Waste Segregation using Smart bin and Optimization of Collection Routes

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***Abstract*—Waste management is one of the crucial universal problems at present. The rapid growth in world population, their intricate living styles and the pace of urbanization has increased the amount of solid waste produced. Therefore,having a legitimate checking component is an absolute necessity to deal with the situation.India has policies to deal with all kinds of waste but implementation is weak and not monitored effectively. Plastics stay an issue of concern.Protests over strong waste dumping across India have increased.Our Objective is create a model which will be used to segregate and optimize waste management and collection process.The proposed system will sense different types of waste and segregate them at the user end and will inform the authority when the waste bins are getting filled. It will also provide users with a proper dumping technology to put their waste into the assigned bins and also guide them to the nearest bin if they encounter any problem with bins.**

***Index Terms*—Smart Bin, Waste Segregation, Collection route optimization, Waste management**

I. Introduction

In earlier times, the amount of waste generated by humans was insignificant because of low population density and low levels of exploitation of natural resources. Besides, the waste was mostly organic or biodegradable. The onset of industrialization, along with rapid urbanization that followed, witnessed mushrooming of concentrated population centers resulting in building up of waste or garbage. Industrialization led to economic growth and prosperity triggering rise in income level sands in consumption patterns. Industrialization also led to exploitation of more and more natural resources, including mineral resources,resulting in generation of more waste material a large portion of which was no longer biodegradable. As industrialization progressed, the proportion of non-biodegradable or even hazardous substances in the waste material increased [1].

The sum and kind of waste you produce will depend largely on the type of business you operate. For example, manufacturing organizations will in general produce more waste than those in industries [2]. Cities are now grappling with the issues of high volumes of waste, the costs in question, the disposal technologies and methodologies, and the effect of wastes on the local and global environment [3].But in a city like Mumbai where industrial waste generated is less compared to domestic waste, there should be solution proposed in order manage the waste properly.

Waste management is one of the fundamental services undertaken by municipalities to retain cities clean and healthy. It represents a high priority and urgent issue for many communities around the world.The increasing trend towards urbanization and population growth, combined with a growing environmental concern have created a critical situation for the management of house hold solid waste. Solid waste management is concerned with the control of generation, storage, collection, transportation, processing and disposal of waste according to the principles of public health, economic and other environmental consideration.

Maharashtra generated 82.38 lakh metric tonnes (MT) of city strong waste in 2018, the most elevated in the nation,, said media reports. Of that, Mumbai produces 27.37 lakh MT per year, a third of the state's total. It has been estimated that by 2030, India will need a landfill the size of Bengaluru if the present waste administration situation doesn't improve[4].Therefore in order to deal with such large amount waste. The segregation process followed by the transportation and disposal of the waste needs to be very precise and managed properly so as to avoid the risk to the health and safety of the public. The first step towards waste management is to segregate them properly to where they belong and then send them for their disposal. So our project particularly aims to do the segregation process for 4 types

such as plastics, metals, wet and dry waste. Our aim is to segregate the waste at user level using Internet of Things (IOT) technologies and then optimizes the collection process. The proposed solution will send notification to the user and other authorities when the waste bins are full and they should be emptied. It will also automate the segregation process using various technologies to put their waste into the assigned bins and also guide them to the nearest bin if they encounter any problem with bins.

II. Literature Survey

The purpose of this literature review is to gain an understanding of waste management planning concepts, frameworks, strategies, and components that are current and emerging in the field.

Wesley Pereira and Saurabh Parulekar proposed a Smart bin which has 4 different sections for plastic, wet, dry and lastly for the wastewater from the auto clear feature. It also contains ultrasound sensors for the bin to open when a person approaches the dustbin to throw garbage thus making it hands free and evidently more hygienic. It also contains various sensors that will help in segregation of the waste. Waste thrown away is sorted according to its capacitance [5]. The solution proposed will be using this kind of automated process using similar sensors.

P.K.S.Kumari, et al, suggested a solution to enable the society to automate and optimize waste management process using Internet of Things (IOT) technologies. The proposed solution will notify the user and other authorities when the waste bins are getting filled or when there is an unusual condition inside the containers like having high temperature or high humidity. Users can take necessary action based on the details [6]. The proposed solution would utilize the idea of using temperature sensor to detect unusual condition inside the bin.

Aksan Surya Wijaya, et al, talks about the smart waste-bin that can manage the waste in a smart city project. The system consists of sensors to calculate the weight of waste and the amount(level) of waste inside the bin. The system also adapts with network environment, to manage all information for waste management. As the result we proposed a model of smart waste-bin that is appropriate for many kinds of conventional waste-bin [7]. The proposed system would be using similar technologies for detecting fill level and weight of the garbage.

