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Bin- Eazy: The Tracking-Based Solid Waste Collection System

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ABSTRACT The majority of developing countries, including Sri Lanka, are still struggling to manage solid waste, resulting in a slew of social, environmental, and health issues. In Sri Lanka, as in the majority of other nations, the responsibility for waste management is delegated to Local Authorities (LAs). With rising solid waste quantities, Sri Lanka is now struggling to manage trash. This research, aims to develop an automated solid waste management collection mobile application named as "Bin-Eazy" and a web application to address the above situation in Sri Lanka. These applications facilitate both the municipal council and the citizens to avoid the problems that arise during waste collection. The methodology for the improvement of the waste collection and transportation system was devised based on Google Map API. This system includes a mobile application to organize garbage in various locations. We can communicate directly with the municipal council and provide information on the location of the garbage bins or dump with this mobile application. Python, Image Processing, Flutter, SQLite, and React are technologies that were used in this project. Image processing is the technical analysis of images using complex algorithms. The municipality uses image processing to check whether the citizens have correctly classified the garbage. This system mainly focuses on household solid waste. In a country like Sri Lanka, both residents and municipal councils may save time and money by using this mobile application to collect solid waste. Those are the expected primary goal of this paper.

KEYWORDS: Image Processing, Location tracking, Solid waste disposal

I. Introduction

In today's world, waste collection has become a serious issue. Garbage has become one of the primary problems in a country like Sri Lanka as the population grows.

Municipal Councils		Population (2001)	Daily waste generation (Tons)
1	Colombo	642,163	675
2	Dehiwala	209,787	272
3	Moratuwa	177,190	150
4	Kotte	115,826	125
5	Negombo	121,933	110
6	Galle	90,934	50
7	Gampaha	9,438	20
8	Kandy	110,049	80
9	Matale	36,352	26
10	NuwaraEliya	25,049	20
11	Badulla	40,920	20
12	Jaffna	78,781	NA
13	Rathnapura	46,309	30
14	Kalmunei	105,000	50
15	Kurunegala	38,337	38
16	Kaduwela	270,000	35
17	Dambulla	66,727	67
18	Batticaloa	88,459	60
19	Anuradapura	81,522	37

Figure 1. Municipal waste generation in Sri Lanka Source:

There are no suitable facilities for the disposal of waste produced by households and industries in a country like Sri Lanka. Furthermore, relevant authorities pay less attention to this situation. As a result, people are used to dump garbage alongside the roads. In countries like Sri Lanka, daily life can generate many kilograms of solid trash from homes, industries, businesses, and other locations. The lack of proper management has led to many problems. In Sri Lanka, this garbage collection is usually done under the control of the Municipal Council.

For residents living within the municipal area, garbage should be kept outside their premises on relevant day. But in this process, the municipal council, as well as the citizens, face various problems as Sri Lanka develops, more people are moving to cities for their benefit, due to the increase in garbage production. As a result of these factors, the garbage problem has become a major issue for the wider populace. Various waste collection and management methods can be found all over the world. However, no proper computer based waste collection system has yet been built in Sri Lanka.

A. Objectives

This project aimed to develop an automated solid waste Collection & Management System as a solution to the disposal of garbage in Sri Lanka. This system will create a web application and a mobile application. We named our mobile application "Bin -Easy". It supports both Sinhala & English languages.

The following objectives have been identified with the aim of growing an Automated Solid Waste Collection and Management System.

- To conduct a critical examination of Sri Lanka's current garbage collecting difficulties.
- To analyze the current computer-based systems critically and to suggest an effective waste collection solution.
- To make a project prototype of the system.
- To determine the effectiveness of the new Automated Solid Waste Collection and Management System

B. Resource Requirements

- The development of the mobile application is assured by its compatibility with all other mobile devices running Android, iOS, and Windows.
- The database will be implemented by using DB forge studio for SQLite.
- The web server will be created such that it works with all Windows 7, Windows 8.1, and Windows 10 computers.
- Android Studio and Dart will be used to implement the mobile application.
- The Django framework and the Python programming language will be used to create the administrative interface.

