14TH INTERNATIONAL RESEARCH CONFERENCE

" *Security, Stability and National Development in the New Normal* "

09TH - 10TH SEPTEMBER 2021

ENGINEERING

ABSTRACTS

GENERAL SIR JOHN KOTELAWALA DEFENCE UNIVERSITY

14TH INTERNATIONAL RESEARCH CONFERENCE

SECURITY, STABILITY AND NATIONAL DEVELOPMENT

IN THE NEW NORMAL

ENGINEERING

ABSTRACTS

General Sir John Kotelawala Defence University

Ratmalana, Sri Lanka

This book contains the abstracts of papers presented at the Engineering Sessions of the 14th International Research Conference of General Sir John Kotelawala Defence University, Ratmalana, Sri Lanka held on 9th and 10th of September 2021. No part of this publication may be reproduced, stored in a retrieval system or transmitted in any form, without prior permission of General Sir John Kotelawala Defence University, Ratmalana, Sri Lanka.

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Message from the Chief Guest

It is with great pleasure that I send this message to the publication of selected conference papers, under a theme that seems more relevant today than ever.

Throughout the history, security has always been the central notion of our existence as a nation. It will continue to be, as long as the geographical realities that define the country's location remains so. This centrality causes our development paradigm to always have a nexus with security, undeniably linking itself to the overall stability of the country.

As the world was compelled to enter into a 'new normal' with the COVID-19 pandemic, the traditional focus on maintaining the hard component of security was overshadowed by the need to replenish its soft component. The world has recently witnessed struggles of global powers with the highest military might, to maintain and uphold their health security. The less-talked about soft security has emerged to overshadow its counterpart, calling us to re-think and re-define the security-development nexus.

COVID-19 posed an unprecedented challenge to Sri Lanka and all developing economies, calling those States to experiment with new ways for achieving national development while managing the novel challenges to their security and stability. In this backdrop, I am delighted to see that the KDU has made allowance for this paradigm shift and hosted its International Research Conference - 2021 along the theme, 'Security, Stability and National development in the New Normal'.

I congratulate all scholars who have contributed to the conference, in particular, those who have shared their research and findings. My heartiest appreciation goes to the Vice Chancellor, Faculty and the staff of KDU whose undying commitment has made this event a reality, even during the pandemic situation.

Steering a country forward in turbulent times is a task that needs meticulous inputs from the country's intellectual body. I am certain that the KDU Research Conference – 2021 has made its mark in this endeavour.

Mr Lalith Weeratunga
Principal Advisor to His Excellency the President of Sri Lanka

Message from the Secretary, Ministry of Defence

It gives me immense pleasure to forward this message on the occasion of the 14th International Research Conference of the General Sir John Kotelawala Defence University (KDU). At the outset, I must appreciate the leadership and guidance which the Vice Chancellor has rendered to maintain the continuity of this highest academic event of the University despite times of great national and international challenges due to the COVID-19 pandemic which has devastated the world.

This year's conference theme: 'Security, Stability and National Development in the New Normal' has taken the current realities of our time into the consideration and how to achieve security and development in times of instability. In this context, I strongly feel that this is an important and commendable approach with innovation demonstrated by the KDU in focussing the attention towards a timely pertinent theme.

The national developments reiterate the importance of a Defence University especially when our motherland is facing unprecedented challenges due to the pandemic. Therefore, I must highlight that our ministerial guidance and blessings, have given the potential for the KDU to actively dwell on a developmental approach to research with Security and Stability as core drivers. This approach will enable the KDU to reach a leading position to guide and influence policy decisions through the knowledge and insights gained from its expansive research programmes.

Furthermore, I believe that the great minds that will lead research deliberations at this conference should actively contribute to aid the great endeavour of steering our beloved motherland towards greater heights in the security and economic spheres, as it is the ultimate responsibility of all Sri Lankans at this time of concern. Finally, I wish that the KDU IRC 2021 will provide a sheer guidance and lead the way towards national development mitigating all current and emerging challenges posed by this devastating pandemic situation. As I extend my sincere well wishes towards the Vice Chancellor, his team and all the participants of this conference for its successful execution and for their future endeavours, I would like to assure that my blessings and support will be with KDU at all times.

General Kamal Gunaratne (Retd)
WWV RWP RSP USP ndc psc MPhil
Secretary
Ministry of Defence

Message from the Vice Chancellor

As the KDU celebrates its 40th anniversary, the International Research Conference is entering its 14th year and adapting to the new normal conditions and unprecedented challenges that have forced many programmes to be called off indefinitely. The evolution and continuity of the research conference into the successive 14th year adapting to challenges bears testimony for the success of the KDU as a seat of learning that can withstand any challenge national or international in nature.

The sheer number of papers that the conference received this year demonstrates the enthusiasm shown by presenters both locally and internationally even at a time of a grave crisis that has put educational institutions under severe stress, and it affirms the faith scholars have had on KDU. As the only defence university in Sri Lanka, KDU has been committed to research and knowledge production that will influence and shape the policy deliberations of security and development. These are core pillars of the stability and existence of any society, and it is our national responsibility to provide such insights through the organization of premier research dialogues.

This year's theme 'Security, Stability and National Development in the New Normal' bears witness to the civil military fusion that KDU has created and its commitment to achieving balance and resilience in times of global crises to safeguard and advance the security and developmental interests of the motherland.

KDU IRC is a platform of cooperation and diplomacy, and it encourages academic collaboration across Sri Lanka's higher education institutions. Research conferences are the ultimate networking events, and we are proud to provide these spaces of engagement where Sri Lankan and international scholars can present their findings and deliberate on the way forward for the nation and for the global community to thrive at a time humanity's resolve is tested by the pandemic. I wish all the very best for the academics, practitioners and policy makers who want to showcase their research and experience at our research conference.

Finally, I appreciate the dedication and hard work of all those who worked tirelessly over the last several months contributing in diverse ways to make the KDU IRC 2021 a reality under the trying circumstances, especially the IRC Chair, the Secretary, and the organizing committees headed by the Deputy Vice Chancellor (Defence and Administration).