The researchers of the paper " A Guided Local Search (GLS) approach for the Travelling Thief Problem" has proposed a solution to improve further the tour optimization and compared against state-of-the-art techniques. It combines two classical well-known problems: The Travelling Salesman Problem (TSP) and the Knapsack Problem (KP). The main benets were obtained in small and medium-sized instances [8]. The proposed solution would like to check these algorithms for the optimization of the process.

Amine Agharghor, et al, proposed an assessment of a memetic Hunting Search calculation that uses a 2-Opt local search for explaining the traveling salesman problem. Hunting Search is an evolutionary algorithm inspired by the method of group hunting of predatory animals. To show the quality of the memetic calculation, it has been examined on a set of ten benchmark TSPLib instances and it outperforms the results obtained with previous Hunting Search algorithm [9]. This algorithm proved to be efficient for solving travelling salesman problem so it might be used in the optimization process in the proposed solution.

The authors of "Ant Colony Optimization Based Memetic Algorithm to Solve Bi-Objective Multiple Traveling Salesmen Problem for Multi-Robot Systems" speaks about a bi-objective ant colony optimization (ACO) based memetic calculation algorithm to investigate the problem. In the algorithm, a basic multi-ACO is incorporated with a sequential variable neighbourhood descent. A powerful local optimization strategy for bi-objective MTSP is proposed to improve the candidate solutions. In addition, we adopt the strategy for order preference by similarity to an ideal solution method to select a reasonable solution from the optimal Pareto [10]. Through computational experiments, the proposed solution demonstrated the benets of the algorithm as compared with four other existing algorithms. Computational results show that the proposed algorithm is promising and effective for the bi-objective MTSPs.

Cyril Joe Baby, et al, proposed a smart waste-bin that alerts the authorities to assemble the waste which has been heaping up in the containers. It guides the garbage-trucks to gather the trash just from those territories where the bin is critically filled through Email or text messages. The 'machine-learning' concept has been used to accumulate data about the habits of waste generation in that region and estimate the amount of waste that will be generated in the near future [11]. Apart from that, the analysis of the continuous data is also done that has been sent over the cloud in the form of graphs. The idea of sending notification will be utilized in the proposed system.

Haoran Luo, et al, talks about applying FWA to the traveling salesman problem. They propose a discrete fireworks algorithm for TSP consolidating the general structure of FWA and current ideas for solving the TSP. They call it DFWATSP. In DFWA-TSP, 2-opt and 3-opt edge exchange heuristic are implemented as the basic explosion operation in FWA. An adaptive strategy is designed to decide the explosion amplitude. A particular mutation method based on insertion is likewise used to cover the lack of edge exchange and another determination technique dependent on the quality of firecrackers is embraced to get great firecrackers

proficiently. This paper concludes that the proposed algorithm outperforms Ant-colony and genetic algorithm based on various experiments, especially on large-scale cases [12]. This algorithm proved to be effective for solving travelling salesman problem so it might be used optimization process in the project.

The authors of this research paper found one of the best routes for collecting solid waste in cities. This work has developed a methodology based on real genetic algorithm for effective solving the TSP. This GA comprises real value coding with specific behaviour taking each code as it is (binary, integer, real or name), rank selection, and efficient uniform genetic operators. It is concluded that real GA approach is robust and is easily applied to dynamic and complex system [13].This algorithm proved to be efficient for solving travelling salesman problem so it might be used optimization process in our project.

Raulc ezar M. F. Alves, et al, talks about multiple Traveling Salesman Problem (mTSP), and the objective is to minimize the overall distance travelled by them. It presents the development of Genetic Algorithms to reduce both the overall distance and balance the distance travelled by each salesman. Since there are more than one goal to be upgraded, two approaches were evaluated. A multi-objective GA and a mono-objective GA with a tness function that combines both objectives. Experimental results show the effectiveness of the proposed GAs. The results further indicate that, considering both objectives, the multi-objective GA produces more balanced solutions for almost all instances [14]. The effectiveness of the algorithm used in this paper might boost the effectiveness of the project.