II. Literature review

The amount of waste produced increases as the population grows. The more people a city has, the more complicated its activities and companies become. Industrial, biological, and domestic garbage are all dealt with via waste management. Waste can, in some situations, be harmful to human health. Waste management is also carried out for the purpose of gaining advantages, particularly for people. Based on the belief that rubbish is a resource that may be utilized and even has financial value [7].

A healthy and happy community requires a healthy environment. The process has been prone to human mistakes and neglect with the age-old system of hiring employees to periodically check and clear overflowing dustbins. Furthermore, due to the varying rates of trashcan usage in different places, routine checks based on time services are wasteful because a dustbin may fill early and require rapid attention, or there may be no need for a routine check for a long time. As a result, the current system becomes more of a problem than a solution, as overflowing, smelly trash cans become an issue rather than a solution [4].

A. Existing systems

According to the research done by R. Zade et.al, [8] they had this study introduces a novel system that will aid in keeping cities clean. This system monitors the garbage bins and notifies users via a web page of the amount of waste collected in the bins, as well as alerts users via a buzzer and LEDs. The ultrasonic sensors (HC-SR04) in the system are utilized to detect the rubbish level over the bins. The depth of the waste bins is then compared. The system's hardware architecture includes an Arduino module, an LCD, a sensor, and a buzzer. On the LCD panel, the level of rubbish collected in the bins is indicated. The system is remotely monitored via a web page created in LabVIEW using the VISA tool. When the amount of garbage collected exceeds the stated limit, the buzzer indicator goes off. As a result, by informing the public about the rubbish levels in the bins, this system contributes to keeping the city clean.

It handles with a real time trash bin observing scheme by using various identifying equipment and new technologies to the research paper "GARBAGE MONITORING AND CLEARANCE USING ROBOTS" [3] studied garbage disposal that isn't done properly pollutes the atmosphere, endangering living organisms. Recent technological advancements are proving to be more beneficial to humans, and their recommended approach for waste collection is excellent. An ultrasonic sensor attached to the bin lid shares the garbage level as data with the robot, which tracks the bin using the line follower technique and recognizes the filled bin using RFID scanning, then disposes rubbish from that bin. When an Ultrasonic sensor provides data to the Arduino board, the garbage monitoring and clearance robots begin their work. The exposed ultrasonic sensor is a form of audio sensor that can be categorized as the transmitter, transceiver, or receiver. Ultrasonic sensors have transmitters those turn signals into ultrasound, and receivers that translate ultrasound into signals. The period between delivering an ultrasonic pulse and receiving an echo will be taken as the distance. The sensor sends out a wave, which is reflected by the obstructions. It detects the amount of rubbish and sends the data to the Arduino Uno.

This paper describes [6] the concept of a GSM-based garbage monitoring system. People are disposing of their junk in the trash container. At the top of the garbage can, they are installing ultrasonic sensors. Currently, the ultrasonic sensor can detect the level of garbage. If the amount of rubbish produced continues to rise, it will soon hit the limit. As soon as the threshold value is met, an automatic alarm will be sent to the registered range via the GSM module, informing them that the trash value has reached a distance of around 5cm from the ultrasonic sensor. The garbage cans are emptied, and the data is forwarded to the appropriate authority for processing. For real-time information, they used GSM. It is the most important component of the communication system because of its low cost, high performance, and ease of implementation. Even if the threshold value crosses the range, the LED will illuminate if somebody tries to dump their trash in the garbage can. This strategy reduces the amount of time, fuel, and money used. In the future, this technology will be beneficial to a large number of rural areas.