Major General Milinda Peiris
RWP RSP VSV USP ndc psc MPhil (Ind)
Vice Chancellor
General Sir John Kotelawala Defence University

Message from the Conference Chair

KDU International Research Conference in its 14th iteration is held amidst celebration of its 40th anniversary and situated in local and global environment that is challenged by a new form of microbial security threat in the form the Covid19 outbreak. KDU stands strong and unbowed to maintain the continuity of this apex academic event this year on the theme, Security, Stability and National Development in the New Normal.

Challenged with the most potent wave of the pandemic, we remain undeterred thanks to the leadership of the Vice Chancellor. The organizing committee has put their heart and soul into adapting and evolving the conference formats that could withstand and confront the new normal conditions in organizing the international research conference.

Academic communities in the world are beacons of hope and resilience and given the sheer number of research papers that were submitted to the conference this year is a testament that KDU remains a space of hope for such communities and a sacred ground where research is encouraged even at trying times.

The theme of this year was a conscious decision to confront the realities that Sri Lanka and the world had to encounter since March 2020, that Covid 19 was a harbinger for a new reality. Universities are centres of resistance and renaissance and the KDU in Sri Lanka sets an example to all other institutions to emphasize the will to confront any challenge.

In this context KDU research conference is nourished by the presentations and deliberations of esteemed plenary speakers and research presentations that will provide vital insights into the key themes of security, stability, and national development. I extend gratitude and best wishes to all presenters who believe in the research culture evolved by the KDU and may you be treated to the finest KDU hospitality that transcend from physical to the cyber space and may you all be contributors to a greater cause for the sake of all humanity.

Dr Harinda Vidanage
PhD (Edin)
Conference Chair

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ORAL PRESENTATIONS

Verifying of 'Orifice Plate' Connecting Duct Lengths to Validate Performance of a 'Vent Test Rig at Australian Maritime College' by Computational Fluid Dynamics (CFD) as Part of the Oscillation Water Column Power Take Off

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Oscillating Water Column (OWC), ocean wave energy converter, transforms the energy of ocean waves into low pressure pneumatic power. This pneumatic power is extracted by a turbine and converted to electric energy through a generator. Australian Maritime College (AMC) has set up a vent test rig to conduct experiments on 'OWC' operation, quantify air leakage, and find differential pressures across the orifice plate as per the Australian standard of fan performances. However, the upstream and downstream of duct lengths of vent test rig did not match the given specified standards due space restriction. Therefore, the technical team of AMC chose Computational Fluid Dynamic (CFD) application as an alternative method to continue the investigation with economy of effort. Subsequently, it is understood that, CFD is a very attractive method to carry out investigations and obtain a detailed report with all tested parameters and conditions. In addition, it is revealed that the shape of the flow pattern which cannot be seen during the experimental study. The objective of this investigation was to apply CFD instead of vent test rig experiment and carry out modelling, and then compare the outcomes with experimental results. Further, CFD application was used to test differential pressure across the orifice plate with the same upstream and downstream lengths of pipe, which were utilized during the vent test rig experiment. In addition, CFD was applied again for specified lengths of pipe with the same orifice plate to measure the differential pressure across it. Finally, it was proven that specified duct lengths directly impacted the performance of the vent test rig and decreasing of the generating pressure along with the length of the pipe due to relative roughness.

Keywords: *oscillating water column, inflow radial turbine, vent test rig, orifice plate, computational fluid dynamic.*

A Hybrid Diesel Engine Simulator as a Skill Development Tool for Marine Engineering Undergraduates

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This paper explains a prospect of using a scenario from a marine engine room simulator as a device for educating marine engineer undergraduates. Basic technical parameters have been indicated for the entire scenario of the marine engine room simulator which is used to educate marine engineer undergraduates of the General Sir John Kotelawala Defence University (KDU), Sri Lanka. The Hybrid Diesel Engine Simulator (HDES) is primarily a training method that simulates a realistic engine room set-up, through a controlled environment for marine engineer undergraduates and engine room watch keepers training on-board ships in operational circumstances. Further, HDES can be utilized for training engine room watch keepers in both war and peace times equally. Subsequently, to comprehend the actual operational parameters of Main engines and Auxiliary engines and the smooth functioning of the vessel, the engine room watch keepers will be able to respond to any defect with efficiency, expertise, and confidence gained from training in similar situations. The authors argue that the projected tutorials in the simulator could significantly contribute to the development of alert and responsible machinery utilization of trainees during marine engine room operations.

Keywords: *hybrid diesel engine simulator, niigata 6M26AGT marine diesel engine, thermodynamics, engine room watch keeper, machinery control room (MCR), console, simulation mode, actual mode*

Design Approach to Optimize Water Jet Performance: A Case Study of Coastal Patrol Craft, Sri Lanka Navy

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Commercial water jet manufactures publish their water jet performance curves mostly in the form of thrust/power against boat speed. The common approach is to foresee the performance of craft with candidate water jet(s), to simply plot the developed bare hull drag curve by a Naval Architect against the published power/thrust curves in graphical mode to establish the best fit. Yet this traditional approach does not uncover information of craft performance in the entire speed range or water jet model efficiency as the best choice for a particular local application. This case study incorporates approaches to seek a reduction in the craft bare hull drag, to develop an adequate analysis that shall combine engine RPM analysis to understand the availability of full rated engine power absorbed by propulsor/water jets. Therefore, the research employs a comprehensive mathematical based methodology as compulsory, to evade performance glitches and to outline an accurate and fruitful design structure. Thus, the employment of "universal water jet coefficients" has been considered to validate the design and eliminate the flaws associated with the traditional "thrust-resistance" plotting technique. A naval project designed by the authors was used to demonstrate how the authors averted possible complications and optimized the design through a new calculation methodology.

