptic messages, or sexual content. Mainly through cyberstalking attackers create major psychosocial impacts on victims. Victims reported many serious consequences such as depression, fear, stress because of cyberstalking and cyberbullying. January is the National Stalking Awareness Month since 2004 which raises to aware the impact of stalking and helps victims to get rid of depression, stress, and fear of cyberstalking. A survey revealed that 6 to 7.5 million people get stalked in the US each year and the 18-24 age limit is the highest risky age group being stalked. The survey found that 1 out of 5 people changes their daily routine, 1 out of 6 people change their contact details and social media accounts, 1 out of 8 employed people lose their jobs because of cyberstalking. According to

the survey, 7% to 40% of students reported being stalked. (Telloian, 2019).

### B. Identity theft

Identity theft means obtaining Personally Identifiable Information (PII) of people through social media platforms. Credit and Debit card frauds, online shopping frauds, driver license identity theft, child identity theft, mail identity theft, etc. are some identity thefts that occur mainly. Attackers use the information of victims to get access to their bank accounts and other sensitive information. This will be a huge problem for the security of victims' data. Identity theft is the category of cybercrimes that got the most complaints in 2020 (Institute.org, 2020).

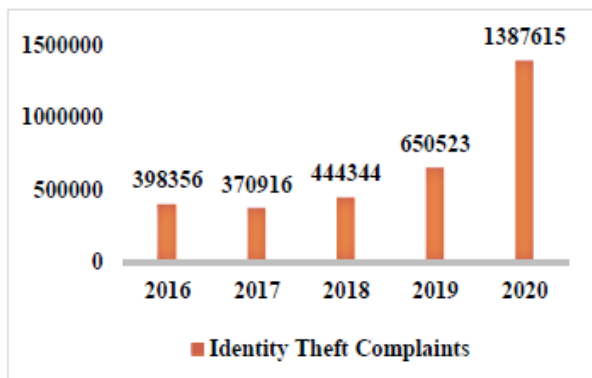


Figure 3. Identity theft complaints from 2016 to 2020. Source. (Institute.org, 2020)

### C. Social engineering and phishing

Social engineering can be defined as tricking a user into giving up his or her private information. Phishing is a type of fraud that uses social engineering techniques. It is an attempt to acquire sensitive data of people such as passwords and credit card details by masquerading as a trustworthy person or business in an electronic communication. According to the Federal Bureau of Investigation (FBI), phishing is the most used cybercrime type in 2020. Phishing incidents doubled the frequency from 2019 to 2020. Federal Bureau of Investigation stated that phishing complaints raised 11 times in 2020 when compared with 2016.

### D. Burglary using social networking

Social media burglars search for the personal information of people such as place of work, birthday, contact numbers, interests, etc. using

their bio. Burglars keep attention to the posts shared by people about their trips, dinner outings, etc. to make their targets easy. According to a survey conducted in the US and UK with the prisoners convicted of burglary. The results of a survey were 30% of social media users mentioned their future holiday details in their accounts and 70% of users post Instagram photos when they are on trips (Verisure.CO.UK, 2017). It will be very easy for burglars to attack their empty homes. A survey was conducted with 500 burglars in New York and New Jersey in 2016. The result of the survey was 10% of burglars find their targets by checking current locations of people through social media (Verisure.CO.UK, 2017). It is recorded that a professional burglar attacked 33 women in California using GPS data of their Instagram and Facebook photos in 2015 (O'Reilly, 2021).

### E. Malware (Malicious software)

Malware can be defined as a program file that will be harmful to computer users. It includes computer viruses, trojan horses, bots, worms, spyware, adware, etc. Through malware deleting sensitive data, monitoring user's activities, stealing data, encrypting sensitive data can happen. These malware attacks happen mainly through clicking un-secure links and opening un-secure attachments. If users click on these destructive links or documents, the virus will infect their accounts.

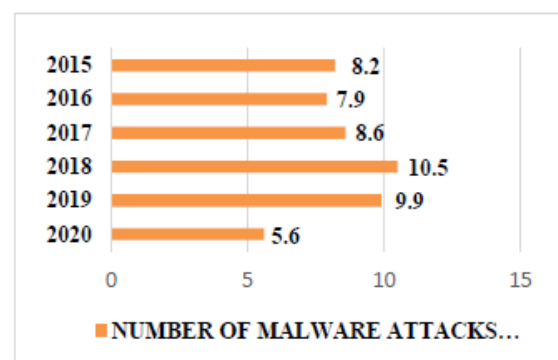


Figure 4. The number Of Malware Attacks Worldwide (2015- 2020). Source: (Johnson, 2021)

### F. Cyber-casing

Cyber-casing uses geotagged text, photos, and videos to criminals. Geotagging refers to the process of adding geographical identification to the photographs, videos, etc. At present geotagging is a major trend in social media

platforms. Geo-tagging is the root cause for the cyber- casing, which helps the attackers to plan their cybercriminals.

*G. Cyber intrusion and data breaches*

In Cyber intrusion, hackers use automated computer programs or files to access the computers or social media accounts of users. Data breaching means accessing the sensitive information of people without their permission. In data breaching also hackers use the personal information of people such as financial details, medical details, etc. Cyber intrusion and data breaches can be considered as a new emerging crime (Soomro & Hussain, 2019).

Table 1. The annual number of data breaches and the number of exposed records through data breaches from 2015 to 2020

Year	Number of Data Breaches	Number of exposed records through data breaches
2020	1001	155.8
2019	1473	164.68
2018	1257	471.23
2017	1632	197.61
2016	1106	36.6
2015	784	169.07

Source: (Johnson, 2021)

**III. DISCUSSION**

Social media plays an important role in the life of people. The main communication mode use now is social media. People use social media to stay in touch with their friends, stay updated with news and current events, get entertainment in their free time, network with people in the world, share photos or videos with friends, promote businesses, buy products from online stores in social media, etc. People can use preventive methods to enhance the security of their social media accounts such as using strong passwords, use different passwords for accounts on different social media platforms, etc. People should not click un-secure links, should not open un-secure attachments, should not access their social media accounts using un-secure Wi-Fi networks, and do not share passwords with friends. Relevant

authorities such as companies and legal authorities should take appropriate actions to secure the social media accounts of users.

*A. Preventing Cyberstalking, Cyberbullying*

To prevent cyberstalking and cyberbullying people can keep a low personal profile while utilizing privacy settings, without sharing personal details such as an address, phone numbers, and other real-time information such as where you are and who you are with. You can use separate email addresses for office work and social networks to ensure your security. And if possible, you can use a nickname on social media platforms like Instagram, Twitter, etc. And mainly you should not add friend requests from fake profiles. Fake profile holders mostly use a name of a famous person or any other commonly used names (These names may vary from country to country). They don't share their pictures in profile pictures, sometimes they use photos of people in military uniforms. Fake profiles mostly don't contain any shared contents or sometimes have fake content and those accounts have no mutual friends or few mutual friends. And another important thing to prevent stalking and bullying is updating the software because software updates are developed to patch security threats, hiding IP addresses, maintain good digital hygiene and avoid disclosing sensitive information. According to the studies conducted women get affected by cyberbullying and cyberstalking than men (Zsila, et al., 2019). When anyone is being cyberstalked by someone, they should block the person, report that person, inform the police and other relevant authorities, and take illegal actions to ensure security. Most of the time it is difficult to track professional attackers because they know how to anonymize themselves. When discussing the legal aspects of cyberstalking most countries don't have laws to regulate cyberstalking. Cyberstalking in the United States is discussed under harassment and anti-stalking laws. A fine or imprisonment is given depending on the severity of the case (Tripwire, 2018). Techniques that can use to prevent cyberstalking and cyberbullying are rule mining, text mining, signature-based data mining, and cyberstalking detection framework.

*B. Preventing Identity theft*

People can freeze their credit cards to prevent prospective creditors from accessing their credit files. Freezing helps to prevent opening accounts to your name by others. And people can safeguard their social security number, can be alert about phishing and spoofing, can use strong passwords, can add an extra authentication step to access their social media accounts, users can check their mails credit reports regularly, and monitor financial and medical statements. It is important to destroy expired driving licenses and other identity documents and shouldn't share identity documents on social media platforms. People should keep their credit cards, debit cards, and other personal identity documents securely with themselves. People can report identity theft problems to the Federal Trade Commission, postal service and credit bureaus, and police departments. Then they can follow the recommended steps to make a recovery plan. Preventive techniques for identity thefts are using three-factor authentication, biometrics, anti-virus software, genetic algorithm, logistic regression, hidden Markov model, and outlier detection. Credit card fraud is also widely occurring in identity theft. To prevent credit card fraud can use the techniques such as Address Verification Service (AVS), Card Verification Value (CVV), hidden Markov model, decision tree, and genetic algorithm.

#### *C. Preventing Social engineering and phishing*

To prevent social engineering and phishing people should be suspicious about e-mails and messages which asked for their personal information. Most user-friendly anti-phishing techniques are one-time password (OTP), CAPTCHA, digital certificates, genetic and attribute-based anti-phishing algorithms. People shouldn't provide their details unless verifying the identity of websites, emails, and messages and should refrain from sharing any personal or financial information on social media. If anyone doubts these messages, you can directly contact the relevant organization to verify the problem. And people should mainly concern about the Uniform Resource Locator (URL) of a website is secure or not. Installing anti-virus software, firewalls, and email filters help to reduce social engineering and phishing attacks. If anyone is a victim of these types of attacks, they can inform the administrators of the relevant company

about the suspicious activity. Then take relevant legal actions by informing the police and Federal Trade Commission. If financial accounts get attacked people can inform the financial institute and close your accounts. Another key step is to change passwords. If people use the same password for multiple accounts, they are more likely to be hacked. The use of neural networks is a good technique to prevent social engineering and phishing.

#### *D. Preventing Burglary using social networking*

People can take appropriate decisions to prevent burglary. People can share their posts only with their friends and followers because if they share their posts publicly anyone in the world can see their posts, it will be very risky for their security. Also, through the settings and privacy of social media accounts, people can avoid being tagged in other people's posts. Limiting connections to known people is also a good way to get rid of burglary. Sharing personal information like address, phone number, birthday, workplace, day to day outings is a good target for burglars. Don't give a chance to burglars to target your home or workplace. If you are a victim of burglary, you can inform the police station as quickly as possible, then they will get appropriate steps to find the burglars. People can use security cameras, door locks, motion-activated lights, etc. to ensure the physical security of their places. Preventive techniques for burglary are genetic algorithms and case base reasoning, time-series approach, multi-layer perception, rule-based induction, and random forest-based model can be mentioned.

#### *E. Preventing Malware (Malicious software)*

The most suitable way to prevent malware is by installing anti-virus software. It can scan your computer and protect against malware. A regular software update is also a good solution to prevent malware. Mainly users shouldn't click suspicious links and avoid downloading un-secure documents. Always should be aware of the fake websites which asked for your personal information through them anyone can get a direct attack to the computer. Installing a firewall is another solution to prevent malware. A firewall can provide an extra barrier to malware when compared with anti-virus software. Regular backup is important to protect your valuable data from malware and should always

be aware that the Uniform Resource Locator (URL) of a website is secure or not. Signature-based malware detection, anomaly-based malware detection, hybrid features, assembly instructions, N-gram models in Natural Language Processing (NLP) are some techniques to prevent malware.

#### F. Preventing Cyber-casing

Switching off Global Positioning System (GPS) is a solution to prevent cyber-casing. It is important not to share your vacation photos publicly on social media before returning home. People should avoid sharing their daily outing times on social media.

Techniques that can be used to prevent cyber-casing are Support Vector Machines (SVM) classifiers, use online tools such as geoimgr.com to remove the geolocation of images.

#### G. Preventing Cyber intrusion and data breaches

Cyber intrusion and data breaches can be minimized by upgrading devices, enforcing Bring Your Device (BYOD) policies, and enforcing multi-factor authentication. Deploying an intrusion detection and prevention system is the best solution to prevent cyber intrusion and data breaches. Techniques that can be used are verification and validation, Personal Identification Number (PIN), Card Verification Method (CVM), National Vulnerability Database (NVD), and Common Vulnerability Exposure Database (CVE)

Table 2. Preventive precautions and recommendations that can be taken by users and preventive techniques.

Cybercrime	Preventive tips and recommendations to enhance the security of social media platforms	Preventive Techniques to enhance the security of social media platforms
Cyberstalking, Cyberbullying	<ul style="list-style-type: none"> <li>•keep a low personal profile while utilizing privacy settings.</li> <li>•Use a nickname on social media platforms.</li> </ul>	Rule mining, text mining, signature-based data mining, and cyberstalking

	<ul style="list-style-type: none"> <li>•Updating and upgrading the software on time.</li> <li>• Use different email addresses for personal accounts and work.</li> </ul>	g detection framework.
Identity theft	<ul style="list-style-type: none"> <li>• safeguard all identity documents</li> <li>• Be alert about phishing and spoofing, can use strong passwords,</li> <li>• Add an extra authentication step to social media accounts</li> <li>• Check mails credit reports regularly</li> <li>• Monitor financial and medical statements regularly</li> <li>• Destroy expired driving licenses and other identity documents</li> </ul>	Three-factor authentication, biometrics, anti-virus software, genetic algorithm, logistic regression, hidden Markov model, and outlier detection. To prevent credit card fraud can use the techniques such as Address Verification Service (AVS), Card Verification Value (CVV), hidden Markov model, decision tree, and genetic algorithm
Social Engineering and Phishing	<ul style="list-style-type: none"> <li>• Shouldn't provide details unless verifying the identity of websites, emails, and other messages.</li> <li>• Should refrain from sharing any</li> </ul>	One-time password (OTP), CAPTCHA, digital certificates, genetic and



	<p>personal or financial information on social media.</p> <ul style="list-style-type: none"> <li>• Can directly contact the relevant organization to verify the doubts about emails or messages.</li> <li>• Installing anti-virus software, firewalls, and email filters help to reduce social engineering and phishing attacks.</li> </ul>	<p>attribute-based anti-phishing algorithms, and neural networks</p>
<p>Burglary using social networking</p>	<ul style="list-style-type: none"> <li>• Don't share locations when sharing photos</li> <li>• People can share their posts only with their friends and followers.</li> <li>• Through the settings and privacy of social media accounts, people can avoid being tagged in other people's posts.</li> <li>• Limiting connections on social media.</li> <li>• Don't share personal information like address, phone number, birthday, workplace, day to day outings on social media</li> <li>• Use security cameras, door locks, motion-activated lights, etc. at homes and workplaces to get extra security.</li> </ul>	<p>Genetic algorithms and case base reasoning, time-series approach, multi-layer perception, rule-based induction, random forest-based model</p>
<p>Malware</p>	<ul style="list-style-type: none"> <li>• Installing anti-virus software</li> </ul>	<p>Signature-based malware</p>

	<ul style="list-style-type: none"> <li>• Updating and upgrading software on time</li> <li>• Shouldn't click suspicious links and avoid downloading unsecure documents.</li> <li>• Aware of the URL of websites are secure or not</li> <li>• Installing a firewall</li> <li>• Regular backup</li> </ul>	<p>detection, anomaly-based malware detection, hybrid features, assembly instructions, N-gram models in Natural Language Processing (NLP).</p>
<p>Cyber-casing</p>	<ul style="list-style-type: none"> <li>• Switching off Global Positioning System (GPS)</li> <li>• Don't share vacation photos publicly on social media before returning home.</li> <li>• Avoid sharing the daily routine of life on social media.</li> <li>• Use online tools such as geoimgr.com to remove the geolocation of images</li> </ul>	<p>Support Vector Machines (SVM) classifiers</p>
<p>Cyber intrusion and data breaches</p>	<ul style="list-style-type: none"> <li>• Upgrading devices</li> <li>• Enforcing Bring Your Device (BYOD) policies</li> <li>• Enforcing multi-factor authentication.</li> <li>• Deploying an intrusion detection and prevention system</li> </ul>	<p>Verification and validation, Personal Identification Number (PIN), Card Verification Method (CVM), National Vulnerability Database (NVD), and Common Vulnerability Exposure</p>

		Database (CVE)
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#### IV. CONCLUSION

The above statistics prove that cybercrimes via social media are gradually expanding with each passing year. If people give priority to personal security, most of the cybercrimes through social media can be reduced. Most people are victims of cybercrime because of their negligence. This paper discussed seven major cybercrimes that can occur through social media, as well as the tips and techniques that users can undertake to minimize cybercrimes. As discussed in this paper, most social media-related cybercrimes can be avoided by sharing photos and other personal information only with friends, using separate email addresses for personal and professional accounts, adding an extra authentication step to social media accounts, strengthening passwords while using unique passwords for different social media platforms, and limiting connections on social media platforms. People shouldn't provide their details unless verifying the identity of websites, emails, or messages, and shouldn't share locations when sharing photos. And people can enhance their security by installing anti-virus software, firewalls and updating and upgrading software on time. Apart from that, this paper discussed the preventive techniques that can use by social media companies and other cybersecurity authorities to enhance the security of social media platforms and these techniques include Natural Language Processing techniques, Neural Networks, Genetic Algorithms, Biometrics, Digital Signature, etc. It can be concluded that most social media-related cybercrimes can be minimized if people use the above-discussed cybercrime preventive tips for their social media accounts. In addition, cybersecurity authorities and social media companies should use preventive techniques discussed in this paper to enhance the security of social media platforms.

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## Six Thinking Hats Method for Lateral Thinking in Software Development Organizational Problem-Solving Process

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**Abstract** - Six Thinking Hats is a method that presents different thinking styles required by an individual while effectively analysing a given problem. The method gives different thinking perspectives used in a systematic problem-solving procedure using different coloured hats. By considering each coloured hat, one is able to focus on the different styles of thinking patterns and scopes associated with each coloured hat, so that the same problem can be analysed in different angles. This method supports lateral thinking and new outputs during problem-solving processes. So, the optimum solution for the considered problem can be found. In this paper, the researcher discusses how to adopt the Six Thinking Hats technique in an organizational problem-solving process. Each Six Thinking Hat is considered to be an independent entity in the thinking process and contributes to predominant personality trait classification with various categories of personnel. In such cases, thinking styles are also associated with these particular personnel/major decision-makers such as CEOs, directors, project managers, administrators, software developers and business analysts. This paper also considers the importance of the Six Thinking Hats method in individual and group thinking in solving software development organizational problems. The paper contains the attitudinal relationship in decision-making using the Six Thinking Hat technique, particular personality types associated with the thinking hats process, and use of this technique in organizational problem-solving Processes.

**Keywords:** *Six Thinking Hats method, lateral thinking, managerial problem solving, organizational decision-making process*

### I. INTRODUCTION

Dr Edward de Bono introduced this technique called the Six Thinking Hats [1]. The technique introduced different thinking styles from different perspectives that are correlated with a different coloured hat. This parallel thinking approach gives insight to the employees and managers in business organizations to analyze a problem from several dimensions. By considering each type of hat, the manager focuses on the style of thinking associated with each colour. For example, meanwhile imagining from the red hat perspective, the manager will state what they feel about a particular situation. While imaging from the yellow hat the manager tends to think about the positive factors of a problem or situation, while the green hat encourages the managers to adopt the creative approach to give the problem to solve. The Six Thinking Hats encourage even the most negative manager in an organization to think of the positive ways, solutions for a given situation. By adopting this Six Thinking Hats technique the managers get a lateral way of solving a problem. Such lateral thinking for organizational problems helps to understand the problems quickly, develop solid solutions generated from different thinking styles, also give the chance to quickly identify alternative solutions to given problems by analyzing such solutions in different perspectives using parallel thinking. The six thinking hat method can be used parallelly with other problem analysis techniques such as SWOT analysis, PEST analysis, or ABCD analysis Technique including ABCD framework and ABCD listing. Other methods such as Critical incident technique: a learning intervention for organizational problem solving and developing ideal system concept and comparing it with practical systems to improve the practical system's characteristics towards ideal system characteristics. In this paper, researchers have

analyzed the use of the six thinking hats technique in the managerial problem-solving Process. A comparison is made between six thinking hat technique and traditional methods like typical interviews or discussions. Also, the importance of the six thinking hats technique in individual and group thinking in solving organizational problems is discussed. The paper also mentions the relationship in decision making using the six-thinking hat method, personality types that are associated with each thinking hats process, and usage of this technique in organizational problem-solving methods.

## II. EXAMINE THE KEY ASPECTS OF DE BONO'S SIX THINKING HATS MODEL

The imagination of wearing different coloured hats, De Bono has designed a model which when applied correctly the person can think critically and create opportunities for solving any problem that might be considered a complex one. The model shows De Bono's belief that "simple methods used effectively are more valuable than complicated methods that are difficult to understand and confusing to use" (De Bono, 1992: p. 6). In explaining the philosophical prospect of these six coloured hats thinking model De Bono (1992) [1] says that "when we attempt practical thinking, there are three fundamental difficulties" (p. 8) that encounters. He identifies those difficulties and explains them as 1) Emotions. We often have a tendency not to think at all but to rely on instant gut feeling, emotion, and prejudice as a basis for action. 2) Helplessness. We may react with feelings of inadequacy: "I don't know how to think about this. I don't know what to do next". 3) Confusion. We try to keep everything in mind at once, with a mess as a result (De Bono, 1992: p. 8). [1]

Then, how does De Bono's method of wearing the six different thinking hats enable them to overcome these mentioned three difficulties? The power of De Bono's-colored hats method addresses these difficulties and

the ability of the hat wearer to take off one coloured hat once they have finished deciding to use it and wear the other one. The process of wearing different coloured hat enables the wearer to bring a different perspective to thinking critically about the considered issue and to trying to find alternative solutions to any

problem. Arguing that "Emotions at the right place in thinking are essential [but] emotions at the wrong place can be disastrous, [De Bono, 1992] the six hats method allows to use emotions and feelings at the right place" (p. 8). Arguing that helplessness arises when don't have a clear plan of action to take when confronted with a problem, De Bono (1992) suggests that the wearing of different coloured hats "provides us with a basic framework for thinking actions and define next steps that can be taken" (p. 8) to solve the problem. And as for the third problem, De Bono (1992) says that "confusion arises when we try to do too much at once, but the six hats method allows us to take one direction at a time" (p. 8). [1]

The six thinking hats method represents six different cognitive approaches for critical thinking and analysis. to understand the problems and issues and helps to come up with an appropriate logical solution. In the method, the six hats are coloured as Black, Blue, Green, Red, White, and Yellow, and each coloured hat represents a different logical approach to critical thinking about a problem and helps to solve it. Figure 1, which summarize the conceptual thinking associated with each hat. De Bono (1992) says that "the six hats method allows students to think more richly and more comprehensively" (p. 15). [1]



Metaphorical Coloured Hat	Conceptual Meaning of Each Coloured Hat
	<b>Black Hat Thinking</b> <ul style="list-style-type: none"> <li>• Cautious critical thinking</li> <li>• Questioning, checking and checking out the feasibility of alternative approaches to problem solving</li> <li>• Assessing situation being confronted</li> <li>• Trying to identify what's wrong so as to fix it</li> <li>• Examining the weaknesses in suggested approaches</li> <li>• Evaluating and passing judgement about bad points</li> </ul>
	<b>Blue Hat Thinking</b> <ul style="list-style-type: none"> <li>• Organisational critical thinking</li> <li>• Metacognition</li> <li>• Questioning organisational thinking to problem solving</li> <li>• Assessing past performance</li> <li>• Analysis of our situation:               <ul style="list-style-type: none"> <li>◦ Where have we been? Where are we now?</li> <li>◦ Where do we want to be? How do we get there?</li> </ul> </li> </ul>
	<b>Green Hat Thinking</b> <ul style="list-style-type: none"> <li>• Creative critical thinking and problem solving</li> <li>• Coming up with the ideas to advance understanding</li> <li>• Critical analysis of alternative ways to solve current problem</li> <li>• Envisioning new ways to solve problems</li> <li>• Coming up with hitherto non-considered proposals</li> <li>• How about trying this new approach to problem solving?</li> </ul>
	<b>Red Hat Thinking</b> <ul style="list-style-type: none"> <li>• Critical thinking expressing personal emotions</li> <li>• Being intuitive as we approach a problem to solve</li> <li>• Drawing upon personal feelings and hunches</li> <li>• Allowing feelings to be expressed without need for justification</li> <li>• It is okay to feel different</li> </ul>
	<b>White Hat Thinking</b> <ul style="list-style-type: none"> <li>• Calling for information that facilitates problem solution</li> <li>• Gathering data to understand the issue or problem to solve</li> <li>• Asking questions about available evidence</li> <li>• Raising questions about additional data needed to get to the truth.</li> <li>• What information do we already have? What does it tell us about the problem?</li> <li>• What more information do we need to solve this problem?</li> </ul>
	<b>Yellow Hat Thinking</b> <ul style="list-style-type: none"> <li>• An optimistic approach to problem solving</li> <li>• Here are the good points in our favour as we approach this problem.</li> <li>• These are our strengths that we can use to solve this problem.</li> <li>• We can do this because of these reasons.</li> <li>• This alternative approach will enable us to solve the problem because of these attributes.</li> <li>• This option will work because of this.</li> </ul>

Figure 1. A synthesis of De Bono's Six Thinking hats model.



Source: Using De Bono's Six Thinking Hats Model to Teach Critical Thinking and Problem-Solving Skills Essential for Success in the 21st Century Economy, Charles Kivunja

Referring to Figure 1, De Bono's model presents six different coloured hats. Each hat represents a different way of thinking and how to deal and think critically about how to solve a problem. As summarized in Figure 1, the black hat is for caution in critical thinking. De Bono has chosen the colour black for the cautious critical thinking perspective because the word critical has its origin in Greek where it means to judge. De Bono (1992) So, the colour black is appropriate for this way of judgmental thinking because it represents a serious consideration of problems to solve. Also, the black hat is associated with thinking that always questions and checks the feasibility and validity of proposed solutions, evaluate them and pass judgment. One may think it's too dark a thinking method to follow. But it does not represent negative thinking. De Bono (1992) says, "With the black hat, the words checking and checking out are very important to explaining its uses. These words convey the essence of critical thinking—and do not carry a negative image" (p. 31).<sup>[1][2]</sup> This shows that critical thinking which provides caution also helps to solve the problems. Critical thinking and problem solving while wearing the black hat create a good opportunity for assessing the possible consequences of decision maker's decisions and can save the costs of implementing doubtful strategies or disastrous courses of action.