According to the research paper, "Smart Garbage System with Garbage Separation Using Object Detection" [10] garbage collection is one of the most pressing concerns that the globe faces, regardless of whether a country is developed or developing. The traditional method of manually monitoring and clearing rubbish in bins is inefficient. As a solution to these issues, the smart bin is developed utilizing IoT. The bins have a Raspberry Pi fitted with an ultrasonic sensor for garbage level

detection and a pi camera that uses the YOLO algorithm to segregate rubbish by object detection and opens the appropriate bin lid using a servo motor. The intelligent bin is linked to mobile applications through the cloud for garbage monitoring and disposal, which is accomplished through optimum routing.

In 2020, "Deep Learning-Based Smart Garbage Monitoring System" [9] an IoT-based, automated smart bin monitoring system is proposed in this research. Furthermore, based on the data acquired, a deep learning model was utilized to anticipate future garbage levels. With an accuracy of 80.33%, the suggested neural network model was able to forecast garbage levels. The findings support the accuracy of the rubbish level forecast. Bar charts were also used to assess the data. The combination of IoT and deep learning can result in a technological revolution that can be used for trash management. As a result, forecasting and examining garbage levels may assist municipal authorities in implementing an efficient garbage management system and reducing garbage bin overflow.

B. Related works in Sri Lanka

Over the past 20 years or so, or thereabouts, government entities have been working to identify the ideal waste management strategy in the country. Although certain tactics and initiatives promoted clean landfills, other actions were focused on energy programs against waste. With the goal of "Squander Free Sri Lanka by 2018," CEA launched the "Pilisaru Project," a 10-year waste management framework, in 2008. Unfortunately, the lack of a sensible, long-lasting approach has increased the amount of opaque and pointless processes [1].

The distance between waste producers and recyclers should be closed by igniting more variety of communities and making the cycle more readily available. Plastic, polyethylene, metal, and glass recycling activities should be stimulated and funded at diverse scales. Waste is a resource; hence efficient waste management practices should be implemented. The industry should be set up as a business that generates revenue rather than one that offers no incentives to the corporation [5].

III. Methodology

A. Data collection

Sri Lanka, being a developing country, is currently experiencing fast population growth, infrastructure development, and urbanization. The first step in data collection to create this system was to identify the objectives through a literature review. To identify the existing problems, interviews were held with the municipal employees and citizens who are the primary users, and information was obtained. A comprehensive experimental case study was carried out with Moratuwa municipal council to obtain information. 40 truck drivers and garbage collectors belonging to the municipality were selected as the sample. And 50 citizens belonging to different age groups were randomly interviewed in some selected cities. According to the data obtained, the percentage of citizens who are not satisfied with the existing waste collection system is 68.2%. About 9% of the respondents are satisfied with the current system.

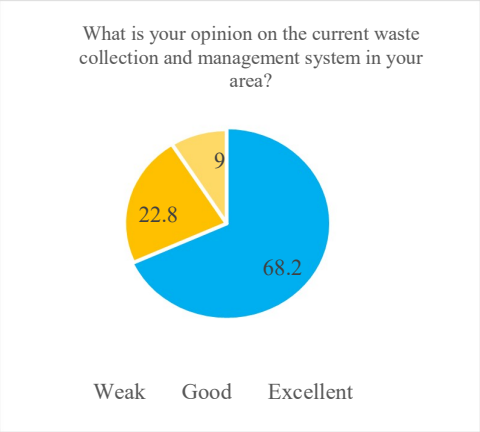
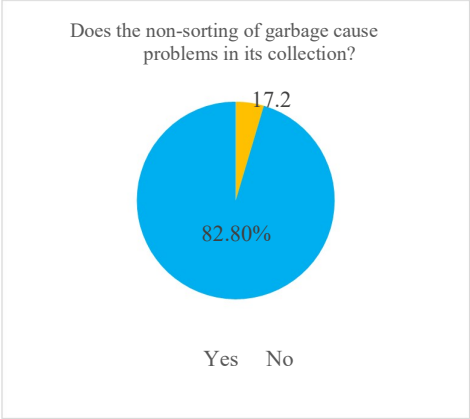


Figure 2. Pie chart I of Questionnaire Survey Results

Percentage of 61.8% of the truck drivers said that problems arise due to the non-sorting of garbage.