Keywords: *traditional approach, water jet efficiency, universal water jet coefficients*

Chronic Kidney Disease of Unknown Aetiology in Sri Lanka: An Implication of Optimizing Recovery Ratio of Brackish Water Reverse Osmosis Plant

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Drinking water is an essential for human beings. At times, the fresh water from the sources of water in the environment such as streams, wells, and other water bodies cannot be used as drinking water because of the high content of dissolved salts and solids. This is most prominent in areas where water is scarce and areas where fertilizers and chemicals are used for different day-to-day processes such as agriculture. With a high level of environment contamination for a prolong period, the chemicals get into the underground water sources. In rural areas of Sri Lanka, mainly in the district of Anuradhapura, the majority of the people are prone to Chronic Kidney Diseases of Unknown aetiology (CKDu). Reverse osmosis technique is used to remove the dissolved solids from the fresh water and bring it to a drinkable level. Brackish Water Reverse Osmosis (BWRO) plants are present in an industrial scale to provide drinking water from brackish water, but at a higher cost. The main aim of this project is to develop a BWRO plant at a lower operating cost with a high recovery ratio to be implemented in areas where Total dissolved solid (TDS) levels are above the SLS standard (500 mg/L), and where even brackish water is scarce.

Keywords: drinking water, brackish water, reverse osmosis, cost, recovery ratio

Finite Element Model of PAAm Hydrogel to Assess Optimum Thickness for Cushioning Applications under Foot

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Hydrogel is considered a potential biomaterial with a cross-linked polymer network swollen with water. Replacement of load-bearing tissues such as cartilage is considered due to this special structure of hydrogels. This paper presents the modelling of polyacrylamide (PAAm) hydrogel as hyper-viscoelastic material by using Abaqus finite element analysis (FEA) software. The compression test data was used to develop the hyperelastic Ogden model, and stress relaxation test data to develop the model's viscoelastic parameters. The developed finite element model was validated with pressure insole test data, and was used to investigate the pressure distribution properties to optimize the thickness suitable for load-bearing and cushioning applications. The results indicated that the thickness of 6 mm to 8 mm polyacrylamide hydrogel was capable of reducing peak pressure below the upper threshold value of 200 kPa.

Keywords: *hydrogels, hyper-viscoelastic, pressure insole, finite element analysis*

Design and Development of Plastic Waste Recycling Apparatus

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According to the Sri Lanka Customs, 1600 tons of plastic are imported to Sri Lanka per month. From that, 480 tons (30%) are exported as products and the remaining 1120 tons (70%) of plastic are disposed within Sri Lanka as waste. From that waste, only 400 tons (35%) are being recycled, and the rest which amounts to approximately 720 tons (65%) is burned, or just disposed to the environment. There are many recycle methods and different kinds of recycling organizations in Sri Lanka which produce value-added products from plastic waste. Eco Spindle (Pvt.) Ltd is a one of the plastic recycle factories in the country which produces a special type of yarns from PET bottles. Still, they do not use the Lid of these PET bottles, and an average of 4-5 tons of lids per month are being disposed. The aim of this study is to design and develop a mechanical apparatus/machine to recycle specifically the Lids of PET bottles and produce plastic sheets. Other than PET, the designed machine is capable of recycling three type of plastics (PP, HDPE, and LDPE). Once the processed plastics is fed to the machine it heats and melts the plastics and presses it to produce sheets with the required thickness (approximately around 1 mm). These sheets can be used to make items such as fancy bags, table mats, pencil cases, hand wallets, and files. A fully automated sheet-making machine was designed and developed successfully. Even though the prototype consists of some deviations to the designed machine, the results of the tests/trials proved the accuracy and the appropriateness of the design parameters and the mechanism. The machine was tested by changing the temperature, and keeping it at 1300^0C for 10 minutes has given the required output paper quality as required. The total cost incurred to fabricate the prototype is around 46,500.00 LKR, and the forecasted cost for a fully automated machine is calculated to be around 64,000.00 LKR. This product can be recommended for the use of plastic recycling industries, and also to small scale family businesses to recycle the waste plastics and make fancy products.

Keywords*: plastic recycling machine, PET lids, plastic sheets.*

Performance Analysis of a Photovoltaic System under Different Configurations

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Solar energy is used worldwide as energy can be harnessed directly from sunlight. Currently, the photovoltaic panel is considered as one of the fastest-growing renewable energy technologies that plays a major role in generating electricity. Sri Lanka receives a significant amount of solar radiation where Global Horizontal Irradiance fluctuates between 1247 kWh/m^2 and 2106 kWh/m^2 throughout the year. The power output generated by the PV panel depends on the irradiance received by the panel. When the irradiance increases, the power output of the panel also increases. However, as the solar irradiance increases, surface temperature of the PV panel also tends to increase. Higher surface temperatures cause degradation of the panel, and as a result, the lifetime of the same is reduced. Cooling of the PV panel can be used effectively to maintain the surface temperature at a desirable level while maintaining a higher power output. This study investigates the performance of a PV panel in terms of its power output under four different configurations at Ratmalana, Sri Lanka. It is observed that the power output increases substantially around 12 noon when reflectors are used along with the PV panel. However, this configuration records a higher temperature on the surface of the panel. It is observed that air cooling enables only a slight reduction of the panel surface temperature. When both air and water cooling are incorporated, panel surface temperature is reduced substantially while generating a higher power output. It is recommended that the conventional PV panel be used until 12 noon, and then switch over to the configuration that incorporates reflectors with air and water cooling in order to produce a maximum power output while maintaining lower surface temperatures of the panel that will increase the lifetime of the same as well.