According to Figure 1, wearing the blue hat brings the perspective of organizational critical thinking and metacognition. This remark blue hat thinking different from all the other hats because while the other hats are concerned with thinking about how to solve a particular problem, blue hat thinking is focused on thinking about thinking that will lead to a solution. Also, blue hat thinking brings to the critical thinking and problem-solving process which involves active control over the cognitive processes in seeking a reasonable solution to a considered problem. It helps to identify strategies and to plan activities that can be implemented to solve a given problem. De Bono mentioned its colour as: "We can associate the blue hat with the blue sky which is above everything. If we were up in the sky, we

could look down and see what was happening on the ground below. With the blue hat, we try to rise above the thinking that is taking place and to get an overview of this thinking. With the blue hat, we try to take charge of our thinking to organize what is going on. (De Bono, 1992: p. 102). Blue hat thinking pattern gives a special way to critical thinking and problem solving which helps to define and get a clear idea about the nature of the problem and then set clear objectives or target to solving the problem. Also, helps to identify alternative steps to be taken in the pursuit of the solution, assess again and again to made clear progress in solving the problem, and continually decide about the next steps to takes place towards the planned output.

Referring to Figure 1 can identify that the green hat is for creative critical thinking and problem-solving.

De Bono (1992) explains the essence of the green hat perspective when he says: "We can look at the word creative in two ways. The first way means "generating, producing, creating something which was not there". The second way means "having new ideas, fresh ideas and ideas that have not been used before". (p. 72)

Also, De Bono (1992) says that the colour green conjures up images of nature and vegetation and so green can easily symbolize the productive capacity and energy bound in the natural resources. It brings to the critical thinking and problem-solving process new insights, new possibilities, new suggestions and proposals which did not offer before. So, it represents thinking creatively and innovatively. "This means moving forward to possibilities and new ideas" (De Bono, 1992: p. 72).[1]

Also, Figure 1 shows that the red hat brings the table to the critical thinking and problem-solving process opportunities to express personal emotions. These are expressed without fear of being judged and with no need for justification. Emotions and ideas are shared under a free environment and free expressions.

If considers a group, group members are free to say how they feel about an approach being taken in attempts to solve a problem, without having to explain the particular idea, or giving excuses/reasons for their feelings. Because there

is freedom of expression and no need for justification. All participants are free to express their feelings without pretending to be logical and rationalising for those feelings. This hat creates opportunities for participants to be real, not pretending, and free to hold on to their beliefs. De Bono justifies the use of red for this hat saying, "Think of the redness of fire. Think of anger and joy but also warmth and contentment. The red hat includes both intense and more gentle feelings" (De Bono, 1992: p. 87).

Also, under the red hat, there are feelings, emotions, and intuitions. The emotions brought to the thinking process with this hat include many emotions such as joy, fear, anger, jealousy and sorrow. Feelings are much broader than emotions and include likes, dislikes, anxiety, uncertainty, interest, excitement, aesthetics,

respect and camaraderie. Intuitions are even broader than emotions and feelings. They surface when one acts instinctively without subjecting their actions to rationalization. They might be logical, but they involve no deliberate cognitive processing, and their probabilities are unknown. Essentially, red hat thinking helps to answer the question "What do I feel about this?" [4]

In Figure 1, white hat thinking brings critical thinking and problem-solving process requests for information that is needed to help solve the problem at hand. Its focus is on three questions; "what information do we have? and to increase the information base, what information do we need? and how do we get the information we need" (De Bono, 1992: pp. 57-58). Also, the white hat thinking provides for going out to collect that information. This involves a single person as well as a group searches for information. De Bono says this type of thinking with the white hat associate information with a typical typed report which provides information on white paper. He also mentions the information in computer printouts which are conventionally produced on white paper. Also, De Bono associates with the colour for this hat is information in newspapers which is again conventionally printed on white paper. He extends his justification for associating the colour white to information by suggesting that the whiteness signifies neutrality and objectivity of the information sought while wearing this hat because all that this hat seeks is

"just information, with no suggestions, ideas or arguments. Feelings do not come into it. Never mind the arguments. What is the information here?" (De Bono, 1992: p. 57). This hat determines its integrity and validity. When the manager wears the white hat it brings a proactive approach to go out and look for data so that members of the group rather than waiting for a problem solve automatically but look for information on how it might be solved.

Referring to Figure 1, yellow hat thinking gives the critical thinking and problem-solving process a sense of optimism and determination to succeed. It is looking for the strengths that have and the opportunities that the situation presents to the team. It seeks the present strengths and successes to advance to project success. Current success rate courage for further success and open up for new opportunities. This hat leads to alternative options that can improve performance and effectiveness of decision making. De Bono (1992) says it involves looking for four facts; "(1) good points, (2) benefits (3) reasons why an idea will work, (4) likelihood of success" (p. 44). De Bono[5] associates this optimistic approach to problem-solving with the colour yellow because he says, "Yellow can mean sunshine and optimism and looking on the bright side of things" (p. 43). This optimism is based on supporting evidence and is not just fantasy or mere wishes driven by emotions. This differentiates between the emotions brought to the critical thinking and problem-solving process under red hat thinking. The optimistic approach not only leads to a great outcome but also analyses the benefits that can flow from those great outcomes and why the actions taken would lead to improved results. The yellow hat, "A suggestion is made, a solution is offered, a plan is put forward. The benefits that are claimed for each of these are going to come in the future. ...we must have good reasons for claiming that these benefits will come through" (De Bono, 1992: p. 43).

### III. SIX THINKING HATS ANALYSIS: MANAGERIAL PROBLEM-SOLVING PERSPECTIVE

The researchers conducted a observation sessions and interviewed 10 different software companys and sample development teams to

understand the nature when it comes to decision making. Considering gathered data, when making decisions about important things in a software development team, it is not easy to conclude which is common factor. The usual traditional approach of communication and thinking is indeed not lateral. Especially when an individual or team decision needs to be taken, it should be collaborative, supportive, 360 degrees thinking, understanding from all angles and then reaching a decision. Researchers found that the six hats thinking extremely useful in the decision-making process both in personal and professional life. Considering the organizational context, a decision to fill a software project manager position may involve various concerns. The question is should promote an existing person from a lower-level position and give time for him to fit the requirements of the functioning or should keep it open and recruit a person from outside who experienced, has an impressive track of record but who might demand much higher amount salary than what you have to pay for the insider. Giving opportunity to the insider will boost the morale of all employees who looking for their turn in future promotions at the organization. It will be rewarding for the promotee too. The organization will save much revenue on paying him or her but will be able to pay much less amount after he or she is trained enough. Also, he or she knows the particular frameworks and procedures used for software developments of the particular organization. So The danger of wrong decisions or delay is lesser than recruiting outside software project manager even temporarily. If the organization have never been anticipating this to happen and have not designed a careful career plan for the employees it is going to be very tough in the end. In either case, a delay of decision is bound to hit the company reputation, revenue and overall business process drastically.

Dr Edward de Bono's Six Thinking Hats outlines different thinking styles that are associated with a different coloured hat. The organization should imagine they are wearing a particular hat when taking decisions.

A summary of each hat for managerial aspect is outlined in figure 2:

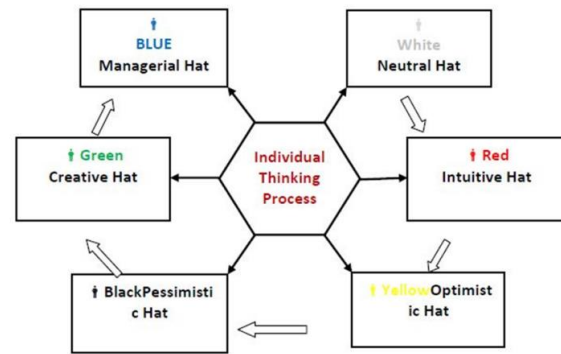


Figure 2. Block diagram connecting six thinking hats to the individual thinking process.

#### A. White: Neutral Hat

White hat's role is to collect data, facts, stats and create information that function as foundations for thinking. In this case, find out the educational qualification like PMP qualified or not, experience in Agile/Scrum project management, and performance of the employee taken into consideration. Collect information on the salary and benefits he or she is getting now and that of the position to which considered. Also gather information on the extent of expertise required for the position of software project manager, the profile of aspirants in the job market in the software development industry and their expectations. Look at the organization's interest up to what limit it can afford to pay or not, the possibility of merging the responsibility with another position.

#### B. Red: Intuitive Hat

The red hat will use feelings and emotions of intuition to find appropriate solutions to the problems. Analyze the feelings of the other software development teams or director board about the decision, what it means to the organization, to the employee to be considered, to his or her superior, and to other employees in the company. Motivation, morale, personal flexibility to work, the relationship between colleagues, how he or she treats others, anger management ability, status quo, changing relationships, all emotional aspects required consideration.

#### C. Yellow: Optimistic Hat

Yellow hat's role is to logically present positive plans of action to be taken that will help overcome the problems in reality. Consider his or

her potentials. How he or she has been doing in his previous jobs to the date, active contribution to the given tasks, ability to grow, self dives, capacity to assume responsibility, respect the command, the loyalty displayed to the organization and the team and above all the company's recognition of his potentials by providing an opportunity to him, and how challenging he will take it.

#### *D. Black: Pessimistic Hat*

The black hat is considered a bad one because of its negative approach. But it is one of the most important hats because it will help to get a better understanding of the pitfalls of your thinking pattern. In this case, can look at the cost of probable damages due to the new promotee's inappropriate managerial decisions. Consider the cost and time required to train him/her. What if he or she fails to live up to expectations even after a given period? What will happen if he or she could not deliver the expected outcome on time? If he or she has poor communication with the client and create problems what kind of damage can happen? What would be the consequence of his or her own wrong decisions on the professional capacity and organizations trust in that person? If recruit new buy how would the outsider adjust to the organization's culture? How long he will last? How to assure that he or she will perform well. If performance is not up to expect what kind of decision to be taken regarding such issues. These are the facts consider when it comes to black hat.

#### *E. Green: Creative Hat*

Green hat role is to bend the rules because of its creative thinking pattern, to think out of the box and expand the possibilities of the improbable in unique ways. The Green hat will help to come up with creative solutions and opening the doors to new opportunities and avenues of thinking. For example, if an organization thought to build a holographic agent program that acts as a software project manager or a project manager sound like Siri.

#### *F. Blue: Managerial Hat*

Blue hat's role is to manage and direct the thinking process, sort out all possible alternative solutions and apply managerial techniques. Finally, knowledgeable to choose best among the

options. Indeed, this phase; managerial problem solving is very challenging. This is the phase they decide whether they recruit outsider or promote insider and train or build a programme which can act as a software project manager.

Even though the Six Thinking Hat model seems specifically targeted as a personal problem solver who or in group decision-making context related to academics and business. But this six thinking model can use for organizational level too which suggests different types of thinking according to six thinking roles for which differ from colours. Through practice and systematic implementation of this process, no one will ever feel the need to give up searching for a perfect solution to the problems or circumstances using this method.

#### **IV. SIX THINKING HATS ANALYSIS: GROUP DECISION MAKING**

In this phase when deciding on a group, members assume different hats of thinking and go forward to share the ideas according to the hats. Different kind of views which can be collect, access and use for effective decision. The key factor in using the Six Thinking Hats and applying them in practical situations depends on the clear understanding of the process and facts that the hats are used for. When considering a specific problem or topic it is recommended to start with the white hat which allows all the foundation information to present and documented. Once the problem is clearly identified and defined then the red hat is used to ask questions from participants about how they feel about the problem or current situation. Then participants' emotions, feelings and reactions are documented. Then next is to use the yellow hat to capture the positive factors of the problem from all participants. Then follow with the black hat. After the black hat process is done then follow the green hat where encouraged to use creative thinking to overcome the issues and develop new alternatives to solve the problems. The red hat usage of at this stage to consider the feelings of group members. Normally, group members who were previously too concerned about the problem now might feel more positive towards the situation after going through the process of using the different hats. As the final phase, use the blue hat which allows group members to evaluate the proposed process has offered proper solutions. Also, the blue hat provides

process control to ensure the right approach was taken by group members. If the solution was not identified, then another process would be suggested as most relevant to solve the problem. Details of such a process are given in table 1.

Table 1: Attitudinal relationship in decision making using six thinking hat technique

Colour of Hats	Basis	Consideration	Attitude	Action
White	Quantitative thinking	Use of facts and figures.	Judging	Apprise the entire background situation
Red	Humanity based thinking	Absorb feelings in form of comments, criticism and careflessness	Assigning	Unearth negative consequences
Yellow	Optimistic thinking	Based on hope, positive and speculative	Defining	Exploring strengths
Black	Negative thinking	Based on negative consequences	Redefining	De-limit drawbacks
Green	Creative thinking	Based on ideas and lateral thinking	Refining	Considering alternatives
Blue	Managerial thinking	Based on planning, organizing, and controlling	Appropriating	Taking appropriate decision

## V. SIX THINKING HATS PROCESS ACCORDING TO PERSON

Each of the six thinking hats considered to act as an independent entity in the thinking process and such attributes affects personality traits. The personality types and the co-relation between hats given in table 2.

Table 2: Personality types associated with thinking hats

Colour of Hats	Way of Thinking	Personality Trait	Type of persons
White	Neutral Quantitative Thinking	Quantitative thinking using facts & Figure	CEO/Administrator/ Stakeholders
Red	Humanity thinking,	Humanity based Thinking based on ethics, Values, emotions & feelings	Human Resource employees
Yellow	Optimistic or Positive thinking	Optimistic thinking based on hope, positive & speculative	Board of Directors
Black	Pessimistic thinking or Negative thinking	Negative thinking based on comments, critics, cautious & careful	Managers
Green	Creative and Innovative thinking	Creative thinking based on ideas and lateral thinking	R&D department employees/ Innovators/ Scientist
Blue	Managerial thinking	Managerial thinking based on planning, organizing and	Managers/Executives



		controllin g aspects	
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## VI. USAGE OF SIX THINKING HATS IN ORGANIZATIONAL PROBLEM SOLVING

Every organization has a specific goal and a set of the objective to achieve along with their vision and mission. Organizational managers have the utmost responsibility to fulfil organizational objectives by making the right decision at right time considering short term and long term problems. Many methods have been used in organizations to find optimum solutions like organizational behavioural theories and operational research techniques. The Six Thinking Hats method can be used in the organizational problem-solving process. This method can use by managers to identify and analyse organizational problems in a logical way. When governing can use six thinking hats method in organizational problem solving and should consider these facts such as Organizations are complex human initiatives which involve functional interrelationship and interdependency, Organizational problems create many complex situations which take considerable time to decision making process, the major challenge is to create the most effective solution in the minimal period, managers have to think from different angles to understand the dimensions of the given problem, data gathering (objective and extensive), consider all qualitative and quantitative information for the decision-making process (White hat).

Next, consider the human factors affected and all made decisions (Red hat), Positive solutions should not overlook because they are vital to any good decisions (Yellow hat), Negative factors of any decision should analyze in caution (Black hat), Creativity is must for good decisions. This will involve risk-taking but also gives the advantage of lateral thinking (Green hat), Then the application of managerial thinking leads to planning upcoming processes, organizing, and controlling to get better solutions (Blue hat), Success of organizational decisions depends on the action taken from team members and organizational problem solving is challenging for top management.

## VII. CONCLUSION

Individual decision making for a managerial problem is by itself very difficult when it comes to organizational matters. The group decision-making process is much efficient considering individual decisions. In the end, efforts made to systematically analyze the problem and leads to various alternative solutions to choose from. In this systematical decision-making process, the six thinking hats method can play a major role in the organizational problem-solving process where a manager or team of managers work for effective decisions. Considering that each subject matter and personality traits of the six hats help the organizational problem-solving process. Six Thinking Hat as a method will help the manager to take control of his problems effectively. With the practice and systematic implementation of the six hat thinking method, the managers will never give up searching for an ideal solution to organizational problems.

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# Automated Web-Based Inventory Support System for Retail Shops in Sri Lanka

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**Abstract** - The inventory of materials is the main piece of current resources and work in any association. The primary disadvantage of the current framework is the absence of information on present day advertising and stock administration keeping up client base, and because of this, it is hard to have a daily perception in the field of stock administration issues, and how to utilize it positively. Most retail shops are actually run with conventional paper-based frameworks because of the absence of information and consideration, helpless deal figures, staying aware of changing client assumptions and holding clients, and discovering innovation issues with the board in the retail shop. This framework requires every client and customer to get to the framework in anyplace and any time, and the framework is created as an entrance electronic application. Further, it tends to be distinguished the cycle the framework information sources. Accordingly, this research paper predominantly gives a powerful answer for the issues featured and to improve the effectiveness of Sri Lankan retail shop stock with emotionally supportive networks. The proposed framework will associate business persons and providers into one stage and store data about stocks, reordering, adding provider subtleties and stock status. The exploration is dependent on the mechanized online stock emotionally supportive network for retail shop, and it is refreshed to an electronic, computerized framework. This inventory support system will permit productive and overseeing of stock things, provider measures, and the treatment of the shop book-keeping and business.

**Keywords:** *inventory, framework, retail shop*

## I. INTRODUCTION

The normal issue with regular old style store is still utilizing a manual framework for keeping up their information, for instance physically recording receipt of client and provider just as keeping up client information. At the point when the products are stock out, the proprietor need to go to other town to purchase things, and it regularly occurs. Subsequently, trust utilizing great arrangement that can take care of these issues with utilizing innovation. Presently a day the quantity of little and huge retail shops is expanding step by step. Study shows that the shops neglect to keep up their item accessibility with at least conceivable stock expense. To beat these issues, legitimate stock emotionally supportive network is important. Inventory support system is the process of ensuring appropriate number of stocks as to be able to meet customer demand without delay. In the developing country, the inventory support system is the main factor to modern super markets, middle super markets, middle level retail shops, and small groceries are available in Sri Lanka. The lot of people in this country use and visit to buy items, products, medicine and etc. at those shops and supermarkets. Using these things people can choose relevant productions and items, available time and facilities due to their preference for buying and selecting items. In finding the problems of existing small and rural area retail shops maintain systems and upgrade that manual system to automated computerized system, this program allows the manual record book system to be replaced and can accelerate information processing, storage, and retrieval.

Therefore, reduce the difficulty of the current manual system and make it convenient for users

to use. In these small retail shops, they record shop details and supplier's details day-to-day status in small books. Sometimes these record books can usually be the major problem for retail shop systems. These record books can be lost, misplaced or destroyed in unexpected incidents and sometimes shop keeper forgets to update or written details. As a result of these reasons can be occur shop privacy and it may be compromised and other works also cannot do properly because shop keeper also have to have to look at other services also. However, the advanced technology is there are few areas in which the retail system may be improved. In the sector of retail area, the inventory support system will help to expand and grow.

So I have implemented this automated web-based inventory support system for overcome those barriers and difficulties. As a conclusion, this research will discuss the effective inventory support system for retail shops, shop keeper and suppliers through the automated system and how to do the process using this system in an effective way.

## II. LITERATURE REVIEW

This research focused on reviewing the problems with the current small retail shop system and how to convert it to an automated computerized web-based inventory support system there are several kinds of existing systems and experiments that may be used to get a better idea of the technologies that have been adopted by other researchers used in this proposed system. New features have already explored in order to improve this system. This literature survey will provide insight into how other researchers approached their study and applied their findings.

Presented paper under the topic "Inventory Support System for Retail Shop". The point of this research is look at the how inventory is required in all activity for gathering, creation, shop supplies or deals or deals to a client? How inventory should be kept up intentionally address the issues of the market, if the great is stock out, the client would be baffled and they would not be accepting on them and they may lose benefits? A helpless stock administration framework might be shown by the disappointment creation plans, helpless gauge,

and insufficient execution revealing the investigation started with an assessment of the development and different kinds of stock emotionally supportive networks. The theory has been applied to different frameworks to decide their utilization and benefits. Stock emotionally supportive network execute dramatic Smoothing is a technique for anticipating that is not difficult to utilize and has been effectively carried out in a few unique kinds of organizations to be utilized as a source of perspective conjecture interest. Outstanding Smoothing first thought was established and clarify simple exponential smoothing can be composed by in conditions and utilize gauge blunder for proportion of determining precision and prescient ability is the premise of examination of the chose models.(Tanamal, Nurdiansyah and Firdaus, 2020)

Presented paper under the topic of "Inventory Control System by Using Vendor Managed Inventory" business complexity gave to address inquiries regarding how organizations manage day by day changes, what business activities can anticipate and get ready organizations for change in accordance with innovative advancements with speedy and sensible data trade, business measures particularly for controlling stock can develop quickly. One of the strategies that oversees stock is the inventory emotionally supportive network. It gives full right to the providers to control stock and oversee measures of items stock for stores. Stock emotionally supportive network performs straightforwardness of deals information and stock levels to the providers. This framework reacts rapidly and effectively in addressing client needs just as being a conclusive factor for business endurance and advancement of business forecast. Stock emotionally supportive network is a stock and acquirement approach, in which provider is liable for overseeing and refreshing stock. This appears to negate the rule of pull booking, since the past cycle choosing how a lot and when it will be shipped off the store, retailer. In all intents and purposes the data reference lies with the store, retailer through deals data. (Sabila, Mustafid and Suryono, 2018)

This study researches the issues with stock-outs have been capable adversely prompting client disappointment. Suitably firms are changing

their methodology by utilizing monetary request amount and reorder point for consumer loyalty. Stock supportive network the executives should be coordinated in a consistent manner with the goal that the association can have the option to realize when to request and the amount to arrange. Examination of the explanations of the stock supportive network shortcoming in firm is essential. Individuals explored the purposes for the stock emotionally supportive network failure in firm by execution of ABC method. An investigation uncovers that stock administration at Amara Raja Electronics Ltd. The things under this characterization conspire are orchestrated in plummeting requests of their unit cost. The arrangement of the things dependent on unit cost is chosen totally by the administration. It assists administrators with taking choice on purchasing arrangements which implies things ought not be requested more than required amount. The recurrence of stock checking is additionally started by this technique. Most important things are requiring regular stock checking. (Biswas et al., no date)

The fundamental principle of this investigation transfer is that higher assistance quality improves consumer loyalty, bringing about better monetary execution and the systems by improved happens change. Giving exact proof at the client, specialty unit and firm-level that different proportions of monetary execution (counting income, income change, edges, return on deals, market worth of value and current profit) are decidedly connected with consumer loyalty. (Vu, no date)

For a proficient and compelling stock administration an association ought to have the option to decide how much stock ought to be held at a specific time, when to reorder, what is the lead time the end client will acknowledge, what stock model best suits the association and how could the stock framework be controlled. This investigation expressed that month's end stock level is a key exhibition measure for most retailers consequently stock administration is vital for the accomplishment of any association. Apart from that it is realized that one of the destinations of stock control is to expand the degree of consumer loyalty by abstaining from under-loading. Achievement in production network the board typically gets from

comprehension and dealing with the connection between stock expense and the client assistance level. (AO and, 2015)

This investigation depicts the elements there are two frameworks that addressed the operationalization of the stock control a framework that depends on the assurance of the ideal time for the recharging of the stock, characterized by the second when the supply of a material arrives at certain level that flags the requirement for an extra and a second framework on which is set the recurrence in which stocks will be checked on and in view of existing stock levels for the dates of modification are resolved the amounts needed for the substitution of the stock. Stock administration should consider all expenses brought about of any choice or procedure that will be utilized in the association. Underway designing, stock administration is in activities that permit the manager to analyze whether the stocks are large very much utilized, all around found, all around took care of and controlled. Stress that every association should assess set and structure your own approach of stock and that it is completely lined up with the destinations and the idea of the organization and vital arranging is likewise fundamental for the foundation put forward their objectives of buying and stock, driving the organization to sort out their objectives inside the work market. (Menegon Bristot et al., 2018)

This part presents extensive outline of various recommendations for the choice supportive network for client request estimating and stock administration of short-lived products. Just as the strategy for rendering a high number of individual clients into few groups of clients with comparable interest conduct. The defeat in this examination constructs a reasonable number of conjecture models and apply them inside every client portion. Researched the appropriateness of article bunching and progressive estimating as a feature of a choice supportive network that improves the requesting interaction to build the assistance level. This examination proposed framework addresses by giving interest figures to all articles at store level and provincial level. (Sridama and Siribut, 2017)

This study basically recognizes the issues in stock administration at chose store to research the



variables and causes add to helpless stock administration at relevant store and to decide the arrangements towards the issues of helpless stock administration at chose store. Stock administration lead to stock decrease as is regularly the situation in without a moment to spare (JIT). This methodology of stock administration brings extensive expense reserve funds from lessens stock level and therefore, inventories have been diminishing in numerous organizations found that carry out higher levels of JIT fabricating practices ought to beat contenders who don't it was additionally tracked down that a positive relationship exists between firm productivity and how much waste-decreasing creation rehearses, like decreased set-up occasions, preventive upkeep projects and uniform responsibilities are executed. (Laily Binti Md Hashim et al., 2017)

Study in this paper is consider about enhancement of both amount of request and selling cost together, considering EOQ model for things with deteriorating nature. It depends on the couple of suppositions like pace of interest is reliant upon level of stock showed on rack just according to unit selling rate, additionally, the space for stock presentation is limited. Two numerical models are concentrated to examine the further re examined EOQ demonstrating for acquiring greatest benefits and furthermore foster models for such upgraded arrangements. Legitimization and investigation of the work created and considered is done through affectability examination and mathematical models. (Goyal and Pandey, 2018)

According to the research paper of "Effectiveness of vendor managed inventory systems in retail supermarkets in 'discovered that VMI significantly diminished stock completing expenses and stock issues while simultaneously it offered the capacity to synchronize both stock and transportation choices. The capacity to design better on inventories and conveyances are frequently referred to as significant benefits to the upstream part utilizing VMI and fostered a scientific model to ascertain stock levels and conveyance rates to limit costs for little providers compelled to utilize VMI by bigger customers. One significant finding of the investigation was that decreasing changeability in the sum and timing of the interest expanded the advantages of

brought down costs. (Kaira Irungu and Wanjau, no date)

Pointed under this paper to look at the basic food item production network to distinguish the serious drivers in the production network. In here distinguished set practices, which whenever carried out, could considerably improve in general execution of the store network and showed that by facilitating the speedy and precise progression of data in the store network precisely than the current framework. From ECR, the idea of constant recharging strategy (CRP) is created is a move from promoting items from stock holding regions to maneuvering products onto staple racks dependent on customer requests. (Tyan and Wee, 2003)

This research explores item inventiveness and detectability in an inventory network diminishes manufacturing, extortion building up client affirmation. This is mainly helpful for extravagance things reasonableness, endeavor class versatility and simple administration of shared data, advanced characters, passwords, and archives large enterprises will represent the most elevated blockchain piece of the pie in retail-based industry. (Rajapaksha, 2020)

This paper tracked down that critical, positive connections between deals, the reliant variable and both stock levels and product assortment and exhibit how the expansion of an adequate substitute thing builds administration level as far as accessibility. Likewise, if new things are substitutes for different things going after purchaser dollars more note worthy assortment will in general bring more clients into the store. Utilizing more stock is expected to cover the expectation of higher deals. (Dubelaar, Chow and Larson, 2001)

Introduced paper under the point "Retail location Execution: An Empirical Study". contemplates report that such issues emerge essentially because of store and dissemination focus renewal measures, promoting, stock administration and representative turnover and control for store fixed impacts, stock, and publishing uses and as in their work track down a positive and huge connection among stock and deals at the store level. Just as find that senior supervisors methodically made rectifications on robotized request advices either by moving

requests from top days to non-top days or by changing the request size. (Fisher, Krishnan and Netessine, 2013)

This paper show that RFID labeling enhances the impacts of five (thing cost, deals speed, deals volume, stock thickness and item assortment) of these determinants of stock record mistake (they tentatively control for the impacts of the other two determinants: review recurrence and dispersion structure). For instance, the (positive) impact of deals speed on stock record incorrectness is directed by stock perceivability because of RFID labeling. Moreover, appropriate to the ebb and flow research they exhibit that item classes portrayed by the determinants of stock record mistake showed the best improvement in diminishing error because of RFID labeling. That is the item classes that showed the best abatement in stock record error were those wherein the items had higher deals speed, lower thing cost, higher deals volume, higher stock thickness, and higher item assortment. Subsequently, they expect that such item classifications described by determinant of stock record error would see the best decrease in stock outs because of the presentation of RFID labeling for these item classifications. (Hardgrave, Goyal and Aloysius, 2011)

In short there are various writing audits and practices about stock administration models in the retail business. In any case, there is a conspicuous pattern in this load of models is the expanding reliance on ongoing information and data innovation to hinder the cons of the hypothetical supposition of "steady interest". Simultaneously the detonating effect of volume and speed of information produced from stock framework has caused traditional stock framework unequipped for handling that enormous measure of large information. Subsequently there is a rising worry about the utilization of enormous information examination to all the more likely anticipate request and thus improve stock emotionally supportive network and the executives.