Figure 3. Pie chart II of Questionnaire Survey Results



According to the information obtained from the Moratuwa Municipal Council, the garbage of about 700 houses should be collected by one truck per day, which is seemingly impossible due to extra effort and time. The primary purpose of this data collection was to obtain the data needed to create these proposed systems through problem identification and analysis. Key issues identified through this data collection are outlined below. Problems faced by citizens,

- The resident is unable to dispose of garbage on the scheduled day; he will have to wait until the next day.
- In some areas, the interval between dates maybe four or three days. If it is decaying debris like disposable foods, it will decompose while, breeding

worms and rodents around it, causing odors and polluting the environment.

- The public can have a lot of problems in disposing of non-biodegradable waste and they are many problems with waste sorting as well as recycling.

A problem faced by Truck drivers,

- The main problem here is that even though they have been given the proper roads, they have to park the truck near every road and every house to see if there is any garbage. This consumes their time as well as labor.
- Householders do not properly sort garbage and face problems in garbage collection.
- Similarly, worms and rodents can breed in decaying materials such as disposable foods, which have been deteriorating for days, and they may be exposed to various diseases while collecting garbage.

B. Technology Adopted

Using acceptable tools is essential to developing a defect-minimized productive system. Failure to do so may result in the development of a system with unnecessary bugs and errors using inappropriate tools. Therefore, it is essential to choose the right tools while creating a system so that a superior product can be developed. However, these technologies could lead to the creation of a system that requires a lot of time and resources to complete a task that the system had expected. The usage of application programming languages and the other required tools is crucial for the development of a successful system. As a result, these technologies and tools can contribute to the system's development in the least amount of time. Instead of using a manual approach, this type of application seeks to provide users with a more effective work system. This research purpose is to develop an automated solid waste management collection "Bin-Eazy" mobile application and web application. This mobile application has two types of users: citizens and municipal council Truck drivers. This mobile application supports the following technologies:

1) Google Map API:

Google provides technology and an application called Google Maps for its online mapping platform. The Google Maps API enables you to produce customized maps that can be used in cutting-edge Google Maps-based apps. In all Maps API applications, the maps are loaded using an API key. The API key is free, but Google will monitor your application's use of the Maps API and, if it reaches the use cap, require you to purchase more capacity. (Smita S*, et al*, 2019) Here, Google Maps is mainly used to help truck drivers find the optimal route to collect waste. Truck drivers are shown only the request to collect garbage bins and garbage dump through Google Maps, so they can reach them using the best shortest path in a very short time. Fuel, money, and time can be saved by these methods. The second major step here is that citizens can also use Google Maps to find the garbage truck.

2) Flutter:

Although highly unique, Flutter is also maybe a viable platform that has already gained the interest of major firms that have already published their apps. However, since Flutter implements components, there is no layer of interfacing between the view and the code. Because of this, the graphics engine of Flutter is used to draw buttons, text, media elements, and context. Flutter is used to create The Mobile application front development.

This web application has one user: The municipal council administrator. This web application supports the following technologies:

1) Image Processing:

The technical analysis of images using sophisticated algorithms is known as image processing. Image enhancement, pattern detection, and effective picture coding are three major areas where image processing techniques are used. The mathematical operations that one is likely to run into and how to execute them using optics and digital computers, as well as image description and image quality assessment, are some of the areas of image processing that are covered. The system checks whether the photos uploaded to the system by the citizens through the mobile application have been correctly classified using an algorithm trained by image processing