Keywords: *photovoltaic panel, power output, surface temperature, configuration, cooling*

Review on the Impact of Auxiliary Engine Loads on the Fuel Economy of Light Duty Vehicles

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Due to the overwhelming motorization, the fuel consumption has increased exponentially. Therefore, the fuel economy has inevitably become a major attraction in today's automotive research. There exist several fundamental factors affecting the fuel economy of a vehicle viz. engine factors, drive train factors, vehicle factors, driving pattern, test cycles etc. Besides the said factors, the auxiliary engine loads are one of the essential factors affecting a vehicle's performance pertaining to fuel economy. An auxiliary load can be defined as the energy utilized to operate auxiliary equipment which draw power from the respective engine. Auxiliary loads can be listed viz. alternator, air-conditioning system, power-assisted steering and braking, water pump, cooling fan etc. In reference to the previous studies conducted on behaviour of the auxiliary loads, the impact of the auxiliary loads on the fuel economy of a vehicle will be reviewed in this study. With respect to the research conclusions, it can clearly be stated that the air-conditioning system and the alternator appeal for higher power demand, resulting in higher fuel consumption. Moreover, it can be noted that almost all the auxiliaries depict a closely proportional relationship with the engine speed whereas the auxiliaries appeal for higher power demand at higher engine speeds. During the study, the air-conditioning system, water pump and the alternator operation and characteristics pertaining to automotive operating fuel economy are reviewed and discussed.

Keywords: *fuel economy, auxiliary loads, air-conditioning, alternator, water pump*

Development of a Robust Fire Boat to Operate at Fishery Harbours

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Fires on board of fishing craft at fishery harbours in Sri Lanka have occurred frequently during the last two decades, and in most instances, these spread to nearby fishing craft as well, resulting in heavy damage to property and the lives of the fishermen on-board. The traditional shore-based extinguish methods used to quench the fires proved unsuccessful in every instance. The drawbacks were identified for the existing methods of extinguishing a fire on board of a fishing craft. The most feasible and reliable method was to develop an in-shore patrol craft to hook and tow out the fishing craft on fire away from the other craft, and extinguish the fire with a major firefighting system designed for and installed in the rescuer craft. Thus, a floating fire extinguishing platform was designed and developed in accordance with the international and local fire regulations. The study comprises the designing of the fire main system with the mathematical calculations associated with the designed system and the stability of the craft.

Keywords: *existing methods, fire main system, fishing craft*

Developing an Explosive Laden Unmanned Waterborne Vehicle to Eliminate Liberation Tamil Tiger Elam (LTTE) Suicide Boat Attacks at Sea

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The LTTE was one of the most ruthless terrorist groups, which had operational sea capabilities. In the early 1980s, the LTTE formed a naval wing called sea tigers. Subsequently, the sea tiger leader introduced an elite and highly trained suicide carders to this special element to carry out attacks against Sri Lanka Navy (SLN) ships, using explosive laden boats. The Sri Lanka Navy, thus, was faced with a unique challenge. The highly developed maritime guerrilla warfare, which the SLN faced, had to be fought and won in close proximity to the enemy, at visual range, where speed and manoeuvrability took precedence over long-range weapons and endurance. Then, the SLN decided to build an unmanned waterborne vehicle (UWV), to counter suicide boat attacks of the LTTE without harming its own men. This UWV was unique and operated at a wide range of both shallow and deep waters effectively. Further, it was fixed with 120 kg high explosive claymore mines that could be detonated remotely. The speed, manoeuvrability, and explosion impact of UWV were investigated by ramming it to the LTTE target. It was found that significant damage to the enemy was done by the explosion and shock wave during the test. Consequently, the LTTE suicide boat launching dramatically reduced.

Keywords**:** *Sri Lanka Navy (SLN), Unmanned Waterborne Vehicles (UWV), Unmanned Arial Vehicle (UAV), Rapid Action Boat Squadrons (RABS).*

Inductively Coupled Plasma Optical Emission Spectrometry in Effective Condition Based Maintenance Engineering Plan

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The Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) is a powerful tool for the determination of many wear down elements in a variety of different sample matrices. The Sri Lanka Navy commenced analysis of used lubricating oils in on-board main machineries and shore-based generators since the year 2017 which assists to implement Condition Based Maintenance (CBM) philosophy in the Sri Lanka Navy as a vital component in the P-F curve of machinery maintenance reliability. As per ASTM D 5185, the testing has been carried out. Results of the analysis capture only the particle sizes below 10 microns where the elements are necessary to be oil-solvable. In this, soluble residues are not counted. The paper is focuses on appraising the process practiced by the SLN to study the elemental behaviour of machineries fitted on-board to support the CBM development plan. The annual oil condition monitoring schedule has been published, and sample testing is done according to the promulgated directives. The findings of the analysis are plotted against each of the machinery, and the machinery health is monitored accordingly. Several failures were pre-identified and preventive actions were initiated. The numerical results against each similar type of engines with respect to the running hours of the machinery are compared and specific limitations against each make/model are identified. This will enable us to find the safe operating parameters as a baseline measurement and to promulgate the threshold limits.

Keywords*: inductively coupled plasma optical emission spectrometry, oil analysis, condition monitoring*

Cost Effective Method to Analyse Lubrication Oil

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The lubricating oil analysis is the most common method to identify the condition of any machinery. There are various ways to analyse lubricating oil based on an individual examination of lubricant properties such as Viscosity, Total Base Number (TBN), Total Acidic Number (TAN), Water Content, Impurities (element analysis) etc. However, the equipment required to conduct these analyses are costly, need specific environmental conditions, and generally time consuming. The time consumption of this whole process hampers the maintenance program efficiency. Hence, an onsite, cost-effective, and faster results-giving method to analyse lubricating oil would be a valuable asset. A comprehensive literature survey was carried out to understand the current trends in lubricating oil analysis. Accordingly, the analysis techniques could be categorized as Physical, Chemical, Electro-magnetic, and Optical. The proposed design is based on an optical technique that deals with the Refractive Index (RI) since it is an indicator of the physical as well as the chemical property characteristic of a substance. The critical angle of a material is directly related to RI. Monitoring the critical angle changes leads to an understanding of the quality of the lube-oil. The performance of a proposed lube-oil analyser was assessed using Shell Gardenia 40 (lubricating oil used in high-speed marine engines of Fast Attack Craft) lubricant at different operating hours. The results obtained from the proposed device were compared with the tests carried out according to the American Society for Testing and Materials (ASTM) standards and through a viscometer. Both tests confirm the effectiveness of the proposed device.