### III. METHODOLOGY

The following diagram shows the re-engineered business process with the automated web-based inventory support system.

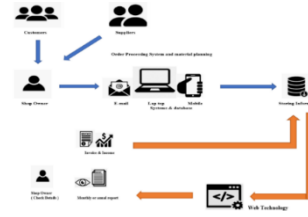


Figure 1. Proposed solution

As demonstrated in the figure over the proposed framework the give office of online assistance measure for the providers, retailer and retail shop. Retailer can add the providers without help from anyone else and ask for mechanized reordering items and things by sending email to purchasers. At the point when we need to stock things in the shop and can advise the providers and can speak with their contact subtleties. (Item name, selling individual or the organization, contact number) Then an instant message will produce and ship off the provider's email. When the provider go to the retail search for the help will be give including the subtleties of the mentioned administrations. The framework client can check whenever what are the things are free or not in the store and can check current status in the retail shop. Moreover, it will deal with the records about the buying of the items to the retail shop.

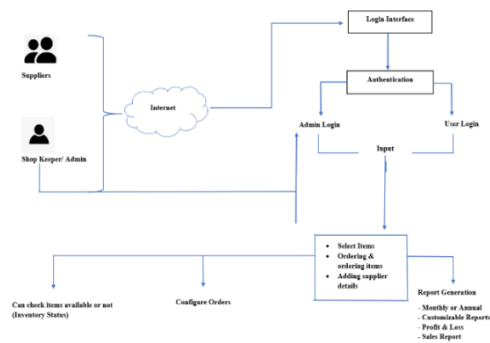


Figure 2. overall system architecture Source: (Author)

As technologies for developing the system as front-end application and I choose as front-end application and Ichoose HTML, CSS and JavaScript. As well as back-end I choose Laravel, Apache, PHP and MY SQL used for database.

### IV. RESULTS & DISCUSSION

In these outcomes and conversation is appeared what are the outcomes and investigation that I have established by distributed examination papers and from the providers the individuals who come frequently to retail shop to offer their

types of assistance and from the proprietor (retailer) the individuals who work in limited scope retail shop. I utilized a few strategies like surveys, interviews, recorded perceptions and document perceptions to accumulate the data about subtleties of stock emotionally supportive networks of chosen retail shop. By following those procedures and techniques and all including these examination articles I distinguished that what are the disadvantages of manual retail shop frameworks and what are the highlights that could be execute in the wake of fostering the manual retail shop frameworks as mechanized frameworks. As per this investigation at last recognized the significant highlights that could be carry out subsequent to fostering the manual retail shop the board frameworks as mechanized frameworks.

### I Login Module

The login function should be used to access system users. To log into the system, users should already have username and password.

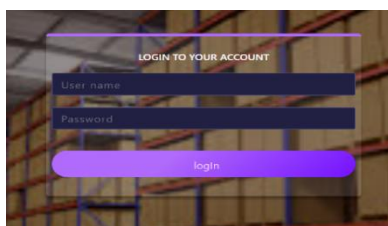


Figure 3. User Login for Admin

### II Adding users

All the external users can add to the system only admin he must gave to them to password and after adding to the system they use their login name and password.

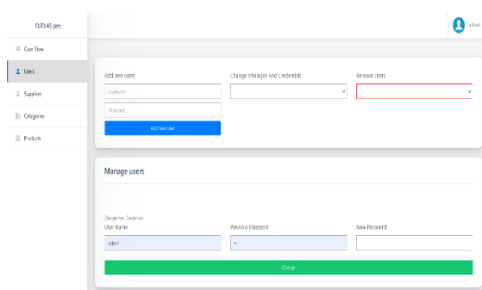


Figure 4. Add users by Admin

### III Add Products and categories

In here let them to suppliers to what products need to the retail shop and admin can reordering products and add product name, product code, maximum discount, marging likewise

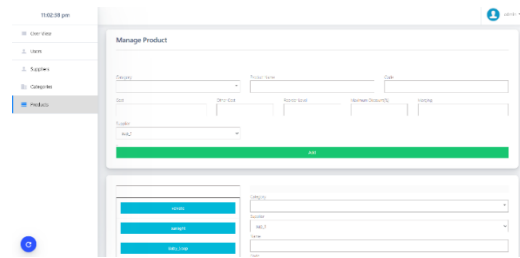


Figure 5. Add products by Admin

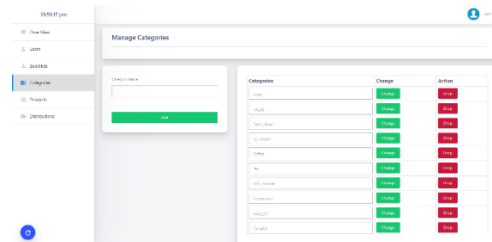


Figure 6. Add categories by Admin

### IV Manage reordering products process.

Before coming to the retail shop, the shop keeper be able to check the shop available items and products. This may be helpful to the retail shop because when the available atock is decreasing in the shop users can put email and order items.

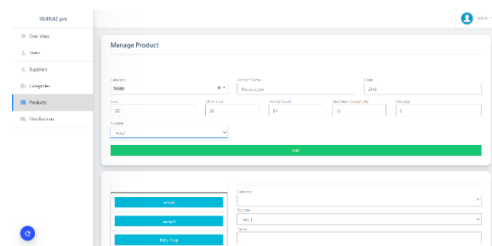


Figure 7. Reordering products by Admin

### V Manage selling and store products details

In a product selling service task, there are number of processes that associate with it. The system should store details about the tasks which are done during the service process.

### VI Manage sold details related to the retail shop details

There are financial related details that generate in the retail shop process. The system should be able to maintain records of these details.

### VII Provide retail shop history records.

One of the major requirements of inventory support system is to keep the shop and customers updated with the details. So, the system should provide detailed reports of the retail shop process history records.

#### *VIII Manage product details related to the service process.*

There are various products associates with the retail shop process. So the organization is purchasing these items from various suppliers and use in the service process and sometimes the customer can separately purchase these items. The system should be able to manage this information.

#### *IX Manage products bar code to the system.*

So the item codes permit to settle on choices dependent on the item expiration. Even on the off chance that it is absurd if the lapse date is close to retailer can give or offer percent esteem off and sell items.

The framework produces vital offices for the adding new highlights for the retail business. After the providers offer support can oversee appropriately utilizing shop measure. In this framework utilizing business person can know about item scanner tag subtleties when close to termination, cash swapping scale for selling things and items, adding day by day insights and producing reports (profit up and misfortune, customizable reports, monthly and yearly reports) in like manner. Utilizing these procedures and strategy business person can without much of a stretch control the all the interaction in the retail shop extremely powerful and proficient way.

The inventory status of the products on the store and it gives data to providers to decide if to reship the merchandise in controlling the store's Inventory. The ready status is deciphered as a notice to quickly take care of business as per the necessities. Stock emotionally supportive network is safer as a result of safe stock computation and stock reestablishment so that can be steady. Safe stock guess that is constantly refreshed every day permits deals exchanges to be accomplished more with stock of existing items on the store. Observing the stock status of the merchandise in the store can give stock data before the stock sum is running out, so the conveyance of products can run again as per the requirements of the store.

## **V. CONCLUSION**

This investigation adds to the disadvantages of limited scope retail shops the individuals who actually utilize manual frameworks for the administration obligations of the retail shops. What's more, the consequences of this investigation dependent on not just the disadvantages of manual retail shop administrations just as the significant highlights that can be executed in the wake of fostering the retail shop framework the executives as mechanized online framework and admittance to the both relevant gatherings of providers and the businessperson to access of the framework. This framework equipped for oversee shop subtleties, providers' subtleties and dissect all necessities of providers and manager of the system. Owner of this system(shop attendant) framework zeroed in fundamentally to offer amazing assistance for the providers as keeping a stock help the board framework is securing clients with the protection and can admittance to the framework by web application, and it works with more highlights to them, for example, report their previous exercises never really shop measures, check the accessible items and necessary things and receipt history subtleties of the past selling's and different works, Profit up and misfortune and thinking about next requesting and so on. This framework gives the offices of send email to the providers to help about the available stocks to remember the shop. In end, in the shopper engaged economy, it is basic that retailers should use their significant data resources for acquire an all encompassing comprehension of clients, items, market requests and supply chains. The target of this examination is to research how retailers deal with their stock framework.

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# Menstruation Cycle Information Analysis for Pattern Recognition: Determination of Algorithm on Stakeholder Requirement

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**Abstract** - The menstrual cycle of a healthy woman is systematic and individually unique. As it is directly related to a woman's physical and mental health, the menstrual cycle plays a major role in individual nutrition, social and psychological decision-making. As women frequently forget the exact date of menstruation, lots of mobile apps are developed to assist them. All such apps use 28 as the approximate date, but the experiences are very dependent. Therefore, to utilize individualized menstruation cycle guidance app development, it is required to develop an algorithm to predict the date of menstruation. Then the objective of this work is to study the collection and analysis of field data to realize what model is suited for cycle prediction. The data was collected using 30 women between the ages of 20-35 with their menstrual cycle dates for one year. Then this time series data was analysed using cumulative moving average (CMA), and Auto-Regressive Integrated Moving Average (ARIMA). The analysis shows both methods can predict menstrual dates with an average accuracy of 90%, which is acceptable to the purpose of the work. However, it is decided to use either method to predict the menstrual date for users who newly registered or use the app for less than one-year period, as the utilized data set limitations. It is required to analyse more advanced seasonal level prediction models when the app is evolved with more users and collecting data.

**Keywords:** *menstruation cycle, prediction, women*

## I. INTRODUCTION

### A. Background

Menstruation is the shedding endometrium of the uterus that occurs once a month. This happens due to the hormonal effects on the body during puberty and menopause in women. Moreover, this is an individually unique cycle, and if this is systematic, it is considered one of the hallmarks of a woman's health. The process can be described as preparing the woman's body for pregnancy once a month, creating specialized tissue in the uterine wall to feed a fertilized egg, but removing previously created specialized tissue when the egg is not fertilized. Counting fertile times for pregnancy, using birth control methods to prevent unwanted pregnancies, and identifying pre symptoms about their body are the main procedures performed using the menstrual cycle. Also, due to the chemical reactions that take place in this process, the body undergoes physical and mental processes (Hillard, 2014).

Furthermore, based on the date of menstruation (after this known as date), it could understand if a woman's body is fertile. Therefore, women need to know the date of onset of menstruation to prepare their bodies physically and mentally and use the contraceptive methods required to conceive or prevent unwanted pregnancies. Hormone levels and body age, mood, diet, action and physical disorders, body weight, smoking, drug use, and stress are all factors that contribute to an irregular menstrual cycle, and the menstrual cycle can be used to diagnose preterm and gynaecological conditions. Hence, women need to know the approximate date (Bae, Park and Kwon, 2018).

### B. Problem

The menstruation cycle is mainly based on the dimension of dates, and those dates need to be counted and memorized. Nevertheless, it is not easy with day-to-day works of gender-specific works. Commonly women practice manual marking on the home calendar or mobile application. However, to predict the next date, many women and most mobile applications use 28 as a recurring cycle. Nevertheless, due to the individual cycle is dependent on the dynamic factors, the accuracy of the predictions becomes very low. Therefore, most women find it challenging to prepare physically and mentally and understand their reproductive health symptoms.

Therefore, the present work's base-work requires to development of a mobile application to provide the woman with a reproductive health plan based on the date. Then to predict the date, it required a better algorithm, and when searching the literature, it found that several works were carried out to develop an algorithm to predict the date accurately. However, most of them are based on evolutionary algorithms and machine learning. Apart from that, for predictions, there are various complex statistical models such as Seasonal Auto-Regressive Integrated Moving-Average (SARIMA) and Holt Winter's Exponential Smoothing (HWES).

Nevertheless, the present work is sufficient to have an 80% accurate prediction. Furthermore, through the initial discussion in base-work, it found that women need to know the exact date, but they, more importantly, look for cycle-related notices and guidelines, such as food and vitamins suggestions (Uthpala and Pradeep, 2020). Hence, rather than accurate prediction, it required individualistic cycle guidance from the future mobile application. For that, it required a straightforward methodology to suggest a prediction for of date.

### *C. Objective*

This study is being done to find a satisfactorily accurate straight statistical model to find the pattern related to the menstrual cycle in women

## **II. LITERATURE REVIEW**

Considering the algorithm to be used for the forecasting process, it can be considered that it is possible to proceed successfully by deriving a

value given by a moving average. In predicting the date of menstruation, future predictions can be made by a moving average based on two dependent variables due to the presence of two simple data, the date of menstruation, and the length of menstruation. Parekh and Ghariya used three methods for this time series analysis named Simple Moving Average (SMA), Cumulative Moving Average (CMA), and Weighted Moving Average (WMA). And showed that the first two methods are best for data analysis in any application. In the case of a simple moving average, the prediction process is continued by finding the mean of the two segments and using that value to predict the value of the next segment. In their research, it used to find the mean between the menstrual days of the previous two months and use that average value to predict the menstrual day of the next month. When searching the cumulative moving average, it calculates the average value by making a cumulative of all existing data as it is based on the availability of the data (Parekh and Ghariya, 2015).

Hansun also evaluates the use of a moving average for future forecasting processes in periodic analysis. They offer five methods adding Exponential Moving Average (EMA), and Weighted Exponential Moving Average (WEMA) to the aforesaid three methods. Focusing on those methods, there is a drawback in the EMA, WEMA, and WMA, compared to SMA and CMA. That is, although all three methods, WMA, EMA, and WEMA, are derived from SMA, they add more weight to the new data values. Therefore, since the SMA and CMA methods have equal weight values, and do not affect other weight factors, the menstruation date prediction process can be done better, simpler, and more efficiently (Hansun, 2016).

Fattah evaluates the use of forecasting for identifying future demand by analysing the historical data. These data do have not any order. Because of that forecasting methods use to categories these data in the correct order. Automated Progressive Combined Movement Average is called ARIMA. Use for statistical and economic, and especially time series analysis and identify the behaviour of given data set. Model is a generalization ARIMA model. Automatic Progressive Movement Average (APMV) is the

parallel methodology the same as ARIMA. Two of those modes are compatible with statistical information to perceive the information or predict the longer term of the series. ARIMA model is that the correct and best-suited methodology used for time prediction. The accuracy of the developed model was evaluated by scrutiny the experimental and the simulated amendment of the information within the same amount. Therefore, this model is often accustomed analyse and model the demand during this situation. The ARIMA procedure of the SPSS statistic module permits estimating the coefficients of the models that have antecedently known by providing the parameters  $p$ ,  $q$ , and  $d$ , employing a quick most chance estimation algorithmic rule. ARIMA has been able to achieve successful results when compared to other methods. Because the release of high precision results has enabled the successful completion of several projects. Also, researchers recommend ARIMA for time series analysis and future forecasting (Fattah et al., 2018).

Karnaker, Halder, and Saeker introduce SMA as a method used to smooth out deviations, and variations over short periods, as well as to show conditions over long periods, and to use the forecasting process after obtaining the mean value after observing the entire dataset. And this responds and confirms the resistance, and support in every single vary. That is an advantage of SMA. Also, the CMA calculates the average value of all the data in a data stream (Karmaker, Halder and Sarker, 2017).

Numerous prognostication models are planned to search out an efficient methodology that will be applied to sensible things. These techniques principally deem complicated statistics, AI techniques, and enormous amounts of meteorological and topographical knowledge. Ideally, these ways minimize the chance of failure among the energy system and forecast its reliability by modelling or simulating future eventualities. The on the market prediction models may be classified into three main classes like qualitative techniques, quantitative techniques, and artificial neural networks. Qualitative techniques square measure supported professional opinion and private judgment. Quantitative techniques square measure supported mathematical models, which

may be any classified as statistic or causative prognostication techniques. ARIMA is not a simple method. It requires more experience and knowledge to maintain the standard and provide quality outcomes. Causative prognostication is employed to spot relationships between dependent and freelance variables. the standard of causative prognostication models depends on the accuracy of the input factors. thanks to the high fluctuation of things poignant radiation, however, the provision and accuracy of those models are questionable. ARIMA is thought to be a modern technology, which applies once all the fairness information is lengthened and the correlation between past observations is stable. Many studies in the literature have used the ARMA and ARIMA models for radiation predictions. The ARMA and ARIMA models are additionally compared in terms of suitability values designed to enable log-probability to function. As a result, the best statistical models for prediction and the corresponding parameters can be determined in detail. Several possible comparisons are made for forecasting purposes. In the previous work, the forecast function of many models did not have an adequate and temporal sequence of information (Alsharif, Younes and Kim, 2019).

Apart from the utilized methods, the Auto-Regressive Integrated Moving Average (ARIMA) also has been identified as a powerful fundamental prediction model in statistical studies in the subject area.

The present work selected CMA and ARIMA which represent two prominent predictions used in the present discipline of the study as candidate methodologies to be automated in the app development.

### III. METHODOLOGY

The present research proposed to predict the next date of a woman based on the average dates of the past data available. First, it has done a literature review to identify the suitable statistical models which can be used for time-series data prediction. Then to find the accuracy levels of different prediction models, it launched a field data collection. The resulted data set was analysed using two candidate models and make recommendations.

### A. Data Collection

Then, a random sample of 30 women between the ages of 20 and 35 years was selected, and data were collected using a well-designed structured form. When this form was set up properly, several steps and versions followed the standard and structured the form. It was first sent to a peer batch mate to get feedback on the form's shortcomings and where it needed to be redone. Subsequently, the form was sent back to 3 other women to inspect the existing adjustments in the new version, redesigned in response to those responses, and to receive feedback. In this way, the correct new version of the form (as shown in Figure 1.0) was created based on the feedback received so that the form fillers could easily and clearly understand and sent to the selected sample of 30 women.

The sample of the women was instructed to fill out this form. Then in the month, the survey was started, the 30 women were contacted on a separate telephone conversation to find out the date of their menstrual period over the phone, and with the help of that date, the researcher updated a separate sheet (As shown in figure 2.0). The researcher also instructed the 30 women to fill the monthly report, including their menstrual dates. Throughout the year, both the forms were filled by each woman and the author. After doing so, the researcher performed an analysis of the accuracy of the dates in the updated forms. Subsequently, the classification process for the analysed data was carried out over the phone with the 30 women.

<u>Monthly Data Entry Sheet</u>				
Code Number				
Date (the first date of the cycle)				

Figure 1. Form filled by a woman (English Translation)

<u>Monthly Data Entry Sheet</u>				
Code Number				
Code Name		Tp. No		
DOB		Education		
Marital Status		Known Cycle length		
Date (the first date of the cycle)				

Figure 2. Form filled by the researcher (English Translation)

### B. Data preparation

The first is to study the data set and removed such outliers. The removing considerations are failing to mark more than 20% of the dates, and women started to use birth control pills, drugs for menstrual cycle issues, and alcohol. Eighteen women in the sample failed to fill out the form for various practical reasons, such as suffering from illness during that month, personnel reasons, social needs, and ethical conditions such as losing close relationships where the author also loses control of acquiring data. Also, 10 out of the remaining 12 women successfully and systematically presented to the researcher a set of data that included the first day of their menstruation. After interviewing the other two again, it could obtain missing data. Furthermore, after collecting the datasets, the dates were sent back to the 12 women for certification and utilized in analysis with their consent.

Further, it found that abnormal cycles varying from 45 to 56. Then those outliers were normalized using equation 1.

$$CD_n = \left( \frac{CD_{n-1} \cdot CD_{n+1}}{2} \right) + CD_{n-1} \text{ ----- Equation 1}$$

Where  $CD_n$  is the date of the abnormal cycle,  $n$  is the date.

### C. Data Analysis

Initially, using the CMA (equation 2) and Auto Regression Integrated Moving Average (equation 3) the collected data were analyzed.

$$CMA_{n+1} = \left( \frac{x_{n+1} + nCMA_n}{n+1} \right) \quad \text{-----}$$

Equation 2

Where n in sequence number of data, x is data.

$$y_t = \varepsilon_t \sum_{i=1}^q \theta_i \varepsilon_{t-i} \quad \text{----- Equation 3}$$

To do the data analysis process using ARIMA model, initially, a time series plot was constructed to identify the nature of the menstruation cycle lengths of women and that is shown in Figure 3. And in there, menstruation cycle lengths of a particular women with WID 01 were considered. This is because from woman to woman, the menstruation cycle, which is caused by the hormonal effect on their body, shows a unique pattern to each other.

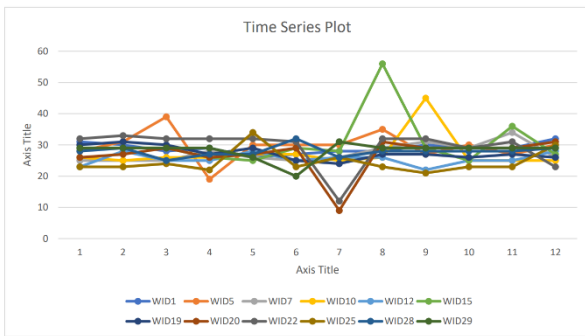


Figure 3. Time Series Plot time to identify the nature of the menstruation cycle lengths of women

And to do the analysis in that time series, used two functions named Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF). They are initially similar to each other, but the two functions differ from each other in the process of incorporating or excluding the correlations in the calculations.

According to the ACF plot given in the following figure, up and down fluctuations can be identified. Also, autocorrelations of all lags are insignificant except the initial lag.

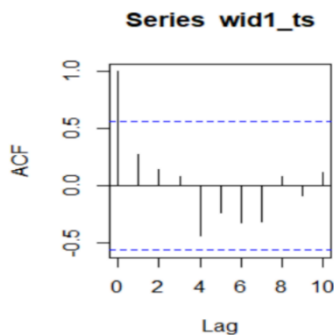


Figure 4. Autocorrelation Function plot

According to the PACF plot partial autocorrelations of all lags are insignificant.

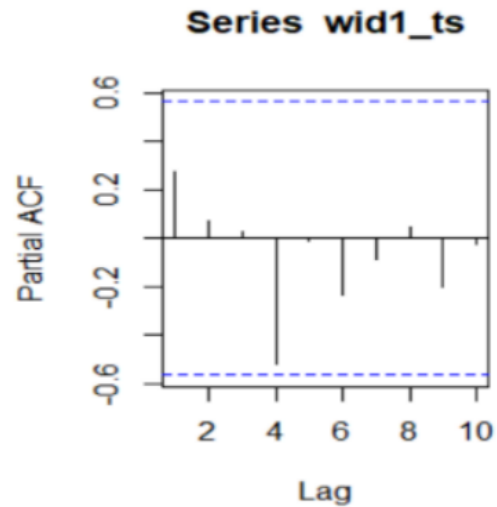


Figure 5. Partial Autocorrelation Function plot

In the checking process of the analysis, Stationarity of the original series was checked using Dickey-Fuller test.

Hypotheses for test the stationary of series:

$H_0$ : Series is not stationary

$H_1$ : Series is stationary

Table 1. Augmented Dickey-Fuller Test Data

Dickey-Fuller	Lag order	p-value
-3.3235	0	0.08841

According to the Table 1.0, p-value obtained by Augmented Dickey-Fuller Test is not less than 0.05 at 5% level of significance. It concludes that the original series is not stationary.

Since the original series is non-stationary the first difference series was considered.

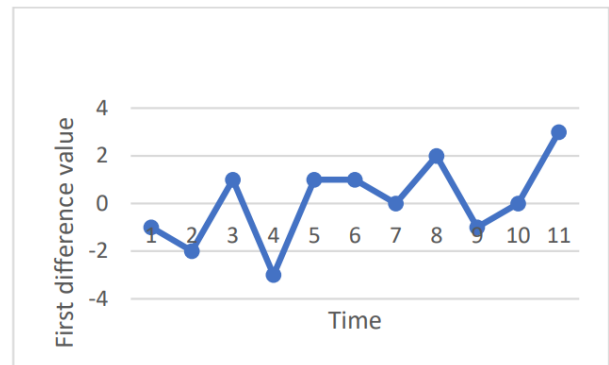


Figure 6. Non-Stationary Original Series



Stationarity of the first difference series was checked using Augmented Dickey-Fuller test.

Table 2. Augmented Dickey-Fuller Test Data

Dickey-Fuller	Lag order	p-value
-4.6522	0	0.01

According to the Table 2, p-value obtained by Augmented Dickey-Fuller Test is less than 0.05 at 5% level of significance. It concludes that the first difference series is stationary.