IV. Experimental design

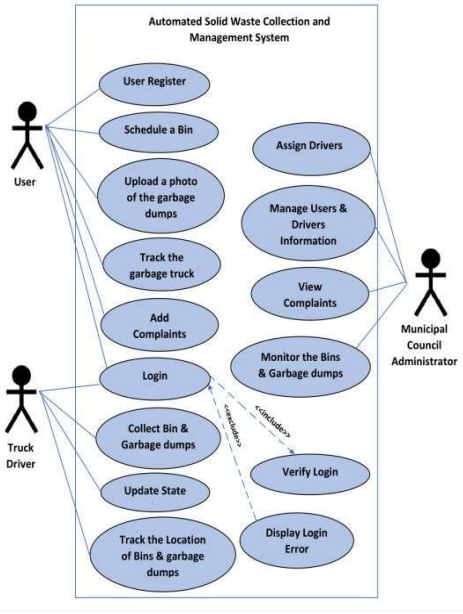


Figure 4. A use case diagram for experimental system design

A. Mobile application

Mobile application users the truck drivers and citizens. In the waste collection system process first, the citizens and truck drivers (users) should create a profile. Next, they should log in to the mobile application by providing the username and phone

number to the system. Citizens and truck drivers have a separate interface after the authentication process. This mobile application is provided in both Sinhala and English languages.

Figure 5. User register interface

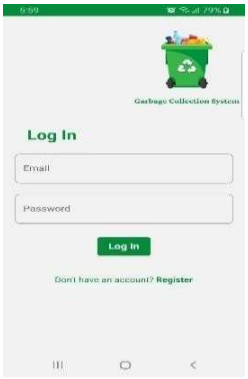


Figure 6. User login interface

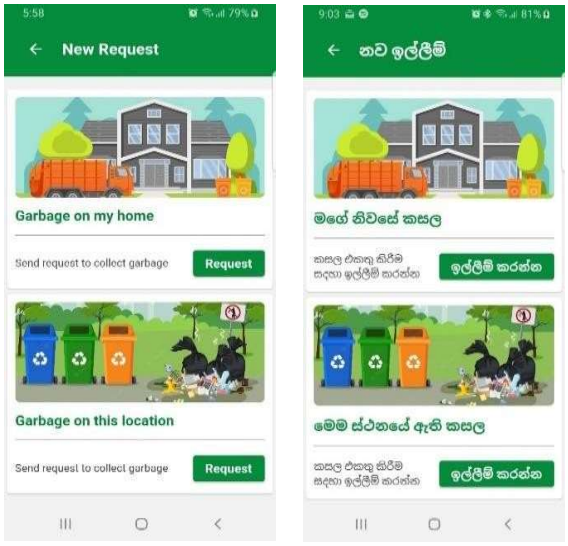


Figure 7. Request interface for citizens (English & Sinhala)

As in figure 7 above users can then use the mobile application to request that their trash be picked up. And also, as in figure 9 citizens should take photos of the requested garbage dumps and upload them to the system to see if they have correctly sorted the bins. After they get the approval of the request then they can track the garbage truck location.

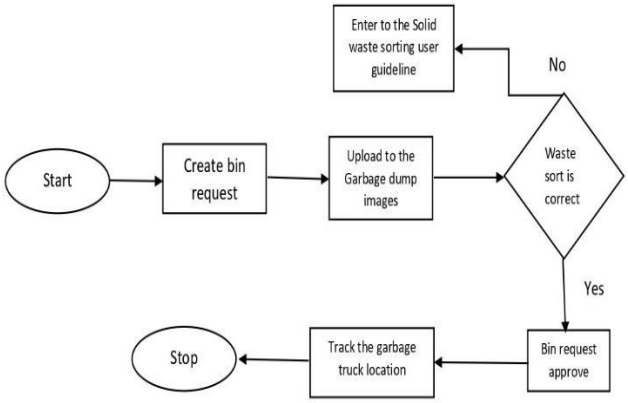


Figure 8. Process flow diagram for citizens bin request process

Figure 9. Request the Garbage bin Interface and show the identified garbage type using Image Processing

Truck drivers are shown only the request to collect garbage bins and garbage dump and their locations through Google Maps through the mobile application. After tracking the bins' locations, they will be shown the shortest route through google Maps. Garbage collectors should report bins' status to the system after collecting them.