III. Existing System

Every city's current waste collection logistics in India is carried out by emptying containers according to predefined schdules and routes which are repeated at a set of frequency, Such a system has major disadvantage: A. Time consuming B. High cost C. Greater traffic congestion D. Unnecessary fuel consumption E. Increased noise and air pollution as a result of more garbage trucks on the road. There are number of existing systems closely related to the proposed idea to deal with waste management and segregation. To analyze these systems a literature survey of the proposed systems was done. The proposed case study was designed around certain relevant sources related to waste management, waste segregation and optimization of collection routs.
The current existing system are:
(i)A Smart bin which has 4 different sections for plastic, wet, dry and lastly for the wastewater from the auto clear feature. It also contains ultrasound sensors for the bin to open when a person approaches the dustbin to throw garbage. Waste thrown away is sorted according to its capacitance
(ii)At 2010, Ohri, A, used GIS to solve the problems of transporting waste from collection to landfill, the site is based on the lowest cost for time, track length and digitization, spatial data in the GIS environment in the city of Varanasi (India).
(iii)Citizengage is a waste-to-resource technology startup has built an end-to-end waste management system that helps communities and businesses manage their waste at source.They used GIS tools to resolve the solid waste collection problem from household doors in a community. They suggested an approach to replace the municipal service through transferring solid waste by residents to central warehouses
(iv)Started in 2010, Paperman is a Chennai-based organisation that runs more than 250 waste paper marts over the city to help citizens clear trash at their doorstep. They used GIS for the previous and suggested collection patterns models.The ArcGIS system was used to determine the optimal method for a minimum cost of collections and identify workflow and best practices for future analysis. The organisation has, till date, recycled over 190 tonnes of trash
(v)A smart bin that alerts the authorities to gather the waste when the bin is full. It notifies them through Email or text messages. The 'machine-learning' concept has been used to assemble data about the waste generation habits in that area and henceforth estimate the measure of waste that is destined to be generated in the near future.
(vi)Hasiru Dala caters to over 25,000 households and manages more than 700 tonnes of waste every month. The non-profit provides waste management solutions to apartments, corporate offices and at events.They used the GIS methodology to improve the waste collection and transfer system in Banglore through the redistribution of waste collection garbage can, Improve vehicle orientation in terms of time and traveled distance.
(vii)A system using multiple Traveling Salesman Problem (mTSP), and the objective is to minimize the overall distance travelled by garbage collector. It presents the development of Genetic Algorithms to reduce both the overall distance and balance the distance travelled by each one.

Following some of the limitations in the existing system:
(i)These existing majorly focus on recycling and reusing the waste.
(ii)They first collect all the waste and then segregate in manually and send them to respective places for further processing.
(iii)Most of the existing system are not automated.
(iv)Use of IOT and Software are minimal.
(v)There is no automated process to segregate plastic waste.

IV. Proposed System

The main concept of smart waste management is to handle all the waste in the city and monitoring all the process.

1) Mobile Application
   For efficient waste management, a mobile application is also made to help worker picking and managing

the waste bin.The application will read data from the firebase database. Then based on the data the respective authority will get notification about the location and fill level of the bin through the Android application. So it can make the handle of a fully waste-bin faster.Android studio software is used to develop a mobile application which will run in android platform.