Since the first difference series is stationary and ACF plot depicts that the autocorrelation of all lags is insignificant except the first lag and further PACF plots depicts that the partial autocorrelation of all lags is insignificant, ARIMA (0,1,0) model was decided to develop.

So, summary of ARIMA (0,1,0) model can be defined as follows.

Table 3. Summary of ARIMA (0,1,0) model

sigma <sup>2</sup> estimated	log likelihood	aic
2.818	-21.31	44.61

Table 4. Box-Ljung Test Data

X-squared statistic	df	p-value
12.234	10	0.2697

According to above Table 4. p-value of the test statistics provided by Box-Ljung test is greater than 0.05, Ho: cannot be rejected at 5% level of significance. Therefore, it concludes that the fitted model is adequate.

And to analyse the appropriateness of a linear regression model use the Residual analysis. So, should do a Normality test for residuals.

Normality test for residuals:

Hypotheses for the Shapiro-Wilk normality test:

Ho: Data are normally distributed

H<sub>1</sub>: Data are not normally distributed

Table 5. Anderson-Darling normality Test Data

AD statistic	p-value
0.21752	0.7936

According to the Anderson-Darling normality test result, P-value of AD statistics (= 0.7936) is greater than 0.05. Therefore, Ho is not rejected at 5% level of significance and concluded that the residuals are normally distributed.

Also, according to results of the residual analysis, it can be identified that the underlined distributional assumptions of residuals are satisfied by the fitted model. The verification the accuracy of the fitted mode is shown in Table 6.0 as a Summary of the ARIMA (0, 1, 0) model.

Similar procedure was carried out for menstruation cycle lengths of other women and the following results were shown in the Table 6.

Table 6. ARIMA prediction accuracies

Women ID	ME	RMSE	MAE	MPE	MAPE	MASE
<b>Regular</b>						
WID1	0.08591667	1.6073	1.252583	0.1168456	4.360667	0.9185611
WID7	0.41875	2.466452	1.91875	1.186714	6.50708	0.917663
WID19	-0.3939803	1.781854	1.374286	-1.682596	5.19745	0.889244
WID28	0.169	2.738625	1.835667	0.1094403	6.622261	0.9178333
<b>Irregular</b>						
WID5	0.08566667	7.664859	5.252333	-3.988727	20.34526	0.9170741
WID10	0.002166666	8.010413	3.8355	-2.869634	12.4637	0.9171848
WID12	0.1685833	2.549518	1.83525	0.194647	7.22495	0.917625
WID15	-0.08091667	12.04506	7.252417	-5.194676	20.93612	0.9169722
WID20	0.002166666	8.736898	4.668833	-13.32729	28.70533	0.9170923
WID22	-0.08066667	8.046744	3.919333	-8.578921	20.59257	0.9172908
WID25	0.001916666	4.966559	3.001917	-1.640782	11.6066	0.9172523
WID29	0.002416665	3.763873	1.83575	1.83575	7.001574	0.917875

According to the accuracy measurements given in the Table 6, accuracy measurements (RMSE, MAPE) are significantly small for the models fitted for the menstruation data of each woman with regular cycle length compared to the women with irregular cycle length.

## IV. RESULTS AND DISCUSSION

### A. Sample Size

The study has only 13 data instances for a single woman. As the studied works of literature proved the utilization of three data to accurate prediction. Further, for software development evaluations Pradeep and Wijesekera, (2012) mathematically proved that thirteen samples can be utilized to achieve more than 85% accuracy. Hence the present study satisfied with the sample size.

### B. Sample data

Among the woman who participated in the study, 42% were married and 58% were unmarried. 50% of the sample have completed the advanced

level education and 25% each completed either ordinary level education or territory education. The distributions of age and occupancy levels are shown in Figures 4, 5 and 6.

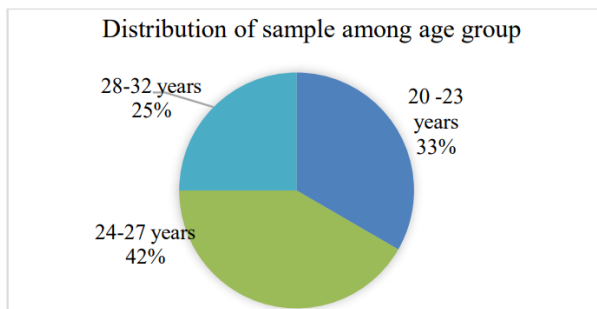


Figure 7. Age groups distribution of the sample

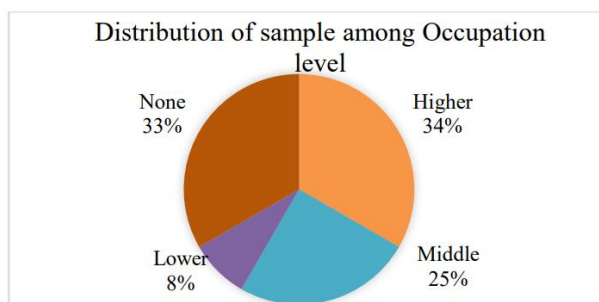


Figure 8. Occupation level distribution of the sample

As the base work is targeting to develop a mobile application for younger women, it can predict that the Higher 34% Middle 25% Lower 8% None 33% Distribution of sample among Occupation level 20 -23 years 33% 24-27 years 42% 28-32 years 25% Distribution of sample among age group selected sample is fit with the study and facilitate make suitable decisions.

### C. Sample data

Table 7. CMA prediction accuracies

ID	Age	Occupation Level	Marital status	Average days of Mensural cycle	CMA Method	
					Average Variance of the prediction	Prediction Accuracy
1	22	Top	Yes	28	2	92.9%
2	22	No	No	28	2	92.9%
3	23	No	No	28	2	92.9%
4	23	Middle	No	28	1	96.4%
5	24	Middle	No	29	2	93.1%
6	24	Middle	No	30	2	93.3%
7	26	Top	No	26	3	88.5%
8	27	No	Yes	30	4	86.7%
9	27	Low	No	25	1	96.0%
10	28	Top	Yes	24	2	91.7%
11	32	No	Yes	25	1	96.0%
12	32	Top	Yes	28	2	92.9%
Average				27.4	2	92.8%

The CMA and results are shown in Table 7.0 and ARIMA results are shown in Table 5.0. Identically both the results show very high accuracy, i.e., 92.8% in CMA model and low error rate in ARIMA

model consecutively. However, as shown in Figure 4.0, there is no collectively significant effect of utilization of amount of data to the prediction. When individually calculate the correlation between the number of cycles used and prediction variations, the coefficient average is 0.007, the median is -0.001 while the maximum value is 0.622 and the minimum is -0.584. Further, the result shows that the calculated average menses cycle (27.4 days) is in the commonly accepted range of 28.

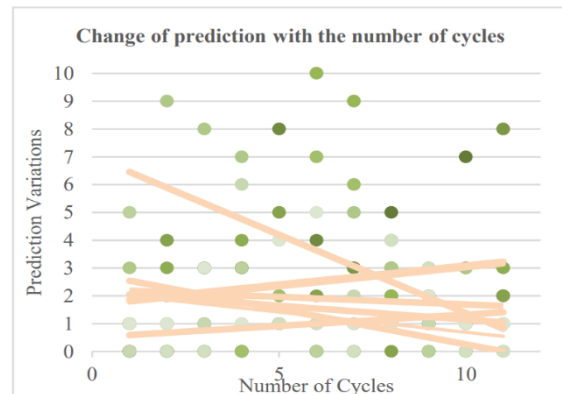


Figure 9. Number of cycles effect on the prediction accuracy

When compare the CMA and ARIMA results, the ARIMA result is much accurate than CMA. However, to calculate the ARIMA it needs to develop excessive software codes than the CMA and also ARIMA model is suitable for only regular menstruation patterns. As well, the prospective mobile app is planned to commence the calculate the mensural cycle using the value given by the user. Then it must provide prediction with the minimum usage of data. Hence, the app needs to change its cycle calculation method with time. Then it is suitable to utilize the simpler CMA method which utilizes fewer resources to develop and deploy at the initial stages.

### V. DISCUSSION

Even though the menstrual cycle of a healthy woman is systematic, irregularities are inevitable. Hence prediction of the mensuration cycle needs to be realistic to the application, rather than the absolute accuracy. Then, the present work is required to select a substantial, simple, and straightforward method to calculate the next menstrual date for utilizing in the app development project.

A systematic field data collection was launched with 30 selected women but end up with twelve samples. However, the sample is appropriately distributed among the expected age group. Furthermore, rather than most of the availed data sets, present workable to administer to capture 13 events and 12 consecutive cycles. Therefore, the present research could evaluate the prediction accuracies for one year. Hence it considered the sample size is substantial for the research.

Among wide range of prediction models, then it used CMA and ARIMA methods which are popular fundamental timeseries statical methods. This is because the focus of this research is on identifying a menstruation cycle pattern that is unique from woman to woman, rather than identifying a menstrual cycle pattern that is common to all women. And those two methods are frequently used in the menstruation cycle calculation, the present work analysed the available data set. Both the methods provided resulted in high accuracies such as 92.8% (CMA) and low error rate in ARIMA model, showing confidence in the required mobile application development.

However, further analysis on the prediction accuracies found that the varying correlation between the number of cycles used to predict and the accuracy of the prediction from 0.6 to -0.6. Hence it can state that the software algorithm developers should pay more attention when utilizing either method of CMA or ARIMA to predict the individual women's menstrual cycle.

Starting from a simple method is more sustainable in software evolution as the management of the model is under the control of the programmer. Then the present work suggested utilizing the CMA, which is a less complex method to automate the menstrual cycle prediction, as the model needs to be customized in evolving passion.

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# Fault Detection of Mechanical Components using Machine Vision

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**Abstract** -In this paper, an automated system isolates defective bolts from conveyor belts to increase the efficiency and accuracy of detection compared to manual labor. This system consists of a conveyor system, a Raspberry pi development kit, and a high-quality pi camera. The image analysis is carried out using Convolutional Neural Network (CNN) to detect faulty bolts. Bolts that have dimensions outside the standard measurements are labeled as faulty in the proposed system. The prototype fault detection system implemented identifies bolts of various sizes from standards, with an accuracy of nearly 80%, which is a significant achievement.

**Keywords:** *machine vision, automation system, fault detection, CNN*

## I. INTRODUCTION

In the manufacturing industry, defect detection of mechanical components is crucial to maintaining the final product's quality. Thus, detection of faults in mechanical components has become one of the primary concerns. Object detection has many practical applications and also has long been studied through computer vision. Early faulty components detection is beneficial for reducing the emergency repair cost and abrupt failures of products.

A fastener is a piece of hardware that mechanically attaches two or more items. As an example, the mechanical industry uses bolts and nuts as fasteners. Hence, nuts and bolts are essential components of many machines, and they should be in standard size to facilitate seamless assembly of hardware. Before supplying these components (ex: - nuts and bolts) to the industry, it is critical to check the fasteners across standardized values (C. Bharathi Priya, V.Sudha, 2019).

In the manufacturing industry, products move through a conveyor belt from one point to another for packing. In the traditional setting, the quality check is performed during this stage to determine if the component is under suitable conditions. In manual observations, the quality check is carried out visually through random checks. When executing this manually, there is a risk of increasing the human errors as human performance can fluctuate time to time and person to person. This system, which is still in use, is relatively primitive and ineffective. There is a possibility of human errors occurring due to being continuously involved in checking mechanical components. When buyers are compelled to check for fault and non-fault mechanical parts at the purchasing point, the buyers' satisfaction will be lowered. This is a considerable drawback for the mechanical-parts industry.

In this project, detection of faulty components is a functional requirement, and accuracy, efficiency, and time-consuming are the nonfunctional requirements. Therefore, authors have introduced an efficient, secure, machine vision automation system for detecting the mechanical components which can be used in the mechanical component industry more securely. The system proposed utilizes a pi camera, a raspberry pi board, and captured images were examined using a custom-designed image analysis algorithm implemented on a python environment using the OpenCV library.

In this paper, section I deals with the introduction, Section II reviews the current work, the proposed system is explained in section III. Testing and results are discussed in section IV. In section V, a summary of the work is concerned. And finally, section VI discussed future works.



## II. RELATED WORKS

Recent works are carried out to detect faulty components using image processing techniques, which could increase effectiveness, accuracy, and time saving. This project makes a huge change in the mechanical-part manufacturing sector and can automatically increase the efficiency of the production line.

Few related works have used single board computers such as raspberry pi to detect objects in the industrial settings. The authors have considered the highest accuracy of detecting the faulty bolts as the performance matrix in such systems. Deviating from literature in the proposed system, authors mainly focus on implementing deep learning based architectures, specifically CNN to improve the fault detection.

Greg et al. utilized machine vision to detect "visual cue" problems in automated assembly line. The test was done on a laboratory conveyor that mimic a three-piece assembly line. Several standard webcams and LabVIEW image processing tool kit created the proposed a machine vision system. The technology's overall usefulness is restricted because it can only detect flaws that were recognized before creating vision systems. Edge detection, pattern matching, Geometric Matching, and Color Inspection are used as image processing techniques (Greg Szkilnyk, Kevin Hughes, Dr. Brian Surgenor, 2011).

MWP Maduranga et al. introduce a novel way to automate the sorting of types of tomatoes supplied in supermarkets of acceptable quality. Color sensors are used to detect the ripeness of tomatoes, where red tomatoes are labeled as ripe and green tomatoes as unripe. The display will reveal whether the tomatoes are ripe or unripe. As a result, tomatoes are categorized automatically based on their color features. Three CCD cameras and an image capture card make up the sorting mechanism. Color images are produced under compact light source. The frame grabber digitizes the analog signal received and gives three user-definable RGB buffers. It consists of a camera and conveyor system. and Image processing algorithms assess whether the tomatoes are ripe enough. (AH Abeykoon, ATK Raweendra, KMJ Perera, TCM Perera, HT Pathirathne, and MWP Maduranga, 2020).

R.T Elster et al. carried out their works on accurately isolating the egg from rest of the

objects in an image, while highlighting features of the eggshell, and discriminating between shell fractures and noise. The picture of the egg must be isolated from the rest of the background using image processing techniques to exclude the edge of the egg from the following edge detection method. The backlit image's illumination shows a great contrast between the crack and the rest of the egg. After processing, the backlit image revealed fissures in the form of brilliant streaks. Backlighting generates more contrasted visuals than the front and side lighting. Edge-based thresholding is proven to be more effective at isolating splits than single-line and variable thresholding strategies. The image of the egg must be separated from the rest of the background to exclude the egg's edge from the future edge detection method. They used edge-based thresholding techniques, enhancement, smoothing techniques, contrast stretching, and histogram equalization techniques (R. T. Elster, J. W. Goodrum, 1991).

This paper describes a method for detecting visual faults in empty bottles. The critical constraint is the real-time operation, since the bottles move along the conveyor belt continuously. The authors use the generalized Hough transform to find the position of the bottle in the image. To inspect the bottle's surface, RGB camera obtains photographs of the bottle from various angles at various positions in the conveyor belt. The authors have used three cameras to obtain a distinct perspective on the bottle under study. The goal is to locate the bottle and take pictures. Real-time object recognition using the Hough transform is employed for this. Once the position of the bottle in the captured image has been determined, to the system inspect the area of interest (in this case the bottle) for any faults. This stage necessitates a thorough examination of every pixel on the bottle (Faisal Shafait, Syed Muhammad Imran, Sven Klette-Matzat, 2004).

Yant et al. proposed an autonomous heliostat problem detection and diagnostic system for solar power facilities that employ machine vision technology and ordinary CCDs (a new method for automatic placement and problem detection of automatic solar heliostats). The vision-based heliostat fault diagnostics system observes the heliostat field with a CCD camera before using image processing to detect damaged heliostats. The proposed system firstly determines the presence of error, and secondly, provide

information on where the malfunctioning heliostat is located. Each heliostat is equipped with a hard reflective surface that can track sunlight. In the case that the heliostat fails, sunlight is not reflected on the receiver. To capture the image of the heliostat, a CCD camera is placed adjacent to the receiver. The CCD camera in this system can monitor hundreds of heliostats at once, allowing the system to diagnose hundreds of heliostats with just one camera. This will result in substantial cost savings (Yang Song and Wenjun Huang Xuemei Zhu, 2012).

Limei et al. present a deep convolutional neural network-based technique for detecting micro flaws on the surface of metal screws. Surface damage, surface contamination, and loose screws are among the defects. A visual platform for capturing screw photos was created, and a deep CNN-based approach was employed to detect micro defects on the surface of metal screws. At first image dataset of damaged and healthy helical characters were collected to train deep convolutional neural network (CNN). To achieve effective detection, first, the pixel area of the surface of the screw in the captured image was located. Then the detected screw surface information is feed it into a CNN-based defect detector. The CNN model is trained on large amounts of defective and non defective data captured using the proposed vision system. In addition, to acquire more abstract and more profound basic properties of the target, a nonlinear approximation of the activation function is applied. (Limei Song, Xinyao Li, Yangang Yang, Xinjun Zhu, Qinghua Guo and Huaidong Yang, 2018).

The prototype proposed in this work is implemented using Single Board Computer (Raspberry Pi) which is a low-cost solution. Also, the research investigates real-time application of ML in a single Board Computer. These are the two main novelities of the proposed prototype.

### III. PROPOSED SYSTEM

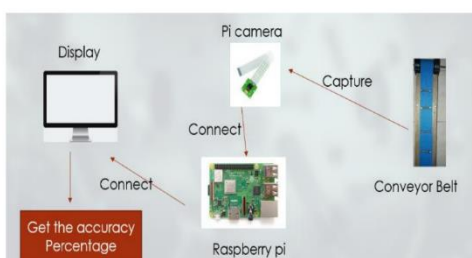


Figure 1. System Overview

#### A. Hardware Design

In the hardware implmention of the prototype, the conveyor belt moves the bolt from start to finish position. The camera is positioned above the belt, near the exist to capture an image (Camera is positioned as in figure 2) of the belt. These captured images are fed to the processing unit to retrieve the size of the bolt. In this project, faulty bolt are mimiced

by changing the length of the bolt, as the authors could not find an actual defective bolt. Due to this problem, the authors took the two-inch bolt as a standard. If the bolt does not to meet the requirements, the Raspberri Pisends a response signal indicating that the bolt is faulty. This means the faulty nut doesn't satisfy the standard limitations given to the proptotype system.

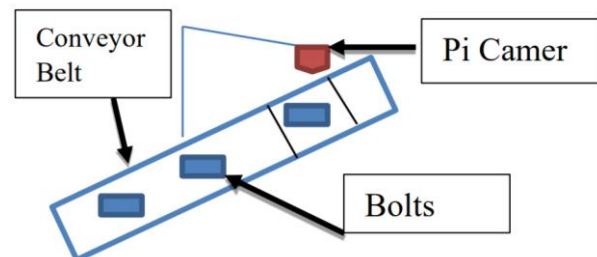


Figure 2. Hardware setup

Finally, the system outputs a summarised results as shown in Figure 3

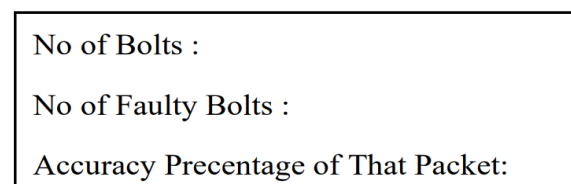


Figure 3: Display output of PC

#### B. Software Design

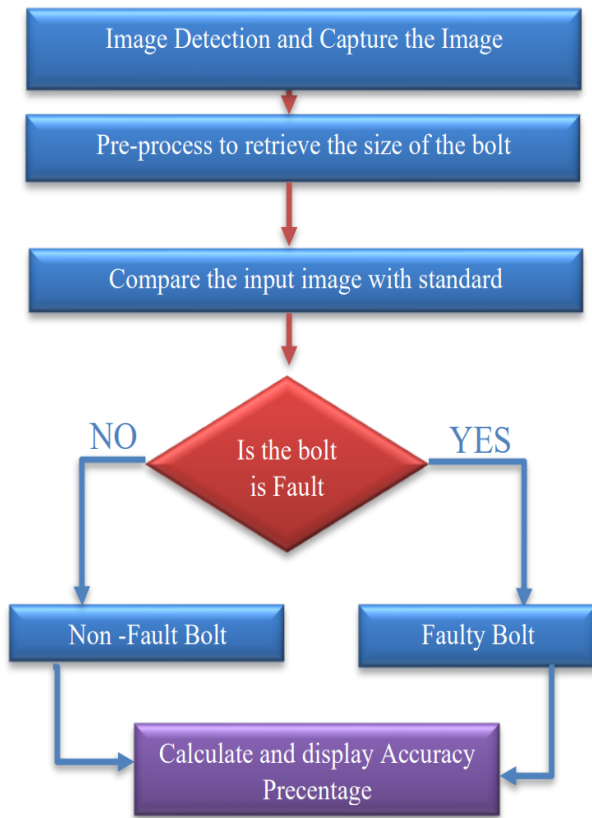


Figure 4 Software Design flow

The proposed system extracts feature and matches features using OpenCV library and TensorFlow package in python. Figure 5 shows a sample image captured by the Pi Came



Figure 5 Captured image of bolt

We have employed CNN (Convolution Neural Network) to detect whether the bolt is faulty or not. Initially, a dataset with 500+ sample images, as shown in Figure 6, is collected to build a dataset of bolts. Then a CNN built using TensorFlow as shown in figure 8 is implemented in python platform to detect the outliers. This trained CNN model with its trained weights is used in the test setup at the deployment



Figure 6 : Data set

### C. Hardware Design and Implementation



Figure 7: Designed Conveyor System

The hardware part consists of a conveyor belt system, control system, and pi cam to capture and separate defective ones from bolts. A raspberry pi is used to manage the pi camera. In this design, it has used a fan motor to control the conveyor belt. Further, an on-off switch for stop and start the system was implemented, which separates the faulty and non-fault bolt, depends on the command received from the raspberry pi.

### IV. TESTING AND RESULTS

Table 1 summarise the training and testing accuracy percentage of the prototype. Figure 8 shows a sample output label produced by the prototype.

Table 1. Results of data

Epoch	Accuracy	Val_Loss	Val_Accuracy
5/20	1.0000	2.4347	0.6393
6/20	0.6667	0.6333	0.6657
7/20	0.4444	0.6908	0.4545
8/20	0.5556	0.7909	0.6393
10/20	0.7778	0.5981	0.7214

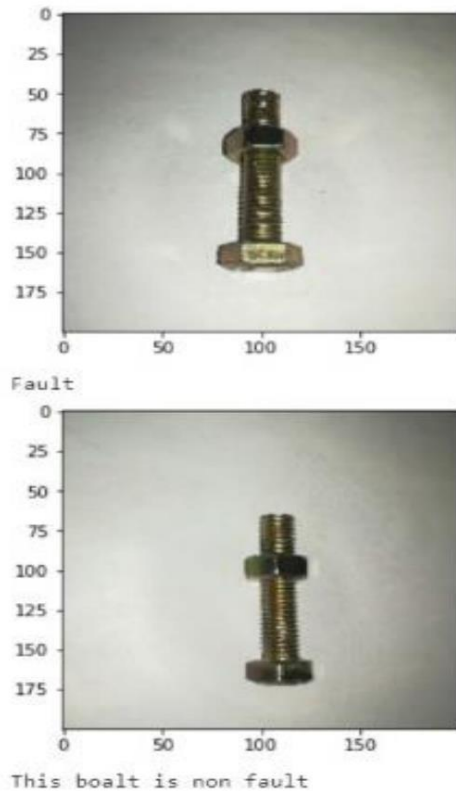


Figure 8: Output of the prototype labelled image

In the 1st trial, CNN is trained and tested with 100 faulty bolts images and 100 non-defective bolts images. When testing the dataset, it identifies 80 bolts as faulty and 110 bolts as non-faulty. Accordingly, the accuracy of identification of defective data percentage is 80%.

In the second trial, above experiment is repeated for the 200 faulty and 200 non-faulty bolts. At the testing, CNN identifies 193 no of bolts as defective and 207

bolts as the non-faulty. Accordingly, the model gives 96.5% of accuracy.

Hence, it is concluded that the CNN model trained with less number of data gives low accuracy and a larger dataset would improve the accuracy of the model.

## V. CONCLUSION

Authors have successfully designed and implemented a prototype for separating faulty and non-defective bolts in the mechanical industry. Database of faulty and non faulty bolts were created using pi-camera and by changing the length of the bolt. The results shows that the prototyped hardware system with CNN model can be effectively used for sorting bolts in a manufacturing plant.

## VI. FUTURE WORK

As future extension of the work, comparison between other deep learning algorithms, can be carried out. Also, the system could be enhanced such that any mechanical component could be sorted and parallel sorting supported.

Table 2: Summary of testing Trail

Trail	Fault	Non-Fault	Accuracy (Fault )
Fault - 100 +Non Fault 100	80	110	80%
Fault - 200 +Non Fault 200	193	207	96.5%

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# Low-Cost Developing Board for PIC Microcontrollers

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**Abstract** - Microcontrollers are single-chip computers that include a minimum of microprocessors, memory and input-output module. A number of experimental-level and commercial quality development boards are available for microcontrollers, because the coding process of the microcontrollers is difficult. This paper presents a comparative description of existing microcontroller development boards and proposes a new development board for the microcontroller programming, especially for school students. Further, this study also identifies related issues and challenges of the PIC microcontrollers, and why users are not much focused on them. Finally, the paper proposes a new design of the development board for the PIC microcontrollers, which is capable to reduce some of the said issues. The proposed microcontroller development board has been tested with a PIC 16F877.

**Keywords:** *microcontroller, microprocessor, bootloader, development board, embedded system*

## I. INTRODUCTION

Nearly everyone in created just as non-industrial countries cannot think about a day without using microcontrollers. The microcontroller is an embedded computer chip that controls most of the electronic gadgets and apparatuses people use day by day, directly from washing machines to anti-lock brakes in vehicles. The microprocessor is a multipurpose, clock-driven, register-based, digital integrated circuit that accepts binary data as input, processes it as indicated by guidelines put away in its memory, and gives results (also in binary form) as output. Microcontroller is a chip enhanced to control electronic devices. ("Difference between Microprocessor and Microcontroller," n.d.) It is put away in a single integrated circuit which is

devoted to playing out a specific undertaking and execute one explicit application. It is designed circuits for embedded applications and is widely used in automatically controlled electronic devices and contains memory, processor, and programmable I/O.