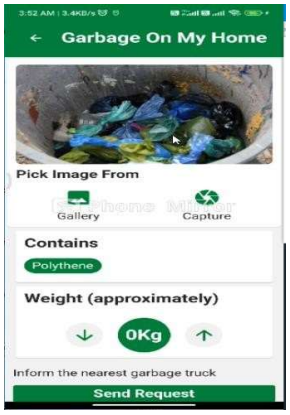


Figure 10. Garbage truck location interface for citizens

B. Web application

Only the municipal council administrator can be accessed using the web application. The details from the mobile application will be presented on the municipal council's web server after they have been extracted. The mobile application will then track the coordinates (longitude and latitude) of the user's location (where the garbage dump is located). The information, including the user's identity, mobile phone number, date and time, and coordinates of the tracked waste dump, is then sent to the municipal council's web server. Using image processing, the image uploaded by the users is checked to whether it is correctly sorted under the given instructions and then their request is approved. According to the coordinates received by the mobile application, the location of the waste will be displayed on a map. The appointed employees will then be dispatched to that specific location to collect the waste. Then through the system municipal council administrators can track their location and assign a driver collect to the waste the web application will send a notification to the user whether the information sends successfully or not. Each information that users send will store in the SQLite server database successfully and for work with the application.

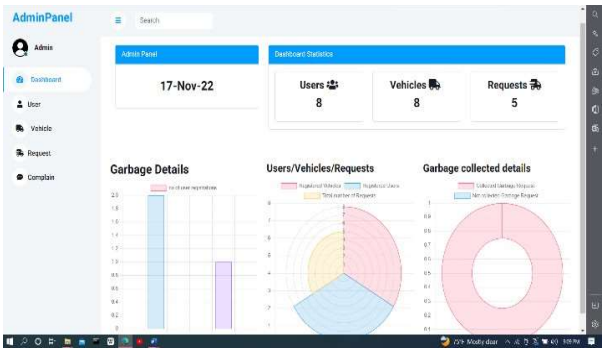


Figure 11. Municipal Council Admin Dashboard

V. Discussion and conclusion

Based on logical presumptions, the results and consequences produced concerning the problem domain's specificity are expanded into broader notions. This chapter attempts to highlight the project's outcomes and findings and to identify how they might be matched in other situations that share issues with those that the developed solid waste collecting and tracking system addresses. To obtain a comprehensive waste collection system to meet efficiency and optimization, this test work requires that the proposed system only knows the exact location of the waste and collects them. When citizens request through the mobile app to pick up their garbage, the system administrator in the municipality directs the relevant truck drivers to those locations and collects the garbage. Similarly, by using modern tools i.e., using image processing, the classification of them into biodegradable and non-biodegradable materials is done through this system. Then it becomes easier for the garbage collectors. Our project's primary goal is to make it possible for city infrastructure put there to communicate with its operators and administrators in both directions. Our objective is to realize a centralized system for real-time monitoring. With this approach, the municipal government and the general public both gain from an efficient system that reduces urban pollution and results in significant cost savings. The research outcome can be stated as follows. Saving time for the Municipal council's laborers and administrators who work on solid waste disposal.

- Reduce the time consumption of the collection of household solid waste.
- Reduce human errors.
- Make the workload of the municipal council more efficient.
- Reduce the workload of municipal truck drivers.
- Increase the efficiency of service in Municipal councils.
- Improve the solid waste management program in Sri Lanka

VI. Future work

There isn't a system in place with a mobile application to address the current problems that have been affecting the waste collection process on the overall traditional waste collection strategy, especially in Sri Lanka, eventhough there are numerous different waste management and waste collection systematic approaches. As well as waste management and related research have already been done in many projects. Therefore, this proposed tracking-based solid waste collection system is presented. With more effective usage of the app and improvement of additional crucial hardware components for future development, the Google map API advanced feature activation can be included as a further improvement. The information on the efficiency of a systematic solution may have been gathered to conclude this research study area by reviewing related works and existing systems, and its evaluation summary provided the points to be taken into account in creating such a real-world application in the future with the digital era and to survive with challenges like pandemic situations and the current new normal.

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