Keywords*: lubricating oil analysis, refractive index, cost-effective lubricating oil analyzer*

Optimization of Industrial Manipulation Tasks Using Parallel Manipulators

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Small-scale product handling industries are at the cusp of increasing their efficiency and effectiveness, where optimization is a considerable factor. Though regular pick and place tasks are nonvalue added steps, it can replace expensive manual labour by increasing efficiency. Hence, this paper discuss the optimization of regular pick and place tasks using parallel manipulators. Out of the evaluations, on alternative manipulators, the 3-link parallel manipulator was of the focus. A simulation and a real-time operation were conducted for the comparison of the two designs in relation to robot workspace. The robot kinematics were derived to define the robot workspace, and for the dimensions of the mechanical components which were equally designed and tested using SOLIDWORKS. Fabricating was done using lathe machining and 3D-printing. The servo and visual systems were decided accordingly for the pick and place application. Control and functionality with the input visual system and kinematics model were mapped and generated in MATLAB, and then transferred to Arduino which drives the motors of the manipulator. This makes the robot end effector to actuate and perform the picking and placing using the solenoid gripper. An accurate result in object detection, mapping, picking, and placing by the delta robot is thereby achieved. The presented model is feasible to be used in the industry which can accommodate regular pick and place tasks in a facility*.

Keywords: *pick and place, parallel manipulators, delta robot, kinematics, workspace, visual servo system, MATLAB*

Auto Balancing Ambulance Stretcher with Active Control to Mitigate the Discomfort of the Patient

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During a medical emergency, the time taken to transport a critically ill or injured patient to the closest medical centre is a key factor determining the life and death of the patient. Although the current ambulances have attained the capability of passenger transport at a higher rate, the inability of the same designs to cater to the level of comfort during this journey has led to an increase in the mortality rates. The solutions for the above problem are either to build an ambulance, or to improve the design aspects of the stretcher, in order to ensure the required level of comfort to the critical patient. This study suggests a stretcher design capable of three degrees of freedom, which is used to counteract the discomfort caused by centrifugal accelerations and vibrations. The tests conducted have proven the capability of the stretcher to reduce the vibrational effect experienced by the subject by 58%, while bringing the maximum vibration well below 2Hz, the effect due to inertial accelerations by 92%, and effect due to centrifugal acceleration by 88%. Considering the ergonomic characteristics and lower cost associated, the suggested design shows feasibility of using the apparatus in developing countries like Sri Lanka.

Keywords: *auto-balancing ambulance stretcher, mitigate discomfort, inertial forces, 3-DOF*

Design of a Magnetostrictive Bimorph for Micromanipulation

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Micromanipulation within a lab-on-a-chip (LOC) device enables precise manipulation of cells, paving the way to diverse biomedical applications. In this research, the design of a magnetostrictive microactuator for micromanipulation is presented. The proposed microactuator is a cantilever-type bimorph consisting of a Poly-methyl methacrylate (PMMA) layer between a Terfenol-D and Samfenol-D layer, which have high magnetostrictive properties, and a Silicon probe tip at the free end. The microactuator characteristics were evaluated through numerical simulations. The designed microactuator can operate under frequencies up to 146.12 kHz. The sensitivity range of the microactuator is 77.6-11323.6 nm/T, while it can exert pressures up to 15.55 MPa for magnetic fields from up to 800 kA/m, demonstrating that it is capable of micromanipulation of cells in LOC devices.

Keywords: *lab-on-a-chip, magnetostriction, MEMS, microactuators, microrobotics*

Framework for Aviation Safety Cost Optimization through Risk Mitigation Tolerance Analysis

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The aviation industry depicts itself to be one of the topmost safety-conscious industries where thorough emphasis is focused on safety management systems as a toolbox for hazard identification and risk mitigation. The promulgation of regulatory safety measures for in-air and on-ground operations has collated additional time and operational costs for all types of aviation establishments. The risk probability and severity aspects of safety models have been vastly studied in previous research mainly through qualitative analysis and risk matrix formulation. In conventional studies, the "risk tolerance" has been mainly incorporated with the probability and the severity of the risks where less or no emphasis is laid on the cost-benefit analysis. Hence, this study focuses on the implications of the "cost variable" on risk mitigation tolerance analysis in a collaborative approach of qualitative and quantitative analysis. The study converges the theoretical relationship of the "safety tolerance levels", towards the "overall safety cost" which aims to bridge a significant gap in the contemporary aviation safety literature. In bridging the unpredictability of the post-failure cost, the optimization of the cost of safety assurance enables expanded forecast ability by mathematically calibrating the strategic positioning of the safety threshold. The scale of the airline and the regulatory mandates have been considered in developing the conceptual ideology. Moreover, the study will span through to the development of a data-driven mathematical model for the cost to tolerance variation. Hence, the theoretical framework of this study proposes a more generalized approach that can be customized for the safety cost-benefit analysis and resources allocation policies of diversified airline operations spanning from low-cost carriers to high-end niche markets with utmost safety concerns.

Keywords: *Safety Management Systems (SMS), Safety Risk Management (SRM), aircraft maintenance cost benefit, risk mitigation, risk tolerance.*

Impacts of Changing Rainfall Patterns on Hydropower Generation: A Case Study of Kehelgamu Oya Sub-basin

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Hydropower, the largest renewable energy source in Sri Lanka, generates approximately 50% of the total energy requirement. The annual electricity generation fluctuates greatly due to the variation of rainfall. Thus, the daily rainfall at Castlereagh and Norton stations of the Kelani River basin during the period 1960-2016 has been analysed on an annual, seasonal, and monthly basis. The aim of this research is to identify the impact of rainfall patterns on hydropower generation in Sri Lanka. Variability of the time series is assessed by detecting the trend using Spearmen's correlation coefficient test. Sen's slope estimator test was used to estimate the magnitude of the trend. Pearson correlation coefficient was used to find the relationship between rainfall and hydropower generation. A significant decrease in the annual rainfall and South-West monsoon rainfall observed at Norton and Castlereagh also shows a similar but not significant decreasing trend. A decreasing trend of monthly rainfall was also found at both stations. The results revealed that the future hydropower generation is in an alarming situation due to the decreasing trend of rainfall.