There are differences between microprocessor and microcontroller. Such that microprocessor is the heart of computer system, but microcontroller is the heart of an embedded system. Microprocessor is only a processor then memory and I/O components need to be connected externally but microcontroller has a processor along with internal memory and I/O components. Microprocessor cannot use it in compact systems and microcontroller can use it in compact system. Not only that, in microprocessor cost of the entire system is high but microcontroller low cost for the entire system. ("Microprocessor - Wikipedia," n.d.) Furthermore, microprocessor has a smaller number of registers, so more operations are memory based. But microcontroller has more register hence the programs are easier to write. Microcontroller uses an internal controlling bus. As far as I think, microprocessor used for general purpose applications, but microcontroller used for application-specific systems. Utilizing these advantages, it is proposed to develop a development board for microcontrollers. ("Microcontroller," 2021)

When focusing on current methods of using development boards users, the most used method is to ask someone familiar with the development boards. The main disadvantage of this method is that they should rely on the scope of that person's knowledge and the recommendation made by one person may not be so reliable. Therefore, as it is difficult to ask many people, the Development Board proposes to make learning easier for everyone by using data

obtained from everyday users. I had to face many difficulties in finding information as there was no written evidence for PIC microcontrollers. The proposed system aims to make it easy to learn PIC microcontrollers. It also aims to create new designs using this proposed development board. To achieve the above aim the following key objectives has been identified.

- All students can study on microcontrollers.
- They can study on development boards and their strategies.
- Critically study on languages that can be used to program a microcontroller.
- Users can study on languages that can be used to design a device driver (library)
- All users study about USB communication with PIC microcontrollers.
- Not only that they can study on features and technologies that includes in existing development boards.

In the proposed system, the user will be able to easily manipulate the development board and learn about microcontrollers easily. Thus, there are facilities for innovation using this development board. The Development Board has the ability to create IoT-based designs through the Wi-Fi module it hopes to create in the future.

## II. LITERATURE REVIEW

Many computer manufacturers manufacture low-cost development boards or evaluation boards. They are very helpful for learning about the specific chip and its capabilities, trying different things with algorithm implementation and developing simple systems. They are useful for program development. The cost of these systems varies from hundreds of dollars to thousands of dollars, depending on the processor and memory configuration. The goal of this literature review is to compare most popular two development board in IT field. In here I have compared some of the most popular development boards among users. (“What is Arduino? | Arduino alternative,” n.d.) (“Raspberry Pi,” 2021) (“NodeMCU,” 2021).

Table 1: Compare the most popular existing development board  
Source: Author

	Arduino Uno	Raspberry Pi	Node MCU
<b>CPU</b>	8 bit	16 bit	32 bit
<b>Wi-Fi</b>	Shield or ESP8266	USB Dongle	Built-in
<b>Programming</b>	C++	Python/Java/C++	C++/Lua
<b>Code Distribution</b>	USB/SPI/Serial	In-situ	Serial/OTA
<b>Storage</b>	32KB flash	Depends on size of SD card	4MB
<b>I/O</b>	13 GPIO/6 ADC	17 GPIO	10 GPIO/1 ADC

After that I compared advantages and disadvantages of these existing systems.

Table 2: Most popular development board advantages and disadvantages  
Source: Author

	Arduino	Raspberry Pi	Node MCU
Advantages	Ready to use structure	Easy to use	Low cost
	Effortless functions	Low power consumption	Integrated support for Wi-Fi network
	Large community	Great for smaller tasks	Reduced size of the board Low energy consumption
Disadvantages	Cost	Cost	Need to learn a new language and IDE
	The structure of Arduino	Limited functions	Reduced pinout
		Very slow	

	Internet connectivity	Bad for multitasking	Scarce documentation
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It is proposed to create a simple development board for microcontrollers, taking into account the advantages and disadvantages of existing development boards and the existing problems for the user. Features of the proposed Development Board for PIC microcontroller.

Table 3: Features of proposed development board  
Source: Author

<b>CPU</b>	8 bit
<b>Wi-Fi</b>	Built-in
<b>Programming</b>	C
<b>Storage</b>	14KB Flash
<b>Communication</b>	UART(1)/ SPI(1)/I2C(1)

These are the advantages and disadvantages for the proposed system. ("Advantages and Disadvantages of Using Arduino - Engineer Experiences," n.d.) ("NodeMcu and Arduino IDE which is based on the ESP-12 module," n.d.) ("Primary Advantages And Disadvantages Of Raspberry Pi | ipl.org," n.d.) (MACFOS, 2020)

Table 4: Advantages and Disadvantages of proposed system  
Source: Author

Advantages	Disadvantages
<ul style="list-style-type: none"> <li>• Low cost</li> <li>• Integrated support for Wi-Fi network</li> <li>• Low power consumption</li> <li>• Easy to use</li> <li>• Easy to learn C programming</li> <li>• Familiar with PIC microcontroller</li> </ul>	<ul style="list-style-type: none"> <li>• Build for one PIC microcontroller (PIC16F877)</li> <li>• Slightly larger in size</li> </ul>

Price comparison of existing development boards.

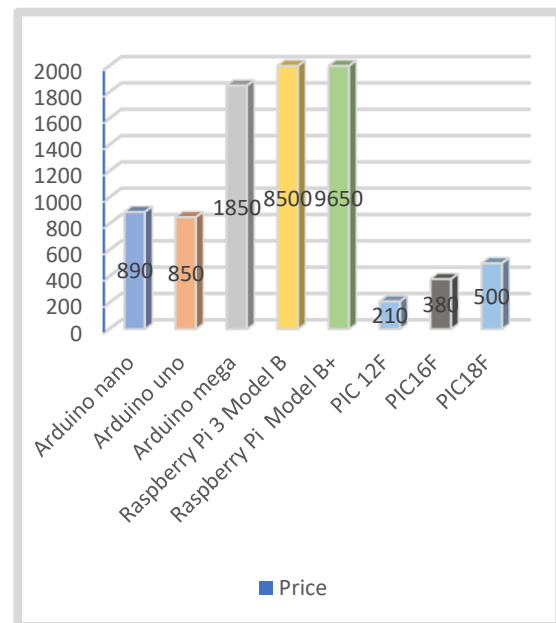


Figure 01: Prices of the development board and compare with PIC microcontroller.  
Source: Author

### III. METHODOLOGY AND DESIGN

#### O. Requirement gathering and analysis.

This study was started by identifying what are the exact problems of using PIC microcontrollers and why users are not used microcontrollers and not familiar to the microcontrollers. For that purpose, a survey was conducted using 50 users (A/L students, Undergraduate student in electronic, computing field, and graduate student in IT field). The survey kept as simple as possible to ensure that it was easy for each user to respond.

With the obtained results from this survey the research objectives were defined and then started to design the proposed system to fulfill each of them. Identified main problems of users are as follows,

- Microcontrollers are smallest and cheapest unit.
- Microcontrollers are no familiar among people.
- There are no direct communication methods for microcontrollers.
- People do not have idea about microcontrollers.
- People are no familiar about PIC programming.

- Other development more familiar among people.

After identifying the research problem, it was broken down into several sub questions to identify that what should be the exact objectives of the project to achieve the project aim. Following research questions were formulated with the aim of identifying areas that need to be studied in more depth to find a proper solution to the research problem. The research study clearly shows that the development board should be designed according to the needs of the user. Also, these research questions highlight the key features of the proposed development board to cover all user requirements.

- Question 01: Do you know what is a microcontroller?
- Question 02: Do you know the difference between microprocessor and microcontroller?
- Question 03: Have you ever used a development board before?
- Question 04: What development board have you used?
- Question 05: Have you used Microcontroller before?
- Question 06: Why don't you use PIC?
- Question 07: If you have used PIC before, for what purpose?
- Question 08: Do you think PIC needs a development board?
- Question 09: If so, what are the new technologies you suggest?

#### P. Proposed system design

The outline of the proposed system figure 5 defines the how the components of the system are related.

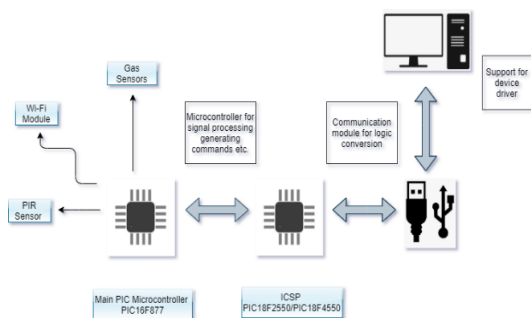


Figure 2: Proposed system architecture

Source: Author

In here to create a communication device that work with the PIC and use it to design a development board so that anyone can learn the PIC. The main reason for creating this is that the use of microcontrollers is not popular among many people and the use of microcontrollers has decreased due to the presence of a development board that can plug and play directly.

The reason why my design is an IoT based project is because its ESP8266 Wi-fi module is designated and can be used direct for an IoT based project. There is a USB port, can connect to a computer via USB and flash to the target chip. In here I use two microcontrollers (PIC18F2550 OR 4550 AND PIC16F877) because if the bootloader program is programmed into the main microcontroller, there is not enough space in the ROM That's why it is difficult to run a large program. This board can connect sensors, motors, relays etc. This board can plug and play directly. Write a driver for the board and then the driver identifies the board with the computer and transmit the data to the board. And this board compatible with MPLAB X IDE, MICKRO C pro IDE.

#### Q. Data gathering

Data gathering phase was an important and hard step which had to face many difficulties in finding the existing problems for the users. Also, there were no manuals to look at the existing development boards before the creation of this development board and to investigate the problems that arose during their creation. There were no research papers. Therefore, a google forms has been created in English medium to gather details and distributed it among service providers. Thus, had to contact each service provider personally to gather data. ("USB bootloading - Northwestern Mechatronics Wiki," n.d.)

They then proposed to create a development board that would keep a list of data and make learning more user-friendly and cost-effective, and new experiments would be needed.

#### R. Technology Adaptation

##### 1). Schematic Diagram for the Proposed System:

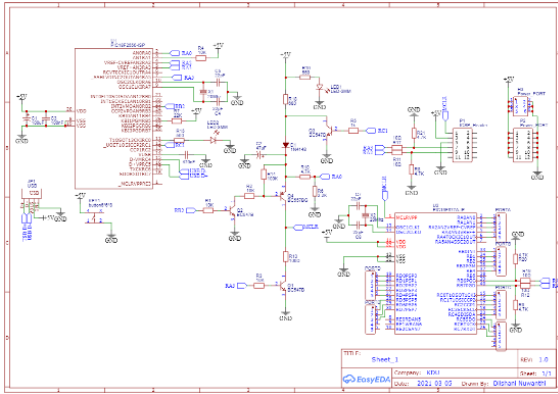


Figure 3: Schematic Diagram  
Source: Author

At the request of many users, it took several steps to create the proposed development board. This is the schematic diagram in the first step. First one is PIC18F2550 and other one is PIC16F877. PIC18F2550 is the USB support microcontroller and the PIC16F877 microcontroller does not support the USB connection. In here I used PIC16F877 microcontroller it is user-friendly, and it has a simple design. The reason for using the bootloader on power-up or reset, it is a section of program memory that runs before the main code runs. It can be used to setup the microcontroller or provide limited ability to update the main program's code. ("In-Circuit Serial Programming (ICSP) Guide," 2003).

2). PCB Design:

This is the PCB design of the schematic diagram mentioned above. In here I designed PCB in two layers. This board is powered via USB. I also hope to supply power through an adapter.

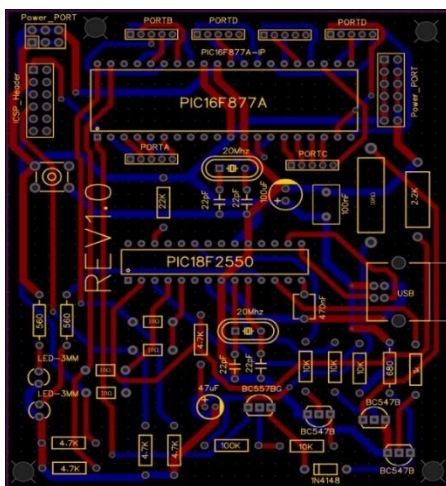


Figure 4 :PCB Design 1 for the proposed system

IV. DISCUSSION

The world has not yet properly developed a development board for learning microcontrollers. Also, the microcontroller is not popular because the language used for programming is not close. Moreover, development boards such as Arduino are so close to man that they are more inclined to create using them.

This paper has reviewed on existing developing boards, Arduino, Raspberry Pi, and NodeMCU, in electronic fields. However, these developing boards are more suitable for the related work for create a developing board for PIC. According to my survey, many people are asking for a development board for microcontrollers as well. Many of them are undergraduate students. The survey revealed that the new development board for the microcontroller, which is expected to be designed according to existing development boards, is designed to use new technologies and make it easier to learn and use for a variety of tasks.

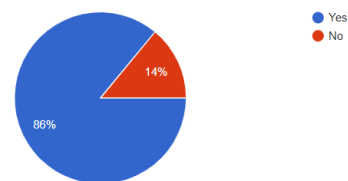


Figure 5: Number of people who have previously used one development board or more  
Source: Author

Figure 6 shows the number of user development boards currently in use. Even now there are people who do not use any development board.

Figure 7 shows the development boards that the user is currently using. It seems that many people there prefer to use Arduino.

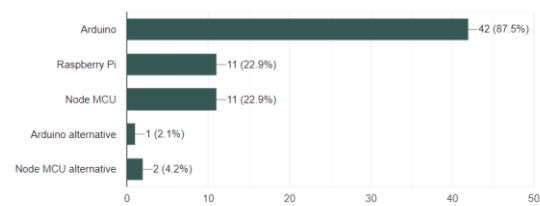


Figure 6: Development boards that users have used so far  
Source: Author



Reasons why PICs are not used by users today as shown by Figure 8. Here are the problems and difficulties faced by the user in using the PIC

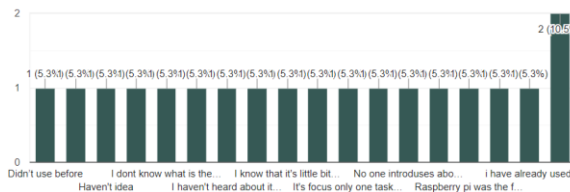


Figure 7: Functions that users have used PIC before  
Source: Author

As this figure 9 shows, many people say that PIC needs a good development board. Therefore, it is important to create a development board using the latest technologies so that the user can learn more about microcontrollers and use them more closely.

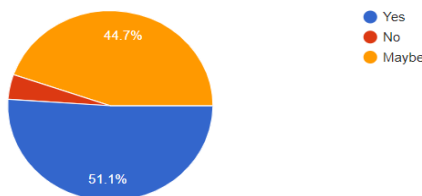


Figure 8: Number of users proposed development board for PIC  
Source: Author

Therefore, it is important to create a development panel using the latest technologies so that the user can learn more about microcontrollers and use them more closely.

Today we can see some PIC-related development boards but most of them are having compatibility issues with software and hardware. The proposed system to design a development board with fewer compatibility issues, to do that best practice is to admire the Arduino boards.

However, the idea was to make it as friendly as an Arduino board, and to make it as close as possible to the language used, and to bring it to the masses as an entry level platform. Proposed to have a universal dev board where you can use PICs IO pins from the board pins itself.

## V. CONCLUSION AND FUTURE WORKS

Creating development boards using novel technologies has become very popular in the world today. Many development boards created using such technologies are still used by people

in IT field. They are used by people for different projects with different technological capabilities. This research study identified the technologies and flaws in the existing development boards and selected the problem of lack of microcontroller popularity, lack of dedicated development boards and low usage. The paper is proposed a lower cost microcontroller development board to provide a closer understanding of PIC and to learn the PIC programming to humans using IoT technologies. A development board for microcontrollers was proposed to make it easy for every user to learn and use. It is also proposed to write a separate device driver for this development board. The limitations of this project are to focus only on the needs of the microcontrollers of school children and university students. This project can be developed for industry-wide projects around the world and for innovative designs using new technologies that are directly used in IoT. Also, this development board can be upgraded to make it more tempting for everyone to write a device driver.

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# An Automated Platform to Manage Customer Relationship in a Gymnasium

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**Abstract** -In this advanced world, the computer turns out to be an increasingly famous and imperative to our way of life. The Gymnasium Management System is a collection of wellness centers designed to make dealings with clients easier and more efficient. The project is a computerized computer-based framework and is used to deal with gym members. This study expects to build a framework for people who want to maintain their health and physical wellbeing on a regular basis, relying on the gym. The manager can see all members from the gymnasium and also their details. This project proposes a strategy for an online knowledge base as well as executive exchanges. The plan framework can supervise recreation center members, gymnasium instructors, trainers, gymnasium gear, diet of gymnasium members, instalments of gym members, instalment of instructors, and equipment details. The framework additionally gives the capacity of search and progressed look for looking through records proficiently. The framework, which will store information, will check the legality of data provided by members, stores data of members as per their ID, and creates reports for various IDs.. This framework is much secured, and to login to the framework one's username and password is required. The framework administers the recreation center part's information exclusively for all activity and gymnasium instructor's information separately in terms of thinking about gymnasium needs, and stores information with respect to normal machines. This Automated Gymnasium Management System is reasonable than the manual information base, since it gives trainers automated framework support, huge capacity limit, more faithfulness and high safety.

**Keywords:** *gymnasium management, fitness, database management*

## I. INTRODUCTION

Everyone knows health is a valuable thing. Without health we don't need anything because there is no value of extravagant vehicle, beautiful house, and without a health, a degree is nothing. The first thing we must remember is to have a healthy lifestyle. Mostly our time depend on our attitudes and how we feel about those issues We have the energy to take on any obstacle when we are healthy and fit. We as a whole know for a person health is a most significant thing and being healthy is first thing that we keep in our brain. We can do anything, anywhere if we are healthy and fit. Actually, great health is significant for calm life. Actual wellness incorporates diet, exercise, and rest. Every person takes appropriate eating routine, appropriate exercise, appropriate rest for sound and upbeat life. These three things are generally significant for non-transferable illnesses free life. Everybody should wise about our health in light of the fact that for healthy and valid life and life is so valuable. Electronic applications are currently a day's gotten exceptionally well known and valuable. A contemporary framework refers to the framework that has been used in the past. The fitness center is putting in physical effort. The current structure is time-consuming and expensive since it requires a great deal of paper effort. The manual treatment of the exercise center framework was a truly troublesome errand. However, today's computerization enables better efficiency at a cheaper cost, as well as a reduction in the weight of paperwork, and freed up time for executives to record the details of every single part and worker, create required reports without any problem.

The purpose of is this project is to plan and built up the mechanized framework, because it

comprises so many obstacles, the existing structure is arduous and costly. The framework isn't proficient. Likewise, there is a weight of paperwork as everything is kept in a solitary register. Because of this, the ideal opportunity for recording subtleties of every single part and worker is massive. The report generate isn't so ordinary. The most significant disadvantage of the project is the need to design and construct an easy-to-understand, easy-to-use, and efficient automated framework. The issue must create associate right and adaptable situation which will kill information excess, also to deliver higher graphical PC program. The arrangement should likewise deal with the security of the information base information by operating login and secret word. The reason or goal of this framework is to digitalize and make a computerized framework. The framework will play out the assignment like adding the new part to the Gym, Eliminating the part or keeping the installments records and other stuff needed in dealing with the gym appropriately. The current state of affairs in the Gym is that records are preserved by handwriting in a document on paper. Physically, each administrative work is completed. In this Gym The board Framework initially motivates the sign-up structure. The client fills in the username and secret phrase, as well as an email address or phone number. If a client chooses to join through email, our system will begin the confirmation process. Client validation will be completed by clicking on a link that will be delivered to the client's email address, and the client will be directed to our main page. On the off chance that client pick telephone number to join, a confirmation code will be shipped off client's given telephone number. Presently if client enter the right check code, If the client enters invalid data, it will be redirected to our framework's main page. On the off chance that client gives both email and telephone number, at that point default validation will be finished by telephone message.

The data about the different things contained in the framework resemble Gym members, instructors, equipment can get by only a couple clicks different to the paperwork required the genuine checking for such data. It helps in making the different group as per their inclination or on the off chance that they need a specific gym

instructor. It made simple to create the reports of different activities replaced in the Gym, look like paying the expense, it tends to be put away and later assessed and get the rundown of people who didn't pay the charge. The framework doesn't just restrict itself to the organization and yet additionally helps the people from the Gym. The Gym members can have choices like participation and charge installment change lot demand. This will improve the straightforwardness between the members which is consistently a decent quality in the framework. It will likewise give the cover of security to the organization and the clients that private approved clients can access by their certifications.

## II. LITERTURE REVIEW

The "SMART GYM MANAGEMENT SYSTEM" has been successfully created and developed to meet the necessary needs established during the requirements analysis process, such as the system being very user pleasant, form level validation, and field level validation operating very well. There were a number of flaws in the old manual system. The present project has been developed to meet the aspirations indicated in the modern age. (Ahmed & Nayeem, 2016).

In today's world, computers are becoming increasingly popular and crucial in our culture. We can use computers almost anywhere, and they are extremely handy in our daily lives. Websites, like computers, play an important role in daily life. We now have the ability to learn about anything in the world with a simple click on many websites. As a result, we set out to create a Gymnasium-themed website for people who want to keep their health and fitness in check on a daily basis. The user of the Gym Management System can save information about meals, employees, people who are at the gym, gym equipment, and so on. This software program allows you to save all of the information about a gymnasium. The newly built Gymnasium site is better suitable than the manual database since it offers features such as huge storage capacity, high speed, greater accuracy, and increased security. The frontend of this project is Visual Studio, and the backend is SQL Server(Jishnu T Jojo2, 2012).

The recreation center administration framework is with progress planned and created to satisfying the necessary necessities, as known inside the necessity's examination part, similar to the framework is inconceivably bountiful easy to use, type level approval and field level approval territory unit playing appallingly speedily. The framework brings about fast recovery of data that is exceptionally indispensable for the advancement any association. Cost is limited if there should be an occurrence of fixed. Weight of manual work is decreased as at whatever point exchange happens, there is no compelling reason to record it in numerous spots physically (Utkarsh Krishak, 2018, p. 8).

It was becoming increasingly inconvenient to use the old manual system. Because the entire organization had to be kept aware of hands, the path to keeping, keeping up, and retrieving information was dismal and long. There used to be a bevy of difficulties in coordinating a particular trade with a certain environment. If any information could be found, it was expected to come across a slew of registers containing records that had nothing to do with the age of the report. While entering and retrieving records, there would almost likely be a waste of time. The force board's work is currently being done honestly, which is causing the division a lot of headaches. The clarification for it is that there is package of information to be kept up and should be recalled while keeping up the business .For this clarification we have given features Present structure is generally motorized (robotized), truly existing system is persevering as one requirements to enter same information at three better places (Vazhacharickal, et al., 2017).

The project 'gym management system' is prepared to eliminate the time required for existing system in the previous system there is no records secured as all the paper work was there and if the paper misplaced then all the records will be gone so to avoid all these problems this gym management system project has been developed. Through these all the records are maintained and secured. In gym management system it requires a system which handle the details easily and security according to user. It also requires software which store data about staff and persons. This is very useful system and beneficial also (Mahima, et al., 2019).

In this gym management system total computerization of the activities of the gym to Maintaining records of everything in the automated system. There will be inbuilt software which can detect mistakes immediately. This is a completely created system that will assist in the management of the gym, so making a mistake is not an option because it would manifest itself in a large form after that. It also requires software to keep information on students, employees, merchandise, and any agreements or deals made in the gym. This is very useful system as it records and maintains all the information related to the people in the gym. (Kumar, et al., 2019).

Our proposed " Gym Management System" is for the individuals who maintain an exercise center business. Prior to busy, we did respectable examination on significant troubles for rec center proprietors. We analyzed cautiously about how to make a gigantic enlisting framework without disappointment just as various capacities for various sort of client relying upon their advantage. The Gym the chiefs requires a system that will manage all the basic and second nuances adequately and genuine data base security in like manner to the customer. They require programming, which will store data about people, delegates, things, money, receipts of people and all trades that occur in Gym. The online rec center administration framework is an easy-to-understand application. This mechanized framework makes all usefulness simpler for the two proprietors and clients. It is extremely basic in plan and to execute. The framework prerequisites are low. Framework assets and the framework can work in practically all setups (Shakoor, et al., 2018).

We are all aware that health is a valuable asset. We don't need a flashy automobile, a large apartment, or a doctorate if we don't have good health. The first thing we must remember is to stay healthy. Because our attitude is mostly determined by how we feel. Being healthy and fit provides us with the energy to accomplish anything. Physical fitness is essential for living a healthy and stress-free life. Diet, exercise, and sleep all contribute to physical fitness. These three essential items are important in everyone's life, and everyone should be sensible about them in order to have a good existence (Monir & Jannatun, 2016).



Our "Smart gym management system" for those who run the company proposed to the gym. Before doing anything, conduct some study on the primary problems that gym operators face. We have other responsibilities for different people depending on their privileges and the memory of how to develop a massive system in safety and carefully considered these concerns. The administration is required to treat them conveniently from the gym and to provide all necessary services based on security and a user database. Members, workers, carrots, chocolate protein, and members who got transactions in the gym are not required to retain data in the software. Each is an internet application with a user-friendly administration structure. This facilitates the automated system owners and other features. (Kumar, et al., 2020).

This venture builds up an administration data arrangement of recreation center in schools and colleges and does site support and the executives of exercise room through the usage of the framework in each college gym. This paper picks VisualStudio.Net2005 as the improvement stage to keep up the data the executive's arrangement of the exercise center, and afterward picks C# as the advancement language. The connected frameworks in this paper can coordinate a wide range of the executive's capacities. It incorporates representative administration, client the executives, site the board, cost the executives and framework the board. At long last, these capacities are coordinated into the framework, and they can likewise share and send information data. The framework gives them various advantages as per the various characters of the client and improves the general cycle of the entire framework. In addition, it understands the objective of the open administration of the everyday data of the college exercise room and can utilize its open interface to understand the reconciliation of the administration framework with different schools and colleges. The examination shows that the data the board arrangement of college exercise center has improved the proficiency of the administration of sports gym and has pragmatic application esteem in the administration of school gym. (Babu, et al., 2019).

Gym Management System (GMS) is a web-based application. In This Project, we don't need to go

to Gym House to Admit Manually. This project can help to reduce Time and record complete details of Gym subscriber. This is a whole process that will be started for member's physical statistics. This Project Requires, which will be stored data about members, employee, products, payrolls information and modify any record. Gym Management System is a fitness facility management system that makes it easier to manage members. The administrator has access to all of the fitness center's members as well as their personal information. The system's basic module is as follows. This project is an internet platform that maintains gym members, personal, and administration. This system also maintains the student's details, to provide the valuable reports regarding the progress of the gym member. (Rahman & , 2020).

### III. METHODOLOGY

The goal of this study is to identify and assess the issues with the current gym management system. and introduce a Smart Gym Management System which to address the issues and increase the efficiency and the automated solution enhances working techniques by replacing the present manual system with a computer-based system, which increases the effectiveness of routine management functions.

The main drawbacks of the solution were identified as the high cost the development and implementation entail, designing a user-friendly system and carrying out end-user trainings. 40 people from the gym had been selected as the sample and semi-structured interviews were held with them. The people selected for the sample were the registered members of the gymnasium for more than 03 months with a good record of attendance. Interviews were conducted by 04 people and 10 candidates were allocated for each interviewer. The interviews were held in the office room as well as in the reception lobby area of the gymnasium for 02 days and the sample were selected and informed in advance in order the interviews to be conducted before a candidate starts working out to ensure the candidate is focused and not exhausted to increase the quality and validity of the answers provided by them. The time allocated for an interview with one person was 8 to 10 minutes and notes were taken to record the answers

given by the interviewees. Moreover, all 40 interviews were recorded using voice recorders with the consent of the interviewees.

Questions for the interviews were formed in order to check the willingness of the sample to work in an automated environment, considering the gym members in the sample as the prospective users of the solution to be introduced. 10 Yes or No questions and 05 questions with Likert Scale were formed in the following areas. Online booking system, Online payments system, Online gym equipment reservation system, Free time schedules messaging system. The data obtained from the interviewees were then transferred to Microsoft Excel for the analysis.

Figure 1 shows the overall architecture of the system.

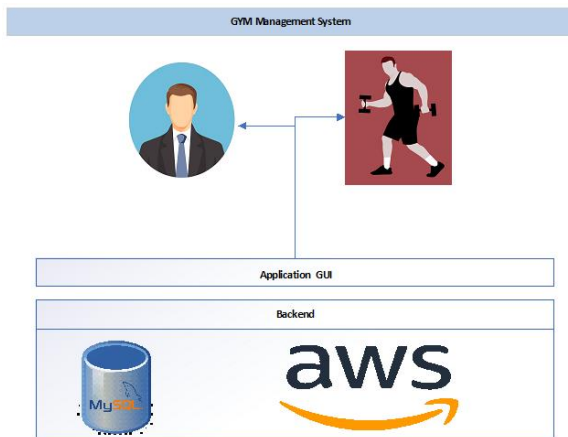


Figure 1. Overall Architecture of the Gym System

In this unit, interpret the results for analysis. I interviewed 50 members of my gymnasium. After interviewing them some future developments were highlighted in the interview. And also, I investigate some features of gymnasium management system need to be developed in future.

Among them I selected four majority of features which most useful for gymnasium management system based on responses of gymnasium members. 40% responses of gymnasium members like to use booking system, 30% responses of gymnasium members like to use payment system, 10% responses of gymnasium members like to use gymnasium equipment reservation system and 20% responses received

for free time schedules message system. The results which I analyzed are presented in graph.

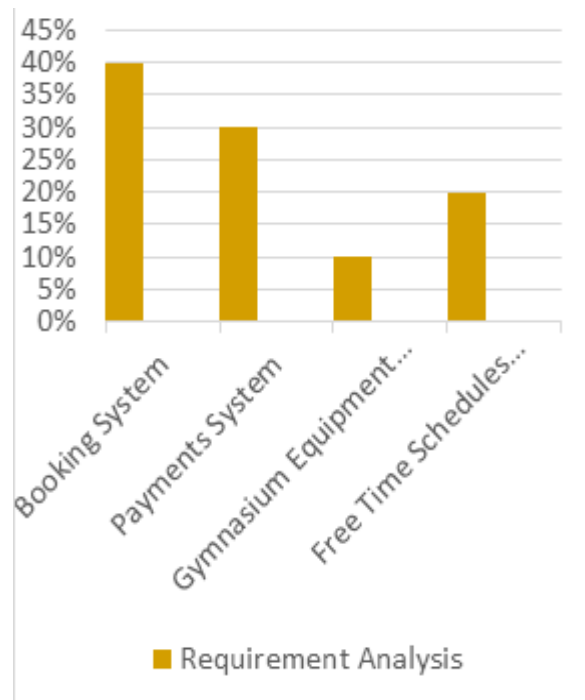


Figure 2. Requirement Analysis for Gym System

#### IV. IMPLEMENTATION

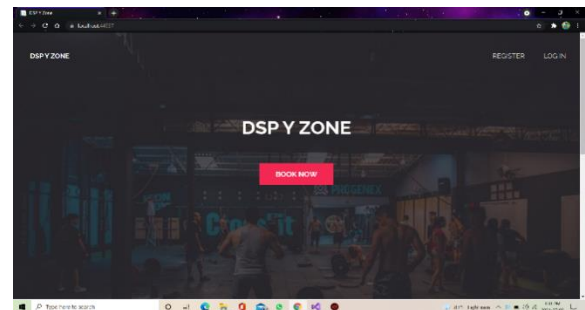


Figure 3. Main Window of the Gym System

Figure 3 shows the main window of the system. In this screen new user can registered to the system by pressing register button. Then figure 4 show the registration window. User can enter details and press submit button.

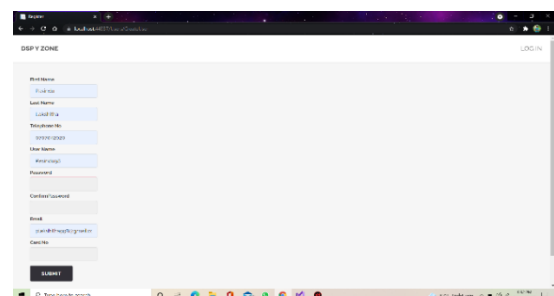


Figure 4. Registration Window of the Gym System

After the registration user get the window displayed in figure 5. By entering username and the password user can login to the system.

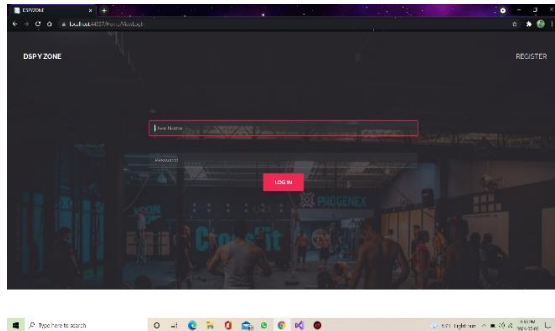


Figure 5. Login Window of the Gym System

Figure 6 shows admin's dashboard. Admin can check all details in the gym system. It includes branches, bookings, and user details.

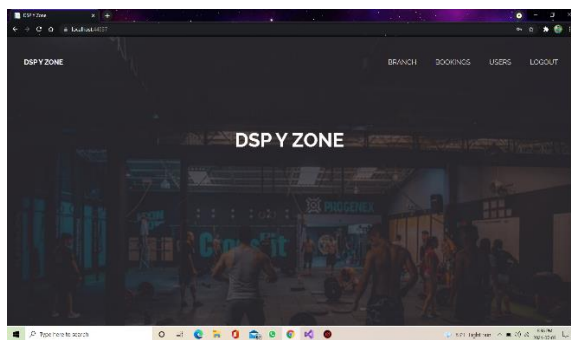


Figure 6. Admin Dashboard of the Gym System

Admin can add branches and edit and delete these details. In this window shown figure 7.

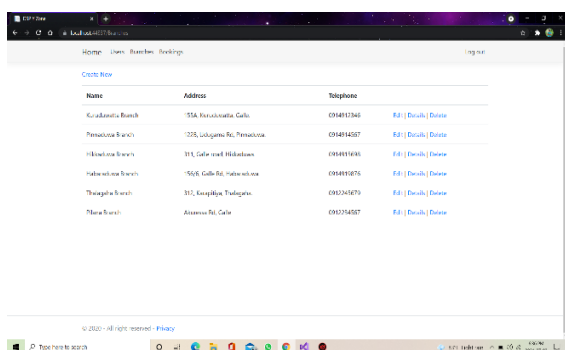


Figure 7. Branches Window of the Gym System

This is a booking window; User can book the gym for particular time period using via system. It shows in figure 8.

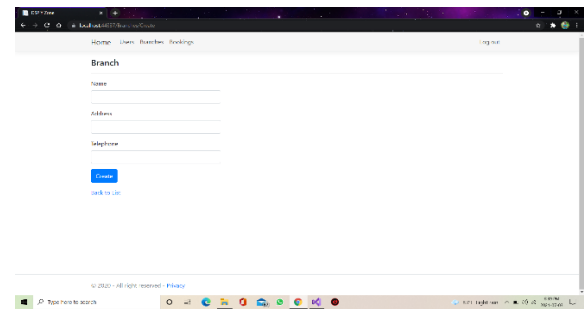


Figure 8. Booking Window of the Gym System

## V. FURTHER WORKS

This gymnasium management system comprises everything from the complete computerization of the gymnasium's activities to the automatic maintenance of all records. There will be built-in software that can immediately detect faults. This is a fully formed system that will aid in the management of the gymnasium, therefore making mistakes after it has established itself as a significant form of the system is not an option. The goal of this project is to come up with a design for managing online databases and transactions. It also provides search and advanced search options for discovering records quickly and effectively. This system uses a graphical user interface to store data and generate reports (GUI). It's usually vital to analyze and recognize the flaws in an existing system during a system study, which can assist in determining the needs for the new system analysis aids in the discovery of several options for a better solution. It also requires software to keep information about gymnasium members, instructors, and equipment, among other things. And any arrangement or deal made in the gymnasium. This is a highly important system because it records and keeps all of the information on the gymnasium's users. This system reduces the amount of paperwork as well as the amount of human resources required. We have automated all of the records in this system, and this is a highly essential and valuable effort. The five goals are: enhancement, automation, accuracy, user-friendliness, availability, and maintenance cost. Each is a user-friendly gymnasium management system that simplifies the automated system for gymnasium owners, gymnasium members, and gymnasium trainers.

## VI. CONCLUSION

The "AUTOMATED GYMNASIUM MANAGEMENT SYSTEM" was successfully built and developed to meet the required needs, as identified throughout the requirements analysis process, such as the system being exceptionally user friendly and working efficiently. There were a number of flaws in the old manual system. The current proposal was created to meet the goals expressed in the modern era. The new automated system was shown to be substantially faster, more reliable, and more user-friendly than the previous method; the system was designed and tested step by step. It eliminates human error, which is nearly certain to occur during activities that require the processing of a huge amount of data. In the case of stationary, the cost is minimized. The burden of manual work is decreased because anytime a transaction occurs, It is unnecessary to manually record it in numerous locations.

The gymnasium management system is properly performed to satisfy all the important requirements that we want in gym. The older system was tackled with so many problems/issues. The present system has been developed to make work easy and efficient. This system is automated system, only use of machine work.

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# Challenges of Manual Attendance System Towards Student Motivation

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**Abstract** -Students must attend lectures to get their primary source of knowledge. Lectures and lecturers guide students to have a productive education. Students can be motivated to study by making them attend lectures. As shown in this paper, students' attendance is important, and they can be motivated to attend lectures. Attendance systems in Sri Lanka are mostly manual and paper-based, which means the process from marking attendance to calculating attendance is fully manual. The current attendance system only produces monthly reports, and some only show the final attendance report. It helps students to be aware of attendance, but is unable to motivate students to keep a better attendance percentage. There are many issues in the attendance systems that are currently in use. In current systems, attendance marking data can be manipulated by students. This is a major issue and will damage the accuracy of the attendance data. It will also decrease student motivation towards attendance. A survey was conducted to verify the problems in the current systems and to identify the requirement for a new system. To keep students attending lectures, they must be motivated and as a solution to this matter, an automated system can be built that allows students to see their attendance. The system should include proper methods to motivate students to reach their required attendance percentage for a semester. It should include an option that enables the student to mark and view attendance instantly. Also, there should be a method in the system, where students with lower attendance are identified and notified that their attendance level is low. QR code is a proper method to verify a student's identity in a lecture. From this method, students can be motivated to achieve their required attendance percentage and reduce attendance frauds. This paper shows

an in-detail solution to all the above problems, by referring related research papers and by using analyzed data of a performed survey.

**Keywords:** *attendance management system, manual attendance, challenges, student motivation, attendance verification method*

## I. INTRODUCTION

The higher education system in Sri Lanka has a rule where a student must obtain 80% of lecture attendance for a semester to sit for an end semester examination. When a student is unable to obtain the above-mentioned attendance mark that student's individual attendance to each subject module is analyzed. In a situation where the student has less than 80% of attendance for a subject, that student will not be allowed to sit for that specific subject in the end semester examination. The attendance of students in most Sri Lankan universities are taken manually and most of them are paper based. Verifying whether a student is attending to a lecture is identified using the students' signature. For each session of each subject module the student must verify their identity by a signature. After that the lecturer also must verify that they attended to the lecture. By that the lecturer takes the responsibility of all the students who signed in the attendance sheet.

In each month-end the attendance of each student for that month is displayed in a notice board where all the students can see their attendance progress. After the provided lecture hours are over, the data is entered to a system where their signature-based attendance is taken as inputs. The output of this system is an attendance report where it includes each student's attendance as a percentage. This report will help in the process of deciding whether a student can sit for the end semester examination. When a student is unable to fulfill the required

attendance that students end semester examination result will be issued as absent and will have to sit for the exam in the next year with junior students.

Each subject module has a specific knowledge area which need to be covered in a semester. As the primary source of knowledge, the students must attend lectures properly. The requirement of 80% attendance is included in the current higher education system to ensure the students are using this primary knowledge source because when a student is not using this primary source, they tend to have a less idea about the subject module than the students who attended to lectures which will not be fair to the students. Presently most students attend to lectures for the purpose of keeping the attendance at an above rate of 80%. But this 80% attendance rule is not making students to attend lectures. This results in having students who has less than 80% attendance or it results in getting less knowledge about the subject modules which may cause getting bad grades for exams and may not be able to sit for an exam.

The next section of the article incorporates files. The literature continues for this study, phase three. The lookup technique used to be ranked fourth. Provides all the small print about facts evaluation and result the ultimate three components incorporate effects. And recommendation for supporters of this predicament Research, future instructions and closing conclusions.

## II. LITERATURE REVIEW

Most higher education institutes use student attendance as a better motivation method to give higher knowledge to students. The primary goal of getting student motivation is to have better student performance for students to learn the proper educational materials. to do that the attendance level of each student must be at a good level. To keep that good level the departmental policies, need to be changed and necessary actions need to be taken for students who have poor attendance. The rule of having above level for a percentage amount of attendance to get the privilege of writing the final exam can be considered as a departmental policy. (e.g., having an above rate of 75% of attendance to get a pass for a subject module) The survey

shreds of evidence that poor attendance leads to poor motivation regarding learning the subject module effectively. To get an idea about student attendance it needs to be monitored regularly. (Muir, 2009)

“Even though attendance is compulsory, establishing a commitment to education is essential if youth are to benefit from what schools have to offer and acquire the capabilities they will need to succeed in the current marketplace.” (Fredricks et al., 2004) According to this whether the attendance is compulsory student should have a motivation to use school study materials and services which are offered by schools to get a better education. It is also important to face challenges in school which will be useful to be successful in the current marketplace. “Dropouts are more likely than other students to have poor attendance, display disruptive behaviors, and exhibit early school failure” (Fredricks et al., 2004) This says that the students who don’t attend school are more likely to be in the less educated category than students who attend to school.

A group of members in the Engineering & Design Department of Eastern Washington University studied the effectiveness of class attendance towards student success. According to that student in engineering technology are studying in different environments when compared to 20 years before. Because of the technology evolvement, students are more focused to study using the internet and wireless materials. A questionnaire was posed, and it included the questions of whether attendance is important and whether the correlation between attendance and student success change due to the progression of students throughout their degree program. The study included students from different faculties through different students from freshman to senior students. The findings of the paper show that the correlation between attendance and student success progressing from freshman to sophomore to junior standing. (Durfee et al., 2012a)

Student attendance correlates with student success and the correlation changes with the knowledge improvement and progression of the student throughout the years as discussed in the above study. Using this study members of the

engineering and design department did a study to identify whether the relationship between student success and attendance when it comes to different faculty approaches to attendance which includes incentives for attendance, penalties for lack of attendance or no requirement of attendance. The outputs of the study are that students are motivated when attendance is rewarded and that the lecturers should use different approaches to keep students' attendance at a positive level. (Durfee et al., 2012b) Many factors will affect the succeeding chances of first-year students which varies from personal circumstances to the educational environment. Attendance is one of the factors that will affect first-year students' success. It says that learning in a student-centered interactive environment is important. The study investigates the gap between the success of first-year students and their lecture attendance. The team have done several measures that prove the student participation in lectures affects the success of students. The findings of the article are that the students who met the required attendance percentage have a substantial impact on the exam results and the end year GPA value. (Bijsmans and Schakel, 2018)

Student absenteeism is a problem in schools across the globe that has an overall impact on student performance. Most schools have good attendance overall, but some schools have difficulties reaching the required attendance margin. An approach was proposed that improves the attendance of students which leverages the market target model (Perera, 2019). It was built on association rule mining and probability theory, to target sessions that are most impactful to overall poor attendance. What they did were rewarding students who have full attendance and improved Monday attendance using themes that will excite students. (Moodley et al., 2020)

Using three consecutive studies about techniques of effective classroom management a study was designed to improve higher education student's attendance. The three consecutive studies were pilot study, culminating study, and replication study. For the pilot study male and female students were taken to test the theory and the other two studies include only female students. the pilot study did not include any classroom

management technique. The methods they used were taken from student interviews and they were taken as those 3 consecutive studies. Each study followed a method to keep the student motivated. The results of the study are as follows. The culminating study found that the late attenders and poor attendance students have lower grades. replication study had an improvement on student attendance. The replication study included points and credits rewarding method for good attendance which were the findings of the study. (Al-Shammari, 2016) Class attendance is a factor used when calculating a student's final performance for a subject. The attendance marking manual process is time-consuming and the manual process makes it easier to attendance frauds. The system included face detection and face recognition algorithms to verify the students. The results of the study show that face recognition is 98.1% accurate and it will be 94% efficient compared to their current manual attendance process. (Alon et al., 2020)

Computers and laptops are increasingly used currently in society. The education system can get a benefit from using smart devices. Since every person has a computer, they can use it to verify their identity which means the student can mark attendance using the computer. The current attendance systems have manual processes and take the signature as a verification of the identity. When the manual system is compared with an automated system, there are several things that makes the attendance marking process efficient. Automated method takes less time, free of human errors and reduces paper works and other manual procedures. There are many systems for attendance that uses software applications, but the other systems use extra hardware devices such as barcode readers. But this system uses the camera module to identify and read student identity. (Khan et al., 2018).

Existing Systems			
System Name and Icon	Technologies Used	Paid / Free	Web based/ Mobile based
attendoplus 	OpenResty, Nodejs, JavaScript, HTML5	Paid	Mobile and web based
Bitrix24 	PHP, JavaScript, core-js	Free	Web based
greythr 	React, core-js, Apache	Paid	Mobile and web based
capture 	React, core-js	Paid	Mobile and web based
Time Doctor 	PHP, JQuery	Paid	Web based

Figure 1: Existing Systems Technologies

In the higher education system of the Kingdom of Saudi Arabia, the lecturer has the responsibility to monitor student's attendance at each lecture. At each end of the semester, students get an attendance register which includes student attendance to each subject also it includes whether the student has achieved the required attendance rate for each course. (Perera and Liyanage, 2021) Checking student attendance manually takes a lot of time and effort. Also, the lecturer must enter all the attendance data into the university system manually. These reasons led them to automate their system. They considered fingerprint, eye recognition and smartphone attendance systems to take attendance. From all those options they identified that fingerprint and eye recognition also take a lot of time and that the smartphone is the most efficient method to take attendance. The proposed system used the university ID card scanned by the smartphone as valid student attendance and the lecturer is also able to get student attendance details using the smartphone application. (Alghamdi, 2019)

Mobile phone is more personal to students than computers and notebooks Also 99% of the people who are around age 20 to 30 have smartphones. By using the smartphone to verify student identity in lectures will be more time-consuming.

The study suggests that the attendance is taken using a QR code which will be displayed when the lecture is started and then the student has to scan it using their mobile phone to mark their presence. (Porwal and Rastogi, 2020)

### III. METHODOLOGY

The study was performed using both secondary data and quantitative data. The data gathered from research were taken as secondary data and the survey data were taken as quantitative data. These data helped in the process of identifying the problems and solutions to those problems. A systematic approach was performed to gather data from research. At first, the related research was found according to keywords and the keywords are Attendance Management System, Manual Attendance, Challenges in taking attendance, Student Motivation and Attendance Verification Method. Then both manual and automatic searches were performed to find the most suitable research. In the searching process, special attention was given to research that were found from ResearchGate and IEEE. The following steps were used in the process of paper selection. As the next step duplicate research were removed. Then read the abstract and keywords of the papers. Then the exclusion criteria were followed to remove the research that are not related to my research area and the papers that are not written in English. Inclusion criteria were followed to select recent papers that can be applied to my study area. As the next step research papers were analyzed. The findings from those papers were summarized in the tabular format as it is an easier method to represent the findings from the literature review.

As the second stage, a questionnaire was distributed among undergraduates as a google form to identify the real requirement. The questions of the questionnaire were designed to gather the details about the current attendance system and the requirement of a new attendance system. The main requirement of the questionnaire was to identify the real requirement and the expected features of the system. The gathered data was presented as pie charts and then the analyzed data were presented in the analysis section of the paper.

#### IV. ANALYSIS

The table below shows the qualitative data and all the findings from the other research are summarized in the table. To get a clear idea about the challenges and the findings of related research papers, they need to be categorized. The table below shows the summary of these findings.

Table 1. Secondary Data research findings

Title, Author, Source	Findings
Student Attendance: Is It Important, and What Do Students Think? (Muir, 2009)	<ul style="list-style-type: none"> <li>Poor attendance will lead students towards poor motivation about studies.</li> </ul>
School Engagement: Potential of the Concept, State of the Evidence (Fredricks et al., 2004)	<ul style="list-style-type: none"> <li>Students must attend lectures to achieve the required knowledge.</li> <li>Students who have poor attendance will have a higher possibility of disruptive behaviors in the workplace.</li> </ul>
Correlating Student Attendance to Student Success (Durfee et al., 2012a)	<ul style="list-style-type: none"> <li>the motivation towards attendance has a linear growth from freshman to senior student.</li> </ul>
Correlating Student Attendance Policies to Student Success (Durfee et al., 2012b)	<ul style="list-style-type: none"> <li>students respond to attendance when good attendance is rewarded.</li> </ul>
The impact of attendance on first-year study success in problem-based learning (Bijsmans and Schakel, 2018)	<ul style="list-style-type: none"> <li>Students who have better attendance will have better exam results and GPA scores.</li> </ul>
Using Data Mining in Educational Administration: A Case Study on Improving School Attendance (Moodley et al., 2020)	<ul style="list-style-type: none"> <li>Rewarding student attendance helps to keep the student's motivation toward their studies.</li> </ul>
Enhancing higher education student attendance through classroom management (Al-Shammari, 2016)	<ul style="list-style-type: none"> <li>Student attendance can be motivated by making students compare their attendance and by rewarding better-attending students.</li> </ul>
Monitoring student attendance using a smart system at Taif university. (Alghamdi, 2019)	<ul style="list-style-type: none"> <li>A smartphone can be used as a time-consuming method to take attendance.</li> <li>University ID is used as a method to verify the student's identity.</li> </ul>
Smart Attendance System (Porwal and Rastogi, 2020)	<ul style="list-style-type: none"> <li>QR code is a better way to take attendance</li> </ul>

Table 2 Existing Attendance Systems

Research Title	Findings
Mobile Barcode based examination attendance system	<ul style="list-style-type: none"> <li>Marking attendance using a smartphone is efficient and time-consuming.</li> <li>QR codes can be used as a method to identify the student's attendance.</li> <li>Using a smartphone to scan QR codes reduces the requirement of using a lot of hardware.</li> </ul>
Monitoring Student Attendance Using a Smart System at Taif University	<ul style="list-style-type: none"> <li>A smartphone can be used as a time-consuming method to take attendance.</li> <li>University ID is used as a method to verify the student's identity.</li> </ul>
Smart Attendance System	<ul style="list-style-type: none"> <li>QR code is a better method to take attendance.</li> </ul>
A YOLOv3 Inference Approach for Student Attendance Face Recognition System (Alon et al., 2020)	<ul style="list-style-type: none"> <li>Face recognition is a 98.1% accurate method to verify student's attendance.</li> <li>Face recognition will have a higher possibility of detecting attendance frauds.</li> </ul>
Mobile Barcode Based Examination Attendance System (Khan et al., 2018)	<ul style="list-style-type: none"> <li>Marking attendance using a smartphone is efficient and time-consuming.</li> <li>QR codes can be used as a method to identify the student's attendance.</li> <li>Using a smartphone to scan QR codes reduces the requirement of using a lot of hardware.</li> </ul>

According to these recent research papers, I was able to create a questionnaire and distributed it among KDU Undergraduates as the quantitative data for the research. The questionnaire was conducted to verify the exact challenges in manual attendance system and to identify the requirement of a new system that include features that reduces the challenges in manual systems according to the student's perspective.



The questionnaire contained 6 main questions. It was distributed among 80 to 100 students and was able to get 65 responses in 5 days. The idea of this research paper is to identify the challenges of manual attendance. As one of the main questions, student's satisfaction with the current system should be identified to verify that this current system is either up-to today's demands or whether it required to be changed.

**Current System Satisfaction**

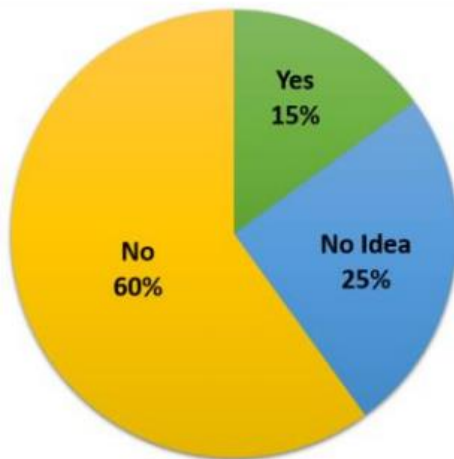


Figure 2: Questionnaire data about the satisfaction of the current system.