Keywords: *climate variability, rainfall trends, Spearman's Rho trend test, Sen's slope, hydropower*

Identifying Current Trends in Source Selection of Household Water Use in Pohaddaramulla, Kalutara

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Sri Lankan Drinking Water Supply Policy is committed for the sustainable use of drinking water, while addressing reliability and safety of the resource. . In this research, trends in the selection of water sources for household use in Pohaddaramulla area are addressed. Tube wells, open wells, and mains supply from the National Water Supply and Drainage Board (NWS&DB) are the main water sources used in the area. However, some areas are not covered by the NWS&DB services as yet. Various trends in selecting water sources by the consumers are found. Ground water sources are used while using the mains supply. Data collected through a questionnaire, rainfall data, evapotranspiration data, runoff calculations, and various other sources were used to analyse the current trends and identify their sustainability. Several types of trends are found in this area. Out of the families that use mains supply, 35% is using the mains supply as their only source of water. Remaining 65% uses other water sources while using the mains supply. A 40% of the sample does not use the mains supply. From them, 66% uses tube wells and 31% uses open wells with pumping. Only 3% of them uses tube wells and open wells. Our analysis points out that the current trend is not sustainable even at present. In the future, it will not be sustainable as the ground water demand by the residents cannot be fulfilled by the current conditions. There is no recharge to the ground water storage. Therefore, alternative water sources are needed. Also, there is a risk of saltwater intrusion. These issues can be further studied in the future researches. The information obtained from this study can be used by NWS&DB for planning the extension of service area.

Keywords: *water sources, tube wells, open wells, mains supply, ground water*

Impact of COVID-19 Lockdowns on Air Quality in the South Asian Region

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Air pollution has become a common problem in most urbanized cities in the world. South Asia is a pollution hot spot since most countries in the region qualify to be categorized as developing nations with poor monitoring and control of industrial-related pollution. The recent outbreak of the COVID-19 pandemic led many countries to lock-down to control the spread of the virus. This resulted in the complete shut-down of most sources of industrial emissions and a heavy reduction in vehicular emissions. Accordingly, most South Asian countries witness a notable reduction in air pollution and significant improvement in air quality. This study measures and compares the change in pollution levels in the first six months of 2020 while using 2018, and 2019 as points of reference. The analysis includes an investigation of daily, weekly, and monthly trends of air pollution concentrating on PM2.5 levels in six countries of the region. Based on the observations of the analysis, significant factors affecting the level of change in air quality were identified. Most cities recorded significant change in the pollution level only after 30 days into the lockdown while the Source of pollution, topography, and location were identified as the main factors which affected the dispersion rate of pollution.

Keywords: *air pollution, COVID-19, Sri Lanka, South Asia*

Indigenously Designed and Developed Control System for Sri Lankan Naval Vessels "Naval Propulsion and Steering Control" System

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Obsolescence of spares for Leader In Propulsion System (LIPS), Netherlands engine/steering control system Fast Attack Craft (FACs) of Sri Lanka Navy (SLN), will be non-operational in the near future, and the manufacturer has provided a proposal for upgrading these at a cost of approximately Rs 93,9 Mn per craft in year 2017. Hence, this effort has been made by studying the existing system with the automation knowledge accessible. This study presents aspects of the engine and steering controls onboard P47 series FACs, by analysing the existing systems based on automation and the use of modern propulsion based on Programmable Logic Controllers)PLC .(Human Machine Interfaces)HMI (have been integrated for advanced monitoring and calibrating purposes which comprised a PLC based control system integrating sensors and actuators with commands given at the engine room, wheelhouse, and open bridge command panels .Processed command data are fed to actuators and the feedback have been obtained, thus forming a closed loop control system. These commands, feedback, and sensor readings are fed to PLCs and interfaced with the HMIs which indicate parameters in real time .Alarms and shutdowns have been set at the specific reference values and indicated on the monitoring displays. Controls are available at the engine room, wheel house, and open bridge for easy manoeuvrability as per operational requirement. The study covers the designing process, implementation process and PLC programming, HMI programming, simulation process, commissioning process, and testing process. Used PID controls in the feedback mechanism to optimize the control process variables are the most accurate and stable controller .The designed system was installed onboard P471 and tested several times under close supervision by experienced Senior Electrical Engineers as well as Senior Marine Engineers of SLN, prior to placing the craft as operational on 03rd January 2019. The cost for the project was only approximately a total of Rs. 3.6 Million which will save approximately Rs. 91.4 Million per craft.

Keywords: *MMM (Mini Micro Module) and LMP (Lips Micro Processor), Machine Interface (HMI)*

A Methodological Literature Review on Non-Invasive Blood Group Detection

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Blood grouping is the method of determining the type of blood inherent in an organism's body based on the unique types of molecules present in their body- namely antigens and antibodies. Blood groups are differentiated based on the general ABO classification system. Identification of the blood group is a key factor, specifically in the field of healthcare. Organ transplantation and blood transfusion require the blood groups of the individuals to be determined rapidly, in case of diseases or accidents. The standard method of blood grouping requires samples of blood to be extracted from the person, which is then directed for further chemical processing. This conventional method is painful and time-consuming; thus, the introduction of a novel non-invasive method would bring convenience to most humans. The proposed systems have generally used visible light for voltage detection, image processing and deep learning algorithms, NIR spectroscopy, and methods of molecular detection in order to yield results. But limited literature based on this subject exists. Hence, this methodological literature review focuses on the existing peer reviewed literature that explores methods related to non-invasive blood grouping. Out of the methods reviewed, voltage detection using visible light and NIR spectroscopy proved to have the highest rates of success.