This graph shows the analysis data of this question. According to the results, most students are not satisfied with the current attendance system which means around 60 % of students in the university thinks that the current system is not compatible with today's requirements. Also, almost 15% of students say they are satisfied with the current system. The rest of the students are neither satisfied nor dissatisfied with the current system. Around 25% of the students respond "maybe". A student should be able to make a specific statement about the current system because these students are using this system to mark and view their attendance. If they are not aware of the current system, it means that this system is not keeping the students updated and specifically it does not motivate these students to attend lectures as a clear answer to this question, 60% of students specifically says that the system is not suitable. 25% of students have a neutral response but it gives the message that this system is no longer functioning to satisfy today's requirements. Overall, 85% of students are not satisfied with the current system.

According to the referred research papers and the analysis of the first question, most challenges in current systems can be reduced by using an automated system. To identify the requirement of a new system, a question was asked from students. The question was whether automating the current system could reduce the time it takes to mark attendance. The intention of this question is to find whether automation will reduce the attendance management process including attendance marking, calculating and report generating. It is specifically asking whether an automated system will solve the issue and if not, student can directly say that it will not solve the problem. Below diagram shows the results of students to this problem.

In the results, around 82% of the students say that an automated system will reduce the time in the attendance management process. Around 11% of the student have a neutral idea about whether an automated system will reduce the time which takes to mark attendance. It means that they have no idea about the current attendance process or whether a new system will be the solution to this problem. 10% of students think there will be no difference between an automated system and the current manual system according to the time factor.

**Students' opinion on time reduction by an automated system**

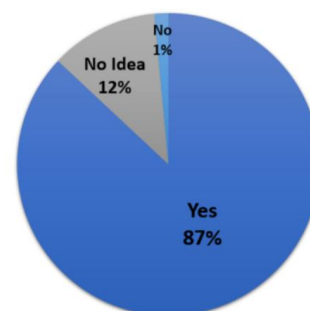


Figure 3: Questionnaire data about students' opinion on time reduction by an automated system.

To fulfil the attendance motivation, students need to have an essential component which is a constant reminder about their attendance. In modern world, every undergraduate student has a laptop or a smartphone. Smartphones have different platforms and building an application should be in a platform where all the students must be able to log in. It means if the application is web based, every student can use the system

easily using a web browser. The solution can also be a mobile application but building a mobile application is not practical because there is more than one platform, and the system should be accessible to all the students. Most of the referred research papers also have stated that a web application will reduce most of the problems in manual attendance. To verify this idea, a question was asked from the students and this diagram shows the results of the question.

#### Suitable Operating system

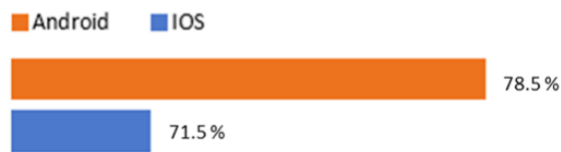


Figure 4: Questionnaire data about the Suitability of Operating systems

According to its results, 78% of the students think an android application is appropriate and 22% of the students think that an IOS based solution is suitable. This shows that the system cannot be implemented in a mobile application. So, it is very clear that a web-based solution will be sufficient to build an attendance system.

To take attendance of the student, there should be an efficient method that will decrease the time it takes to mark student attendance and it should be a practical solution. For that, the survey included 4 methods including the current attendance marking method. The current method used the student signature and according to the chart, around 9% of students like to use their signature as a method for attendance and no more than 1% of students like face recognition. Around 50% of the students are willing to use the method where the QR code is used to detect the student attendance and the rest of the students prefer fingerprint as the method to verify student identity to lectures.

#### Attendance marking method

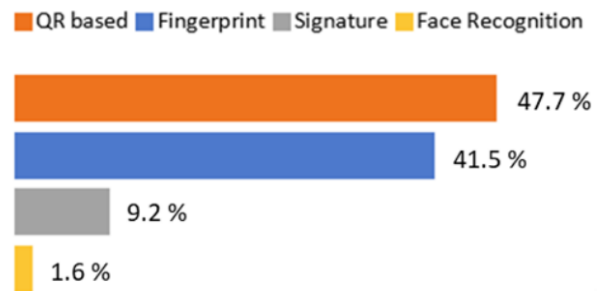


Figure 5: Questionnaire data about methods of attendance verification.

According to referred articles, QR code is the most suitable option to mark attendance and the data from the questionnaire also confirms that it is the most preferred method to mark attendance. As the focus of this paper, the student should be motivated by an automated web application and the recent research papers provide sufficient information to identify that this is a proper solution.

#### Impact on instant attendance view interface

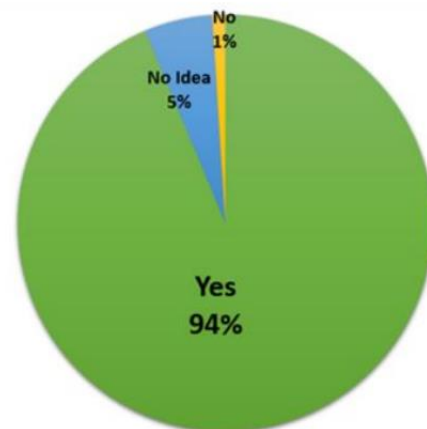


Figure 6: Questionnaire data about impact on instant attendance view interface

The above diagram shows the results for the question of whether students can be motivated with use of a web-based system and according to survey results, 93% of the students think this is a better method to motivate students. Around 7% of the students have a neutral idea about the web application being motivated towards their attendance. From all the students, none of them say that it will not motivate students.

By considering the overall research findings and existing research papers we can conclude that the students have problems with the current attendance system, and they also have less motivation towards attendance. The motivation can be achieved by the web application by showing student attendance instantly. The suitable method to mark attendance will be the QR based method and automation will reduce the time it takes to mark student attendance.

#### IV. LIMITATIONS

The primary concern of this study is challenges of lecture attendance and finding suitable solutions to the identified challenges. Attendance is required to motivate students toward their studies. The current manual system does not support students to get motivated but a web application that notifies about students' attendance daily will increase the motivation that students have regarding their attendance. Even if the students are motivated towards attendance students could have troubles attending lectures because of their personal problems. Also, students could lose motivation towards attendance because of the inability to understand the study materials.

The current attendance system indeed takes time from lecture hours, but all the students, teachers and the medical approving doctors have more experience in the current system, and they have a good knowledge about the current system. This will cause problems when moving to an automated system because all the users who are involved in the attendance process are attached to the current system process.

There are many methods to take attendance from students to verify student attendance in the automated system. In the current system, it uses the signature to identify student's attendance but from this method, it is easier to mark attendance without attending lectures which is an attendance fraud, and it is not fair to other students who attends lectures. It also takes a lot of time to mark attendance because every student has put their signature on an attendance register in the middle of every lecture. As the next method attendance can be marked using a student's university ID card. The ID card can include a QR code and when a student attends the lecture, they can scan their ID card using a QR

code reader which will take students attendance as input. This method has fewer errors compared to the signature, but this method also takes a lot of time to mark attendance and requires extra hardware to mark attendance. Student attendance can be verified using QR code which also takes a lot of time to take attendance because each student must have the required hardware features, but this method is the least expensive of all the attendance verification methods given above. There are many limitations in each method of attendance input and in the process of automating the attendance system but, an acceptable amount of attendance increment can be achieved from that.

#### V. CONCLUSION

many research papers and the survey, could see that Attendance plays a huge role in the student's success. To ensure that a student is getting the required knowledge in each subject module, student needs to attend to lectures regularly. When looking at the data that was analyzed, there are more ways to motivate students towards attendance when it comes to lecturer's perspective. As the purpose of this paper is to find challenges in the current manual system, it clearly says that this manual system is no longer suitable for today's requirement. It involves paper-based operations. It uses signature as the method to input student attendance in every lecture and this current system does not include methods to motivate students to achieve the required attendance level. Also, this attendance system takes a lot of time in the process.

Through the survey created, the drawbacks of the current system and the requirement of a new system was confirmed by sufficient responses from student's perspective. The survey included undergraduates from different intakes in KDU. The questionnaire was comprised of challenges regarding attendance. Quantitative data were deciphered using this survey. Based on the questionnaires we recognized the requirement of an automated attendance system. As per the given responses, more than 85% of the students have trouble using the manual attendance system and some of them are not even aware of the current system. All the undergraduates are engaged within the attendance system. The data gathered from the survey proved that the current

system takes a lot of time to collect student attendance. Overall, data gathered from students preferred to use an automated attendance system with a web application. From this survey, it was able to identify that the most suitable method to take attendance from a student is from their fingerprint. There are so many limitations in the process of automating the attendance system. One of the major concerns is the inability to achieve 100% of improvement in student attendance. Moreover, the student's motivation towards studies can be reduced easily from any distraction.

The paper discusses the fact that student's motivation can be achieved by making student believe that attendance is a primary goal that needs to achieve in every semester. Lecturers are the ones who are responsible for delivering the knowledge for the student, as if there is no student attended to a lecture the lecturer will fail to give the proper guidance to students. After going through the survey and the data that was collected, one of the main points which was noticed is that the current attendance system is not suitable, and it does not motivate students to attend lectures. Also, manual system leads to attendance frauds, and it will result in reducing the number of students attending to a lecture. According to survey results, the manual system should be upgraded with new features including better method to take attendance, keeping the motivation towards attendance within students and reducing the time which takes to mark attendance. The contribution of this study is to review the challenges in the current manual attendance system, how the manual system benefit towards student motivation to study and recommend the most suitable method to enhance the issues in the current manual system.

As for the future enhancements After building the proper automated system, attendance marking of students and keeping their attention to lecture will be prioritized. It will involve methods to monitor student's attendance to lectures via web camera module using Artificial Intelligence.

## VI. RECOMMENDATION

The research focuses on the challenges of manual attendance system and as a solution to the issues In the current system, a project was proposed which develops the current manual attendance

system with an automated system that takes students lecture attendance and calculates the 80% attendance of each student including approved medical reports. The QR-codes will be used as the verification method to identify the student's attendance. In the process of making an automated system, it can be included with a web interface that shows students daily attendance and notify students who has less attendance.

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# Housing Price Prediction using Machine Learning

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**Abstract** - As housing price increases annually, offering unusual prices for houses that are not worth so much is a current problem faced by those who plan to buy a house. Moreover, most property investors also mislead by using fake facts without knowing the trend of houses for a certain location. So, the proposed system allows to evaluate the performance and the predictiveness of a model that supervises collected data from a certain area. The system is stricter on providing accurate values for the houses than the existing systems. This project expects to build a good mutual understanding between buyer and seller. It will endeavor to give the best rates among different calculations when utilizing the public dataset in preparing real-world. The project shows the factors that are affecting Housing Price Prediction on real-world. Furthermore, the observational outcomes show that crime rates, store rates, and public spots impact the house costs contrarily, whereas expansion, year, and joblessness rate sway the house costs emphatically. Overall, in the modern world, with the rapid development of technology and digitalization, a software like this is really required to defend from sellers, who deceive customers verbally and physically by showing inaccurate prices for properties which are not worth that much. It will help investors to achieve their economic ideas without any doubt too

**Keywords:** *prediction, machine learning, housing price, regression*

## I. INTRODUCTION

Housing price prediction or estimation is a major trending project related to the field of Machine learning. Now days, most of the people are used to buy a house rather than building a one. So, eventually there are lot of housing projects going around the world. Investors are happy to invest on those projects as it is more profitable than

other business. There are lot of telecasting ads, website notices, radio announcements about those housing projects. But when buying a house, the buyer has to know whether that price is fair enough or not according to the features of that house. If then, there will be a good understanding between the buyer and seller. Otherwise, people get caught for the houses that are not worth for that much. By introducing a prediction system, people can get use to know about the house and rates before buying a house. They can compare the prices of the seller and the system to buy the most suitable house according to the money which they have.

In Sri Lanka currently housing price is predicted using a manual process of Valuation. But mainly it takes around 2-3 weeks for the entire process and result will be subjected to various fluctuations due to many reasons. The main reason is that the government rates are not congruent with the original rates of market. With the rapid growth of housing schemas and housing projects, availability of Housing price prediction system is essential for Sri Lanka.

## II. A STUDY ON PRICE PREDICTION AND RELATED WORKS

As machine learning is an advanced topic crucial review about the related works will done in this chapter. The problems in the past systems, the solutions they used, technologies they used and the difficulties they faced when creating a housing price will be clarified. The Case of Melbourne City, Australia by Danh Phan is a major related work for the Housing price prediction. It mainly focused on several features related to the city Melbourne is Australia. Land size, property count, longitude, latitude, year are some of them. On this study, they have used histograms as a descriptive model to show how the prices are changed with each feature. In this

work they have prepared data before using by data reduction and exploration. It is said that it will increase the performance and accuracy. Machine learning algorithms which analyzed is that the Regression, Polynomial Regression, Regression Tree, stepwise, Neural Networks and SVM. By all of them the combination of stepwise and SVM which produces the lowest error on this dataset, is the most competitive models. Before using data, they have arranged according to the importance of them.

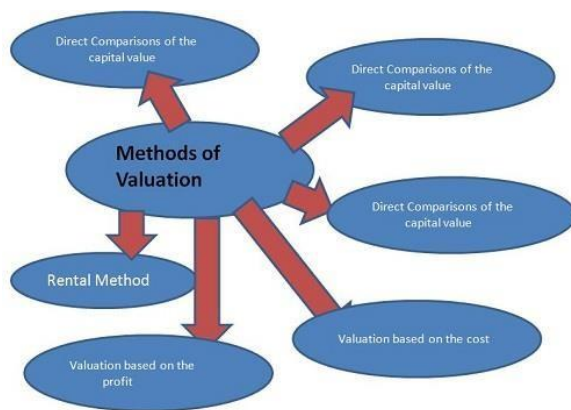


Figure 1: Valuation

For a country like Sri Lanka, it easier to go through with valuation theme because the things like housing price index will not updated regularly in here. Though the valuation process seems like very easy, there is a challenging part also. When once a valuer valued the property with a price with time various new development projects like highway, water projects. Sanitary projects etc will exist and then the price should be change.

Mainly it is consisted with neural networks. Neural network is an advanced technique used in machine learning. This research work is more focused on model training. In here, artificial neural network based on memristor is created to work on several variable regression with back propagation method. Memristor based means including any kind of non- volatile memory. By using artificial neural network, it can learn about the models and predict the values which are closer to original ones. As an example, in this study they have used ANN to learn about linear regression model of some houses in US, and they have predict the housing prices to be close to the real data. In here they have used, Mean Square

error which tells about the closeness of linear regression line to a set of data points. Linear regression line is a linear answer to a set of scaler identities with one or more variable.

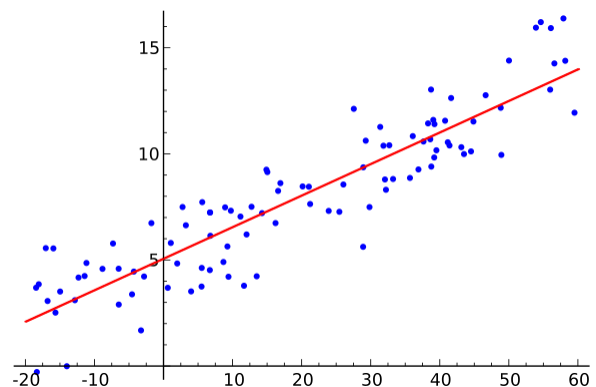


Figure 2: Linear Regression

Mean square error is calculated by taking the distance of each point to the regression line and squaring them. It is calculated as below according to an equation.

$$MSE = \frac{1}{n} \sum_{i=1}^n (Y_i - Y'_i)^2$$

Table 1: Variables for equation

MSE	=	Mean squared error
n	=	Number of data points
Y <sub>i</sub>	=	Observed values
Y' <sub>i</sub>	=	Predicted values

To calculate mean squared error;

1. Find the regression line.
2. Insert your X values into the linear regression equation to find the new Y values (Y').
3. Subtract the new Y value from the original to get the error.
4. Square the errors.

By taking mean square error they had used to check the performance of the network. They had said that to decrease the MSE you have to increase the training data. When predicted prices are reached from training and testing data they must close to the target values.

Otherwise, there is a huge problem in the accuracy.

An important study which has done with minimum errors and same as the machine learning project which is suitable to Sri Lanka. Mainly, in this one features are according to the importance of those green buildings. Unlikely in other projects green buildings focus on the features like energy, indoor environment status, site planning, water, and resources etc. In here, they have used five machine learning techniques namely linear regression, decision trees, random forest, ridge, and lasso.

Features	Description
Transaction Price	Dispose price/sqf (RM)
Date of Transaction	Building Transaction/Months
Lot Size	Lot Size
MFA	Main Floor Area
Tenure	Freehold/Leasehold
Type of Property	Residential/Commercial
No of bedroom	Number of bedrooms
Level Property	Level Property Unit
Floor	Building Floor
Building Facade	City/Park/Lake/Klcc
Age of Building	Age of Building
Distance	Distance to Central Business District
Accessibility	Ease of accessibility
Mukim	Mukim
Certificate	Green Certificate/Non-Green Building
Density	Population Density
Security	Security of Building
Infrastructure	Infrastructure Development

Figure 3: Features

Predictive analytics encompasses a variety of statistical techniques from data mining, predictive modelling, and machine learning that analyze current and historical facts to make predictions about future or otherwise unknown events.

Machine learning techniques have the potential to unearth patterns and insights we did not see before, and these can be used to make unerringly accurate predictions.

Another important tool that was used in system is that the co-relation. Co-relation is the strength and the direction of linear relationship between two variables. It is very useful to get the relationship of string variables in machine learning. If the association is (+) value then the relationship is positive and if the association is (-), then the relationship is negative.

```

correlations = training.corr()
correlations = correlations[["TransactionPrice"]].sort_values(ascending=False)
features = correlations.index[1:6]
correlations
TransactionPrice      1.000000
Main Floor Area       0.715018
Lot Area              0.714555
Population Density    0.452463
Mukim                 0.365324
No of Bedroom         0.339879
Tenure                0.071255
Building Floor        0.067840
Green Certificate     0.023308
Level Property Unit   -0.059356
Building Façade       -0.070940
Date of Transaction   -0.136980
Distance              -0.182399
Age of Building       -0.209287
Type of Property      -0.273990
Security of Building  -0.328196
Accessibility         NaN
Infrastructure Development NaN
Name: TransactionPrice, dtype: float64

```

Figure 4: Co-Relation

It is hardly pushed because to solve some problems in SVM. Selection of decision boundaries of parameters, when matrix scale subjected by the training data, and also when finding solutions for quadratic programming issues LSSVM is very useful. Though this is not a very popular algorithm which use for machine learning it is highly recommended for the prediction functions like in this work. LSSVM regression model can be described as follows.

$$Y = z \times \phi(x) + 1$$

$\phi(x)$  shows the non-linear mapping function and  $z$  is the weight factor.  $l$  is coefficient of invariable.

The last algorithm that they have used is that the Partial least square regression algorithm. It is a special algorithm used for statistical data analysis. In a prediction system it is widely used to find the best function which maps the original data which reduce the sum of squares error. When number of parameters are greater than number of data points PLS is used to construct the model. The mathematical equation of the PLS algorithm can be defined as below.

Where,  $x$  is  $n \times m$  of predictors,  $y$  is  $n \times p$  responses  $T$  and  $U$  are  $n \times l$  matrices.  $P$  &  $Q$  are projections of  $x$  and  $y$ , respectively.

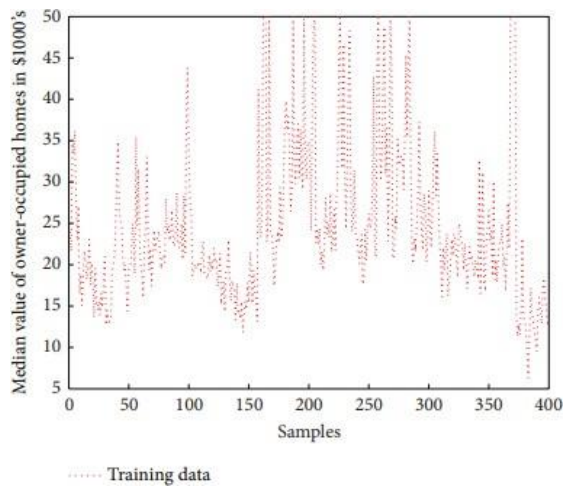


Figure 5: Training Data

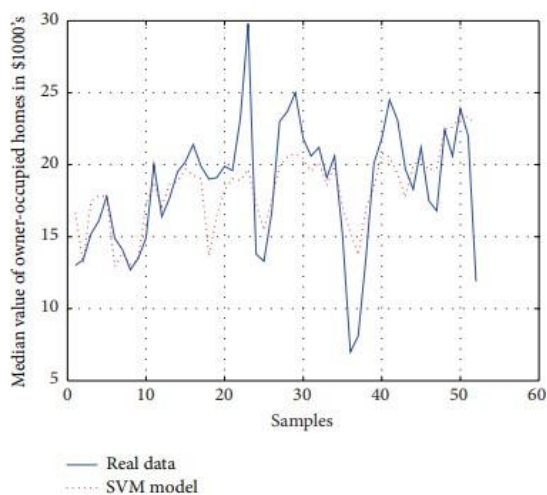


Figure 6: SVM

Study related to the housing price prediction. In this work, it is said that future works can be enabled by the past data. Prediction was reached by a sample data set which consisted of the attributes related to cost prediction. A dataset of real estate agents in US was used to evaluate the cost of houses. The main features that they have used are size of plot, number of bedrooms, number of bathrooms, number of floors, included gas and water facility etc. Data analysis has been done using exploratory approach to minimize data anomalies and to discover patterns.

Mainly their system based on the machine learning algorithm which is called regression. Under the regression their focus had been to linear regression which is based on the equation  $y=mx+c$ . Training of the model has been done by understanding the slopes and positions of all the data points with the line.

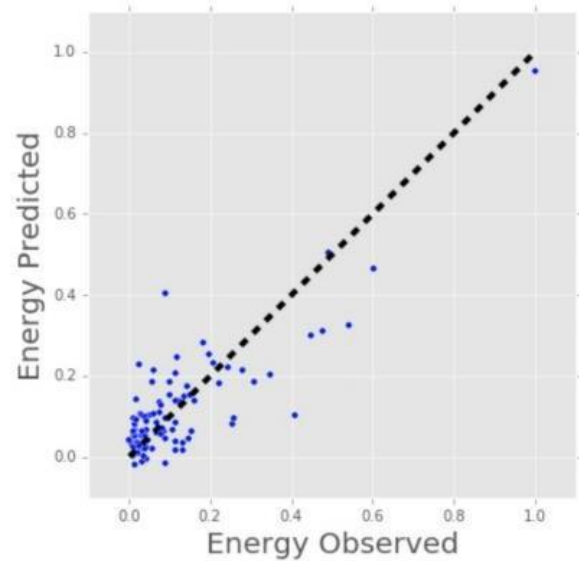


Figure 7: Clustering

The specialty in this work is that it predicts whether a customer will purchase the house or not status also. For that they have used logistic regression as their prediction algorithm and based on single and multiple inputs it predicts the occurrence of the event. Another very important tool that was used was Clustering. It defined that whether the output uses the algorithm instead of using output data for training. Visualization is used to monitor the clustering effects.

By using a user-friendly interface, the work has been able achieve 95% accuracy with the defined variables. Following shows the clear user interface that will display to the client.

### III. DESIGN AND IMPLEMENTATION OF THE METHODOLOGY

Data flow diagram and sequence diagrams will be used to describe the design of the project graphically. The design architecture of the system with its individual units and their relationship with relevant to each other is described here. Requirement analysis, need of the project, the domain, and physical design of the project with its challenges will addressed by the design diagrams.

#### A.Requirement Analysis

Requirement analysis is a major part of a software project. It can change the path of the project towards success or towards the fail. In the

research papers most of the systems fail due to incorrect method of requirement gathering or in the 1st phase of the software development life cycle. As this is a housing price prediction project data related to housing prices with correct feature details should be acquired. In order to get the data related to the Housing prices should contact housing sales agencies because government rates are subjected to various negotiations, and they are diverted from the real-world values. By collecting data accurately, it provides 50% of accuracy because the model, website or price prediction app, everything depends on those requirements.

Projecting on requirement analysis, the 1st step of the analysis was Data collection. Data collection is a process of gathering data on depending on variables related to a project. So, in the case of housing price prediction project, the data collection is process of collecting information on number of bedrooms, number of washrooms, number of perches, number of floors etc in related to the price of that house.

There are nine variables and price of the house in the data collection process related to the housing price project. When selecting those variables, focusing whether they are dependable on housing price is a major challenge in this project. But it was solved by contacting several housing sale companies. Not only solved, but they also helped to give the data needed on those variables related to the housing price. As this is a machine learning project which relies accuracy on the amount of data, 1000 data targets were achieved with the help of two companies.

### B. Sequence Diagram

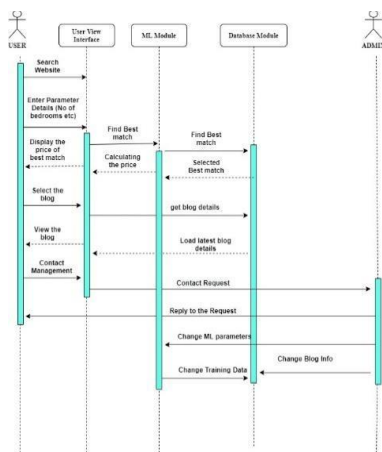


Figure 8: Sequence Diagram

The arrangements of the process when dealing with housing price prediction system is defined by sequence diagram.

### C. Data-flow Diagram

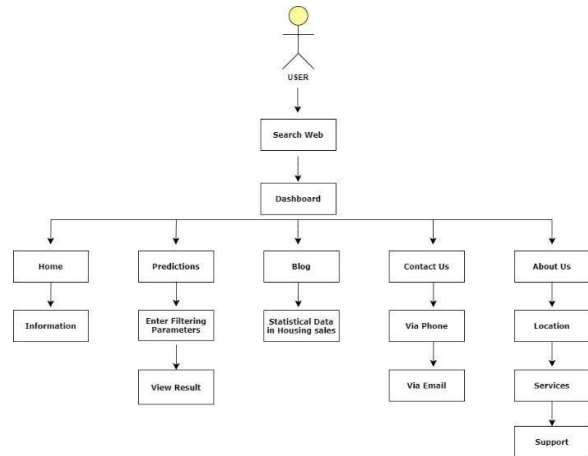


Figure 9: Data-Flow Diagram

Following figure shows the data flow design of the user's website for the housing price prediction system.

### D. Need of the project

Offering unusual prices for the houses that are not worth so much, fake details which are provided to the investors to lose their business path, too much bargaining the prices of the sellers related to the housing sector leads to promote a system of predicting values of the houses before buying or selling them. But in Sri Lanka, as most of the systems are manually ongoing, the prediction also done in manual ways. Though a predicting process is available, the results of those systems are subjected to lot of errors. Those systems are not stricter to provide actual market results which outcomes bad relationships between buyers and sellers.

With the rapid development of technology in the world, other countries are emerged with automated systems and results. But in Sri Lanka, there are not any system to predict the prices of the houses with the automated technology. This housing price prediction system is targeting to produce accurate results of Sri Lankan market by approaching the Digitalization system and to defend sellers, buyers, and investors to achieve their goals related to the housing sector.

### E. Domain



The domain or the subjected area of a software project is the area which the project will hit on. So, in this case the domain will be the Housing market. This domain is special because the domain decreasing per year is 0 % because the amount of houses per year is just only increasing but not decreasing. With the rapid growth of population in Sri lanka, the domain of housing market will not decrease in the future too. So, building an automated system to predict the prices of houses in Colombo area will be an emerging software idea in Sri lanka.

#### F. Physical Design

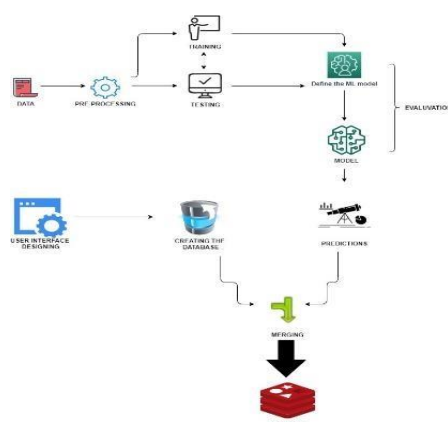


Figure 10: Physical Design

### IV. ORIGINALITY AND INNOVATIVENESS

In Sri Lanka, there are not any software to measure the price of a house before buying it. Over the last few years, the theme of housing price prediction has been highly discussed area in Sri Lankan economy. Not only in economy, but also in academical view it has a major trend because it carries huge employment opportunities. A simple mislead of housing market affects hugely to many social and economic stats of Sri lanka. In Sri lanka, the characteristic features which leads to housing price prediction has changed over the time.

But, in manual process it takes long time to insert those changes for the prediction. Due to those factors the accuracy of those results is subjected to discussion. So, a software system for the housing price prediction will make an interest all over the country and if government could involve in this it will be a massive effort in all aspects as it carries major role in Sri Lankan economy.

Though in Sri lanka we can find house sales agents or websites, there are not any system to predict the prices of those houses by using an automation method. There are only investment analysis agents, and they are also providing only the information related to investments. So, a system like this will focus hugely on Lankan people and also it will help for the investors to build up new housing projects to rise economy of Sri Lanka.

Also, by using a Machine learning approach it is easy to identify the patterns in the housing field and how those patterns change with price. Support vector machines (SVM), linear regression, logistic regression, K-Nearest neighbour, Random Forest are some of the examples for Machine learning techniques. To get the maximum accuracy, have to feed more data into the algorithms as training and test data. Machine learning algorithms use those data to train the model to predict the values of housing price.

```
In [30]: from sklearn.ensemble import RandomForestRegressor
from sklearn.linear_model import LinearRegression
from sklearn.neighbors import KNeighborsRegressor
from sklearn.tree import DecisionTreeRegressor

In [31]: from sklearn import metrics
def predict(ml_model):
    model = ml_model.fit(train_x, train_y)
    print('Training Score: {}'.format(model.score(train_x, train_y)))
    y_pred = model.predict(test_x)
    print('Y Pred is: {}'.format(y_pred))
    print('R^2')
    r2_score = metrics.r2_score(test_y, y_pred)
    print('R2 Score is: {}'.format(r2_score))

In [32]: predict(RandomForestRegressor())
Training Score: 0.93722526279244
Y Pred is: [1.29412000e+08 4.72275000e+07 1.01710000e+08 1.23600950e+08
3.49724000e+08 1.24510020e+08 4.86095000e+08 2.52202330e+08
4.96490000e+07 1.49623107e+08 8.70939000e+07 3.16287000e+08
6.21495000e+07 5.99125000e+08 1.64705000e+08 7.29722500e+08
9.10010000e+07 1.86132000e+07 2.09629000e+08 1.04820000e+08
1.46391500e+08 7.47050000e+07 8.30850000e+07 1.28453000e+08
2.80499200e+08 1.09418200e+09 5.92200000e+07 9.78530000e+07
1.53362000e+08 1.20139000e+08 1.31202010e+08 2.92270000e+07
1.89130000e+08 4.89145000e+07 3.34880000e+08 4.59371000e+08
6.49180000e+07 6.94100000e+07 1.18352000e+08 1.15576000e+08]
```

Figure 11: ML Code

### V. CONCLUSION AND FURTHER WORKS

This system is mainly based on machine learning using python language. Primarily, we clean the all the Data (Variables) and will group them into necessary fields. And then we can classify the parameters according to the importance of them in our system according to pricing value of them.

Nearby local amenities such as railway station, supermarket, school, hospital, temple, parks etc will be our unique approach in addition to our variables. By using Google maps, we can analyze those local amenities near 1km of radius - circle around the main town. And we can increase the price of those Houses in related to each other when we find such amenities in our circle. In the

system, it will use the Linear Regression, Forest regression and Boosted Regression as the algorithms and those results will inputted to a neural network to compare the predictions and to get the accurate results. And finally, the most accurate result will be displayed on the system.

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# Research Direction for Android Based Indoor Navigation Solution for Shopping Malls through Augmented Reality-EasyMap

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**Abstract** - Shopping malls have become extremely popular among society because they are very convenient. A shopping mall is a collection of shops and stalls in one large space. When clients are unfamiliar with the shopping area, it can sometimes be difficult to determine where the store is located, hence time wasting. Requirement gathering and data analysis techniques such as surveys, interviews and literature survey clearly provide the best idea of existing systems, used methods, techniques and their pros and cons. Through the above-mentioned requirement gathering techniques, the best solution for a problem domain is the proposed application for visually indoor navigation. The mobile application is the best way to release it to the masses with indoor navigation to find the destination by using step-by-step directions. Augmented Reality is one of technologies that is rapidly evolving and can deliver new experiences to the world. It can guide visualized directions to users for navigating to the destination through the Augmented Reality environment. Other than the navigation feature, this application provides more different functionalities, such as the user can search the destination using a shop's name or product's name they need to purchase, and categorize the shops and stalls in a shopping mall. The development of this app involves a different variety of interesting tools and software such as IndoorAtlas, ARCore and Android studio SDK. Throughout this paper, a smart solution for the above-mentioned problem and design, used technologies and how they have evolved to the implementation of Android-based Indoor Navigation Solution using Augmented Reality for shopping malls are discussed.

**Keywords:** *mobile application, indoor navigation, shopping mall, augmented reality*

## I. INTRODUCTION

As a result of the world's development and globalization, everything is developing increasingly day by day. Economics and business are one of the major parts in these development areas. Therefore, the growth of international business and competition among countries in the world. As a result of this situation, one of the mainly focused areas is shopping malls in countries. It widely targeted foreigners and local civilians. Now these shopping malls have become a tourism attraction and a major trend among people. Most people like to visit shopping malls because the shopping mall can be explained as everything in one place. They can enjoy it, buy anything and dine in etc.

Shopping and shopping areas are getting bigger these days. When shoppers are unfamiliar with the area, it can sometimes be difficult to determine where the store is. In some shopping malls, the floor plan is enormous, and the maps are complex. Sometimes clients cannot find the staircase in some shopping malls. Some people who are not so good at direction may not understand the map and may not find the store easily. That is one of major problems faced by new customers during their visit to a shopping mall, it is difficult to find the shops they need properly. Some malls and stores have their own applications. However, those applications do not support finding the destination, only provide information on the shops. Sometimes, when a store or store is repaired or closed, customers are not notified, and they become frustrated about

wasting time looking at it. The other major problem is users cannot use Google maps to get direction in the indoor areas.

Nowadays, most shopping malls do not have an appropriate method to navigate users in the indoor area. They already display the floor plan of the shopping mall and provide banners and labels as a navigating method. Therefore, here proposed EasyMap android-based mobile application as the best solution to address the above-mentioned difficulties faced by customers at shopping malls. This mobile app is very helpful to visitors because that application navigates the user at the shopping mall by providing visualizing navigation path. By using this EasyMap application, the user can quickly check out food courts, garment outlets, electric outlets and bathroom etc. when they are categorized. The user can quickly enter the name of the shop or the name of the items they need on the search bar, and the app displays a suitable shop, floor number, details about the shop, daily offers related to the shop or shopping items, navigation map and navigates the user through the camera using AR technology. Therefore, this shopping mall navigation app is more interesting and useful for visitors to do the shopping with happiness and easily find the shops they want.

This research paper walked you through it as follows. First section will give an overview introduction and section two descriptive information about the existing or similar applications to the research and what their pros and cons are compared to the proposed system. Section three will give you the understanding about the system design of this system and section four will give you a clear idea of how the system works with methodology and section five will include different variety of technologies that are being used. Finally, section six will give a possible future works and the conclusion of this research.

## II. RELATED WORKS

As above mentioned, there are so many difficulties faced by customers during their shopping at the shopping mall. Each and every shopping mall uses a mapping method for making it easy to find a destination through maps. They currently map and present the inside location. The survey revealed that some

shopping malls in Sri Lanka are currently using their own software applications for their publicity and to enter details of stalls. However, they do not include maps and navigation methods to make it easier to find the destination in the indoor area.

Indoor navigation technologies and related applications have become a major trend among other technologies. Nowadays, most researchers are focusing on indoor navigation techniques and reducing the gap among other applications. Various studies have been conducted to classify different types of technologies related to indoor navigation. All these studies briefly explain how to address the problems to solve indoor navigation.

A study directly addressing the problem domain of this research (Bakheet, Abd and Ahmed, 2014) has been conducted by Abdalwhab Bakheet and others regarding the Android mapping application. This study was most related to the proposed solution, indoor navigation included a mobile app. This application was originally implemented for the University of Khartoum. They provide two modes of maps such as online mode displaying and an offline mode displaying a pre-downloaded map that does not need an Internet connection.

As a result of the popularity of the indoor positioning technology, indoor navigation applications have been famous around the world. Bo-Chen Huang and others discussed (Huang et al., 2020) the topic based on Augmented Reality Based Indoor Navigation System. In this research, explained the limitations of a 2D navigation map, which can be stressful and confusing for users as they make a connection between the real environment and the 2D navigation map before proceeding. For this reason, they developed ARBIN and enhanced reality-based navigation system that publishes on-screen navigation instructions in real-world environments for ease of use. They used Bluetooth low energy beacons to detect the current position in this system.

Timothy Reu Radaha and others proposed a paper that talked (Radaha, 2013) about "Mobile Indoor Navigation Application for Airport Transits". The main goal of the passenger is to incorporate it into their flight and arrive safely at

their destination. One solution to help travelers through unfamiliar airports is to incorporate technology, especially in the form of mobile applications. The purpose of this research is to develop the logic and concept for a mobile home navigation application and study the benefits to passengers. This article cites some developers who are trying to improve users' place in the home environment, and digital mapping providers such as Google and Meridian have provided a mapping tool for home navigation capabilities. For Google, they developed Google Maps in-house in addition to existing Google Maps, including adding a detailed floor plan of an airport building and an arrow showing a person's orientation and location.

Claudia Barberis and others discussed (Barberis, Bottino and Malnati, 2014) experiencing indoor navigation on mobile devices. They also mentioned the above-mentioned problem, GPS data is unavailable and highly unreliable inside areas such as buildings. Airports, malls and hospitals are the most common places that indoor navigation problems have been overcome. The indoor navigation app aimed to be more than a static map of the environment for showing the path. From a mathematical-algorithmic viewpoint, the possible routes in a building are internally represented as nodes, turning points and edges are the path segments. The shortest path algorithm is used to compute the shortest path between two points.

Sung Hyun Jang was a great researcher found on Google Scholar, conducted (Jang, 2012) many more researches on indoor navigation and proposed a paper that discussed "A QR Code-based Indoor Navigation System Using Augmented Reality". In this paper, it makes clear that many researchers have explored home positioning systems, while other researchers have explored how AR information interfaces integrate with location information. Technologies such as Assisted GPS, Radio Frequency Identification (RFID), Infrared and Ultrasonic are commonly used for indoor positioning. They developed some systems indoor and outdoor positioning using AGPS technology. QR codes are used here to identify the user's current location. They have constructed two instances of using QR codes to

provide in-house positioning data for navigation systems with an AR interface in this article.

Pei-Huang Diao and others had discovered (Diao and Shih, 2018) "Mobile Smartphone AR System for Path finding in a Dark Environment". The developed application name is MARINS. In this study, the Mobile AR Home Navigation System (MARINS) is illuminated only by the LEDs on the phone camera to guide users to exit the 0-luxury backdrop using a smartphone. This system is developed using Apple ARKit SDK and mapping function on the Unity platform. This study developed an iPhone-based AR system, using Apple ARKit SDK on the Unity platform. The system consists of a real-time environment viewing module, AR guide graphic module, LED lighting module, a route witching module and a spatial information database. This research could be developed for the home navigation system specifically for power outages.

Swaleha Khan and others suggested a solution for the stadium using a web application. That talked about (Khan et al., 2020) "Indoor Navigation in Stadium using Virtual Reality". This system is a web application which is divided into 3 major parts: The Front-End, the Middleware and the Back-End. 360-degree photos of each node are captured for each node. The camera used for this is a Samsung Gear 360. Uses Action Director to get a complete photo sphere. The data on each node is stored in the Mongo DB, which is the NoSQL database.

Lilian PUN-CHENG and others conducted a paper that discussed (Pun-cheng, Li and Sar, 2014) "Optimal Path Finding Independent of Center line Topology". This paper addresses and presents a new method for calculating the optimal path with a connection graph. All inputs to the proposed format are just a digital map without any network preparation in advance. The model is based on the specific cell decomposition method to generate a connection graph by connecting a path between two adjacent horizontal cells. Pedestrians can generate possible routes to provide useful information in determining their route. The main advantage of this new system is that a digital map identifies the user's familiar land features to get the desired results of finding the route. Without the generation and maintenance of the arc-node network data, the



format and customized program automatically handle routes and information.

Guillermo Amat and others are researchers, they are mainly focused on the indoor mapping tools. This paper concluded (Amat, Fernandez and Ramos, 2014) the research based on the topic, Using Open Street Maps data and tools for indoor mapping in a Smart City scenario. Google, the world's most important map provider, has launched its Google Home Maps. However, their use is limited to public buildings and their map upload service is not automated. ESRI is also considered a leading provider of geographic information. Their indoor technology is a complete bundle offering indoor mapping, 2d and 3D visualization and routing. The proposed system's architecture's data layer persistence was relayed to MongoDB. The mapping function has three parts. First, first, all spaces and access structures were established following the instructions set out in the OSM's indoor mapping draft. After that, Create a navigable indoor environment with Open Trip Planner. This system uses Wi-Fi fingerprinting for positioning.

Haiyan Hu and others conducted researches based on social functions. This proposed a paper (Hu and Jasper, 2007) that talked about a "Qualitative study of mall shopping behaviors of mature consumers". The study used 30 in-depth interviews to gain insights into the complex business experiences of mature consumers. After this research, they found five elements that are important for mature customers to get a sense of the shopping malls they often visit: choice, convenience, crowd, atmosphere, parking, and hedonic shopping orientation. This paper was widely discussed on the layout of shopping malls.

From questionnaires, surveys, interviews and this literature review, can be identified and get a clear idea about existing systems, used technologies for indoor navigation and pros and cons of currently implemented systems related to indoor navigation. The target group for the questionnaire-based survey is lecturers at the university, software engineers, employees, undergraduates and school students. Another data collecting method is the interview. It is conducted with the Manager of Kandy City Center. For making this system more user-friendly, can be used graphically visualized

method to navigate the users through the mobile app. After analyzing the related works, it is finally confirmed that the best method to implement the navigation function is using Augmented Reality technology because it provides visualizing environment to navigate the users.

### III. SYSTEM DESIGN

This section will briefly describe how the application is designed, what its features and functions are according to the results of the conducted requirement analysis stage. In the requirement analysis phase, data gathering techniques such as questionnaires, interviews and surveys were used to gather qualitative and quantitative data required for creating the requirement specification for the mobile app. A combination of qualitative and quantitative methods was used to analyze data and take into account the project scope to provide adequate action topics to provide the functionality required for software success. The main advantage of mixing those data analyzing methods is the ability to develop a comprehensive software solution that covers all conditions of the system.

Here, conducted two questionnaire-based surveys for collecting the data. One survey is based on identifying the difficulties when shops at shopping malls are located, and another one is to get a clear idea about existing apps used in shopping malls from the population. From the results of the survey, the most common difficulty faced by visitors is difficult to find some shops and time wasting. After analyzing the data, found one best mobile app developed for the One Galle Face shopping mall. However, it does not include any indoor maps and navigation function. It only provides details of shops.

After analyzing data found from different requirement analyzing techniques, the best solution for shopping malls navigation problem is to guide the users through a mobile application. Then, design what functions, features and modules should include for solving the issue. Identified the main functional requirement of EasyMap mobile app as following.

- The system should be able to navigate the user using AR technology.

- The system should be able to provide a 2D map.
- The system should be able to detect the current location of user.
- User can search shops by shop' name or items they need to buy.
- The system should be able to shops will categorize.
- The system should be able to provide user authentication system.

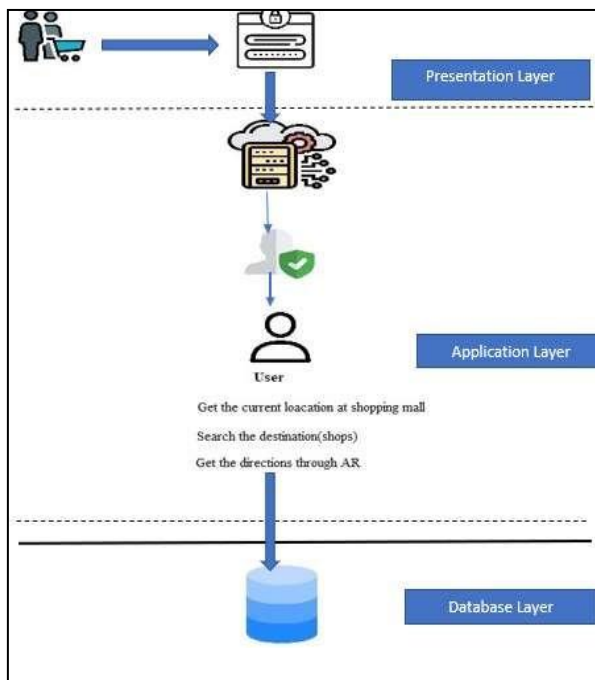


Figure 01: Flow of Activity Diagram  
Source: author

The above-mentioned activity diagrams explain the activities of the EasyMap app and how they interrelated the overall system architecture and the use cases of the developed system.

Each function is assigned to execute one or more activities of the entire system to achieve the desired end goals. The requirements for developing the app using Android Studio SDK, Cloud Firebase (Fire Storage, Authentication), IndoorAtlas, Google SDK Geolocation, Google API and maps SDK, Open Street Map, ARCore for design AR model and language requirements are Java, CSS, JavaScript. First, start the implementation process, application design with the main GUI including all the confirmed features.

#### IV. HOW SYSTEM WORKS

This chapter describes how the EasyMap Android mobile app is developed after the completion of the system designed. The software architecture is mainly considered 3 layers. There is a presentation layer, application layer and data layer. The presentation layer consists of the user-side, that means customers come to the shopping mall. The application layer interacts with the presentation layer where the information is stored and the interfaces in which the interface is run. To predict the current location and find the destination of the user and provide virtual environment applies in the application layer. The data layer is for the storing and managing all the data storage operations and relationship between the entities of the database of the overall system for database requirements of the system. In this EasyMap mobile application, the cloud-based database is used to achieve database functions. The android app uses geo location and google map libraries to track the client's current location and then provide directions to destination by using a cloud server and API's.

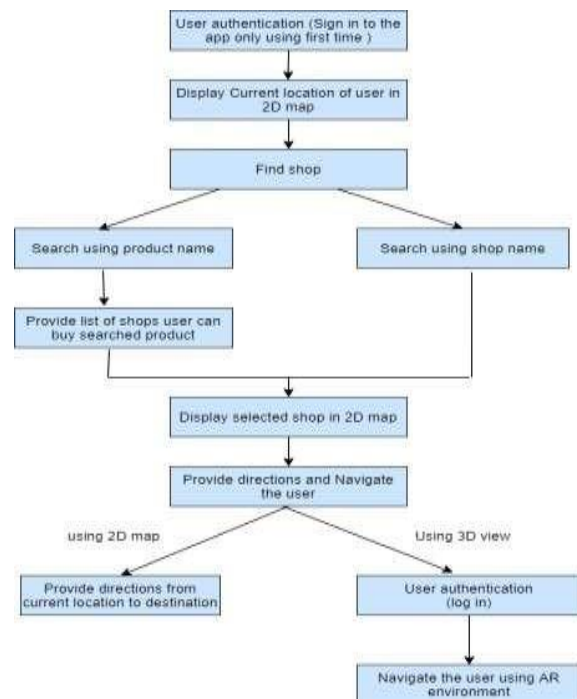


Figure 02: Overall Software Architecture  
Source: author

Methodology of developing the system, Iterative model was used until the complete system is implemented. Because this project is a mobile application. Therefore, many of the key

requirements are clearly defined, however further development requires the addition of certain requirements and the ease of access to the scope of the project throughout the software development life cycle. Major requirements were identified from the beginning of the project and developed throughout the project. Developing the prototype model was given to the users and their rapid feedbacks were used to get reviews and updates and test all the functions and achieve the project final goal with high customer satisfaction.

In this initial stage, the mobile app was targeted to implement for Kandy City Center and chose one floor and a different variety of shops such as clothes, food, electrical etc. to develop this EasyMap. Then using IndoorAtlas to create a 2D map view using the indoor plan of KCC and given coordination to place the map. There are different methods to finding the current position of user at shopping mall. Users can give their current location as manual inputs using such as QR codes or current location etc. Another method is using GPS for finding the current location. For indoor areas, using GPS is less accurate than manual input method. However, users are giving inputs using such a QR code or current location is not user friendly and not feasible, because more than one-time users need to give their current position as manual inputs to the system to find the current location. One of this system's main goals is user friendliness and based on Human-computer Interaction. Therefore, to find the current position, EasyMap used GPS compared with a manual input process. Finally, when the user gives a destination, EasyMap can provide directions using a created AR modelAR model is basically a design using ARCore. It can track the positions through the phone in the real world, and it can be understanding of the surroundings by identifying physical things such as floors and walls in the environment.

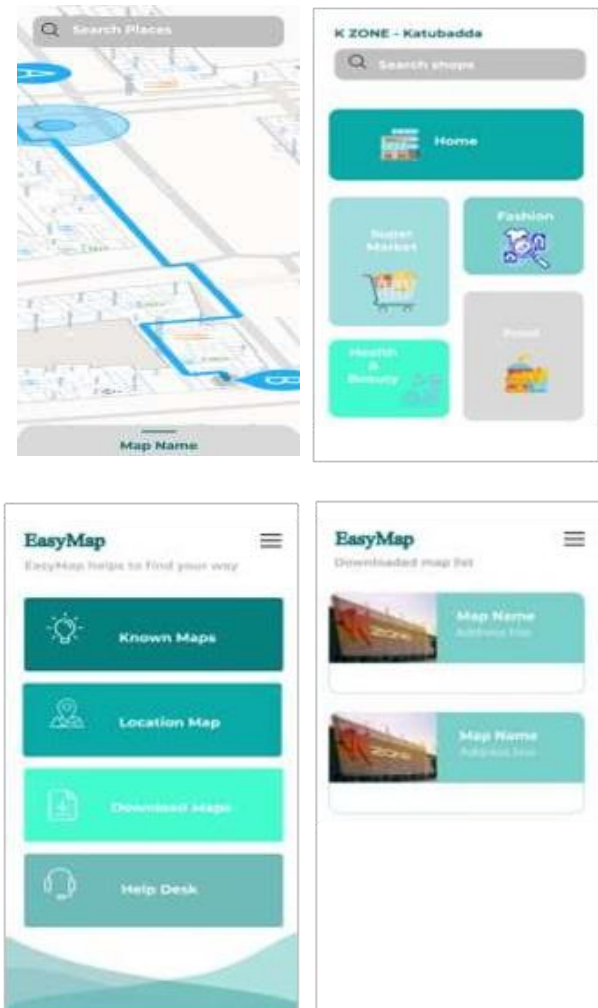


Figure 03: Sample UI designs  
Source: author

Above-mentioned images are some designed User Interfaces for the EasyMap including main functionalities.

## V. RESULTS AND EVOLUTION

Find the destination at vast indoor areas is very difficult. Indoor navigation is a very helpful method, and mobile application is a solution to present it. Therefore, before the implementation process data collection method is very important to identify what are the current requirements and find the best solution for the problem domain. Surveys, Literature review and Interviews are the used data collection protocols for the project pre iteration of project planning. Choose needed requirements and functionalities and design the graphical user interfaces which include identified functions are the main roles of the system design part. Then software evolution is another iteration in SDLC using results of the pre iteration.

## VI. CONCLUSION & FURTHER WORK

This research investigated the future scope of the existing systems and used to understand what features, adaptations and abilities which should be applied to the development. It may be helpful to give the best solution to the problem domain. As a solution, an android-based mobile application is a better way to solve the complexity and not reliability of existing systems, it uses Augmented Reality (AR) technology to solve the indoor navigation feature.

Using this mobile application after user authentication, users can find the indoor destinations at KCC shopping mall quickly and user-friendly. EasyMap finds the current location using GPS in a created indoor map. Then users can search the shops in different ways, such as using the shop's name or using the product's name. According to the user requirements system, find the shortest and optimal path and navigate to the destination through a 2D map or using an AR environment.

At this development stage, EasyMap is implemented only for the KCC. Other famous shopping malls will be added for expansion of the project scope such as One Galle Face, Marino mall, Kzon etc. as further development of the system. Therefore, users can use this EasyMap Shopping mall app when they visit any kind of shopping mall in Sri Lanka. Another main goal of this project is to develop the system based on human computer interaction and also user-friendly to use this mobile app anytime for satisfying the user requirements quickly and easily.

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