Keywords: *ABO blood grouping, non-invasive, methodological review*

Supersaturation Controlled Wet Synthesis of Nanohydroxyapatite for Biological Applications

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In this study, the effect of supersaturation for wet chemical synthesis of Nano-hydroxyapatite HA [$Ca_{10}(PO_4)_6(OH)_2$] was investigated. The nano-hydroxyapatite powder was synthesized using $Ca(OH)_2$ and H_3PO_4 as precursors at five different supersaturations while the temperature for the whole study remained at 30^0C. The supersaturation for hydroxyapatite was caused by changing the concentration of precursors maintaining the constrained molar ratio near 1.67 between Calcium and Phosphorus Ca/P. The H_3PO_4 was added to the $Ca(OH)_2$ suspension at a constant acid addition rate of 4ml/min using a burette under vigorous stirring having maintained the final pH at 10. During the synthesis, the variation of pH of the mixed precursor suspension was measured and analysed. After 48 h aging, the precipitate was separated by centrifuging at room temperature. Then the resulting wet powder samples were dried and characterized. The particle size distribution was obtained by Laser Particle Size Analyzer and Fourier Transform Infrared (FTIR) spectroscopy investigated the bonding structure of pure hydroxyapatite. In addition to that, morphological and chemical analysis was done by Scanning Electron Microscopy (SEM). As a measurement, the time taken by the final precursor mixture to start reducing pH value increased with the supersaturation decreasing. It was clearly observed that the particle size and the standard deviation of the distribution or a broader distribution had increased with decreasing supersaturation. Finally, this model could be used to predict the particle size distribution of hydroxyapatite resulting from a wet chemical routine with the supersaturation which depends basically upon precursor concentrations.

Keywords: *nano-hydroxyapatite, wet chemical precipitation, supersaturation, particle size distribution*

Analysis of Binarization Techniques in Morphology-Based Scatterer Calculation

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The roughness characteristic of an organ surface is a key indicator for examining the finalities of that organ. There are traditional roughness calculation methods based on measurements using the stylus technique (contact system) which causes damages to the organ surface. However, compared to these traditional techniques, roughness calculations based on image processing have shown promising results with higher accuracy. This paper proposes a technique on binary image-based morphological processing to calculate the roughness. Microscopic images of sandpapers were used as raw images and they were converted into binary images using binarization techniques such as Otsu's thresholding, adaptive thresholding, Bernsen thresholding, Niblack Thresholding, and Bradley thresholding. Further, the scatterer size and number of scatterers of the images were calculated by morphological processing. Accordingly, histograms were plotted (X-axis - the size of the scatterer, Y-axis - the number of scatterers in each size) for each image. The histograms were compared using statistical parameters (skewness, kurtosis, variance, and mean) to identify the best binarization technique. Otsu's method has shown positive results in scatterer calculation than other techniques.

Keywords: *morphological processing, roughness calculation, binarization techniques*

POSTER PRESENTATIONS

Drop Down in Speed of Fast Attack Craft

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Sri Lanka Naval fleet consists of 55 Fast Attack Craft (FACs) belonging to the Sri Lanka Navy (SLN) and Coast Guard which are propelled by water jets, conventional V-drive propulsion systems, and Articulated Surface Drive (ASD) powered by twin diesel engines. Recently, the drop in speed of FAC's has been a challenging problem to SLN. The objective of this research is to find out the reasons for the speed drop of FACs, and the effect of hull cleaning/routine underwater maintenance as a solution. The research mainly focused on gathering information related to speed with RPMs and observing changes to the hull, and finally modelling of a similar shaped hull and analysing effects on speed due to the changes in the hull form.

Keywords: *hull cleaning, fast attack craft, underwater maintenance, Sri Lanka Navy*

A Sustainable Future for Rubber Waste in Sri Lanka

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Innovative construction materials have a high demand in the construction industry with the development of the green building concept and sustainable construction. The use of waste materials is encouraged even with the green rating system, and waste rubber is identified as one of the main waste materials generated in any country. Sri Lanka produces 4.5 billion solid waste materials per year. The management of waste material and implementing them in a productive way is essential for a country to promote sustainability. For rubber waste, solutions such as rubberized concrete have been introduced in developed countries. However, in Sri Lanka, rubberized concrete is not popular in the construction industry. Further, it is not clear whether the quality or the quantity of rubber waste available in Sri Lanka is sufficient to promote such application of rubber waste. Therefore, this study reviews the feasibility of using rubber waste available in Sri Lanka for a commercial application such as rubberized concrete. The wastage of rubber from different sources was identified as 1283.6 tons per month in Sri Lanka. Out of the whole batch of rubber wastage, latex rubber and tire rubber wastage were identified as the main types. The quality of rubber wastage is critical when using rubber waste in application. Literature on rubberized concrete suggests recycled crumb rubber and tire chips of 5mm to 20mm in size as suitable for rubberized concrete. Rubber crumbs of this recommended size can be found in Sri Lanka in sufficient amounts, which implies that there is a future for rubberized concrete in Sri Lanka.

Keywords: *waste rubber, rubberized concrete, sustainable, rubber types*

Deep Learning Based Cell Classification for Future Vision Implemented Lab-on-a-Chip Devices

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Cell sensing and classification are significant in pathology detection in the biomedical industry. This paper presents the use of deep learning techniques in the classification of healthy red blood cells (hRBCs) and sickle cells (SCs). Fully connected and convolutional models are proposed and designed for this application. Two datasets containing 40 images and 297 images are prepared using photomicrographs of a human blood smear to train and test the models. In comparison to the fully connected model, the convolutional model produced successful results. The possibility of implementing artificial intelligence (AI) in pathology detection with a larger dataset using a similar software configuration is identified. RStudio software, KERAS library, and Tensor Flow are used as the R language programming tool, artificial neural network interface and the backend respectively. Use of validation split in convolutional models is also studied, and significant variations of accuracy are observed. Yet the maximum testing accuracy remains unchanged in the study due to the lower number of images in the datasets utilized.

Keywords*: red blood cell classification, sickle cell disease, deep learning, convolutional neural network, tensor flow*

Development of a Smart Cricket Bat Concept to Characterize the Orientation in Three-dimensional Space

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On par with the engineering advancements, the technology infusion to sports has substantially taken place. The qualitative approaches that have been adopted by the sports-trainers have gradually been translated into quantitative approaches using contemporary technology. During the stroke-play, it is difficult to understand the accuracy of the stroke, and at the same time, it is hard to obtain a real-time feedback of a stroke during the practice sessions. Consequently, this could lead the player to lose his psychological confidence and decrease the efficiency and the quality of the stroke-play. During the research study, a mathematical model is developed to quantify the orientation and the position of a cricket bat. Subsequently, a real-time, inertial sensor-based positional tracking device which is integrated into the cricket bat has been developed. The two types of inertial sensors that have been used during the study can be cited viz. accelerometer and gyroscope. Filtration process has been adopted to mitigate the noise associated with the signals and a complementary filter has been used in order to provide the user with the precise orientation. Moreover, testing has been conducted for roll, pitch motion, and respective results have been acquired utilizing the proposed bat device.

Keywords: *mathematical model, accelerometer, gyroscope; cricket, orientation, complementary filter*

Study of Estimating Greenhouse Gas Emission from Healthcare Solid Waste Management

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This research focused on the modern-day healthcare waste management and the emission of greenhouse gases from the waste, considering the environmental pollution and the increase of medical problems and the waste due to those increments. This work comprises of the methods and calculations according to the Intergovernmental Panel on Climate Change (IPCC) guidelines and the Institute for Global Environmental Strategies (IGES) Greenhouse Gas emission spreadsheet model. The amounts of waste generated within the facility were studied and information regarding the management was gathered. From the generation, till the disposal of the waste, the required data was gathered. The cycle of generation of the total waste from healthcare facilities from the generation up to the landfill disposal site is discussed. From the processes studied, the emission estimation is found in kilograms of carbon dioxide equivalent per tonne of healthcare waste ($kg\ CO_2e$/tonne of waste). Through the data collected, and calculations with the IGES software and IPCC guidelines, it was found that in reaching net emission to zero, healthcare waste management processes in the selected medical facilities should move to more fuel savings, proper recycling, and composting practices.

Keywords: *solid waste, healthcare, greenhouse gas, emissions*

Design of a Plastic Waste Clean-up Array System for Bolgoda Lake

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The harmful effects of plastic in waterbodies are well established. Its effects extend to animals in higher trophic levels. This paper presents a reliable and cost-effective waste clean-up device capable of removing floating and partially buoyant waste from freshwater bodies. The device described is a passive clean up system which consists of three main phases, namely, catching, concentration, and collection phase. The catching phase traps the waste and directs it towards a collection cage. The collection cage retains the captured waste, and a conveyor belt extracts it. Finally, the waste trapped is transferred to an exit tray which slides the waste into a bin on the riverbank. A prototype of the device was fabricated and tested in Weras Ganga. The majority of the waste extracted was plastic packaging. However, small quantities of organic substances were extracted as well.

Keywords: plastic pollution, trash collector, conveyor belt, rivers

Advancements of Electronic Stethoscope: A Review

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Auscultation is one of the most popular methods of disease diagnosis and stethoscope has been an integral device of medical examination as it is used to listen to internal body sounds. But it inherits many limitations in traditional conventional stethoscope. Hence, an electronic stethoscope provides a much more advanced and modern solution for those limitations, and it increases the accuracy of different internal body sound recognition, assisting medical professionals to make a proper disease diagnosis. Despite the conventional stethoscope, electronic stethoscope amplifies the auscultation sound captured at the chest piece and converts it to an electrical signal which is then transmitted through an advanced designed circuitry to apply further signal processing techniques. The main objective of this review is to analyse the evaluation of medical stethoscope and the advancements that have been done using modern technology to improve electronic stethoscope by adding various features including noise reduction techniques and real time visualization techniques. Further, the paper discusses how wireless data transmission techniques have been included in electronic stethoscope, making it is possible to provide graphical analysis of the sound signal and the advanced mathematical techniques applied to make denoising and feature extraction process in an accurate way. It further reviews the alternations and modifications that have been possible due to electronic stethoscope enhancing the quality of healthcare sector.

Keywords: *auscultation, electronic stethoscope, real time visualization techniques, feature extraction*

Analysis of the Potential Use of the Anaerobic Digester to Treat the Food Waste at KDU Cadets' Mess

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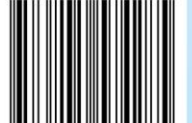
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The global energy demand is on the rise while the resources are depleting in an equally high rate. Hence, it is of paramount importance to take measures to ensure that future generations have access to affordable and sustainable energy sources. "Biogas" is a clean and renewable source of energy that has the potential to reduce (especially in the rural sector) the use of fossil fuels that are depleting at a rapid rate, causing serious environmental problems. Furthermore, it provides a feasible option to reduce dumping of garbage without making any use of the same. Being a developing country, Sri Lanka could save foreign exchange outflow due to importation of petroleum products promoting renewable energy sources such as biogas. In this study, the biogas potential from different substrates found in the daily food waste from the Officer Cadets' Mess of General Sir John Kotelawala Defence University (KDU) was investigated. The total waste generated has been found to be 351.9 kg per day, and the average biogas yield was estimated as 33,518.13 l/day. The average energy potential from biogas was identified as 724.032 MJ/day that would save the consumption of 16.84 kg of LPG on daily basis. Furthermore, it has also been identified that 40,000 kg of liquid bio fertilizer can be obtained from the existing $40 \, m^3$ digester installed at the University. It is estimated that the total potential savings per annum from the biogas plant for KDU is LKR 1,223,881.90 as per present economic status.

Keywords: waste, anaerobic digester, biogas, LPG, savings