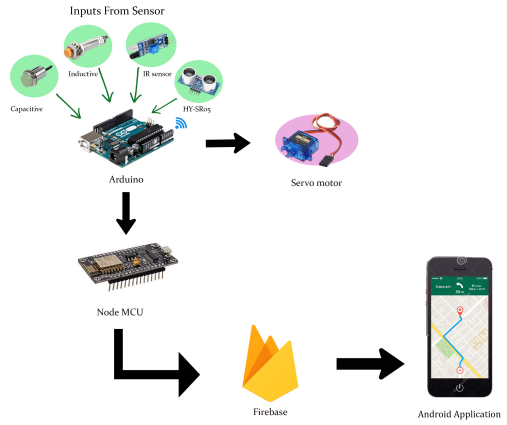

Fig. 1. Architecture

2) Bin
The thought struck us when we saw that the dump truck find their way around the town to gather waste two times per day. In spite of the fact that this framework was performed with care, it was not achieving maximum productivity. For instance suppose street A is a busy street and we see that the level of the garbage fills up really fast whereas maybe street B even after two days the bin isn't even half full. What our framework does is it gives a constant marker of the trash level in a trashcan at some random time. Utilizing that information we would then be able to optimize waste collection routes and ultimately reduce fuel consumption. It permits garbage authorities to design and plan their daily/weekly pick up schedule. Let us now discuss about the execution of individual modules. The micro-controller is the main electronic control unit, various sensors will be connected to it such as capacitive proximity sensors, ultrasonic sensors, inductive proximity sensor, NodeMCU, etc. These sensors will be used for detecting the waste which the user would like to throw and dump those waste in the respective compartment thus segregating them at source. DC/AC servo motors will be used to drop the waste in their respective compartments automatically, they will rotate upon receiving a signal from micro-controller. The ultrasonic sensor will be used to detect the fill level of the bin. The status of the bin will be updated in the database regularly using NodeMCU.All the sensors and the micro-controller is powered using battery. Micro-controller, ultrasonic sensors, etc are supplied with voltage of 5V, DC motor for dropping the waste in the appropriate bin door is with 6V supply. Capacitive proximity sensor and inductive proximity sensor are supplied with voltage of 9V supply.All data that are being sensed by the sensors will be sent to the database for further processing through WiFi. There will be android based application which will be used to interact with the people. An ultrasonic sensor will be attached on the interior side of the lid. As the amount of garbage level increases, the distance between the ultrasonic and the garbage decreases. This data will be sent to the micro-controller. Our micro- controller, the Arduino then processes the data and through the help of WiFi sends it to the databse then from database it is sent to the application. The app will visually represents the amount of trash in the bin with a small animation. This procedure will show all the bins which require urgent notice, leading the user to take the most effective route. .

Benefits of the proposed system:
(i)The proposed system is designed in a user friendly way in order to guide all kinds of people as they play a crucial role in segregation of waste at source.
(ii)It increases the efficiency of the current system by using various technologies and also making it easier for people to use.
(iii)Ensures cleanliness in the city by eliminating the issue of overflowing garbage that is faced currently.
(iv)It indirectly helps in the growth of the country and improves the life of the people.

V. Output

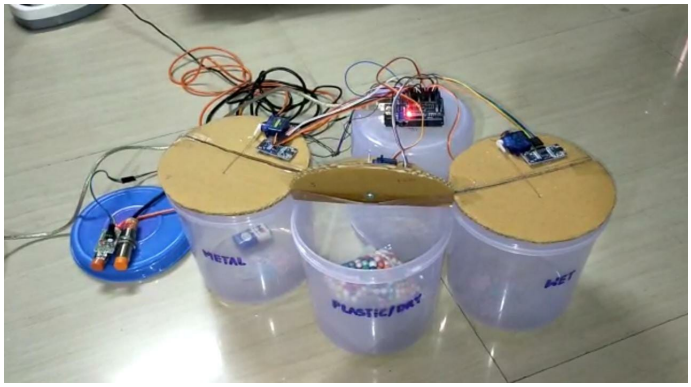

Fig. 2. Bin Structure

(i)Once the waste has been sensed by the sensors appropriate bin will be opened with the help of servo motor and the waste will be dumped in the appropriate compartment.

(ii)Once the bin is full, a notification will be sent to the garbage collector about the fill level of the bin in order to

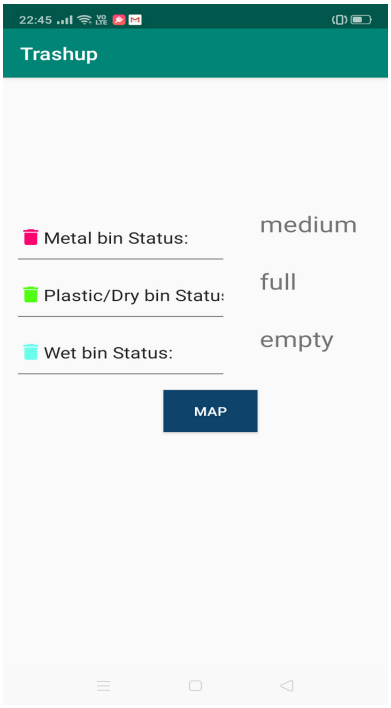

Fig. 3. Profile

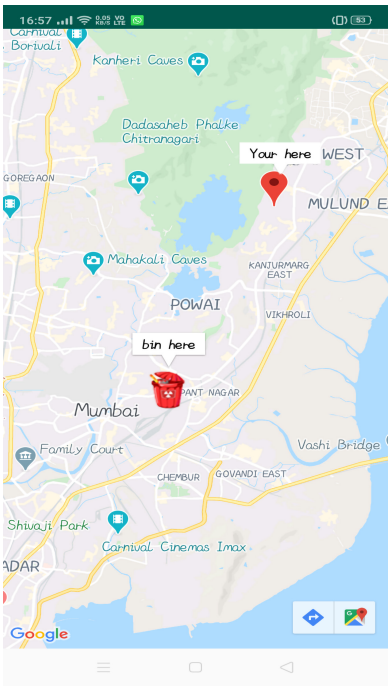

Fig. 4. Bin and User location

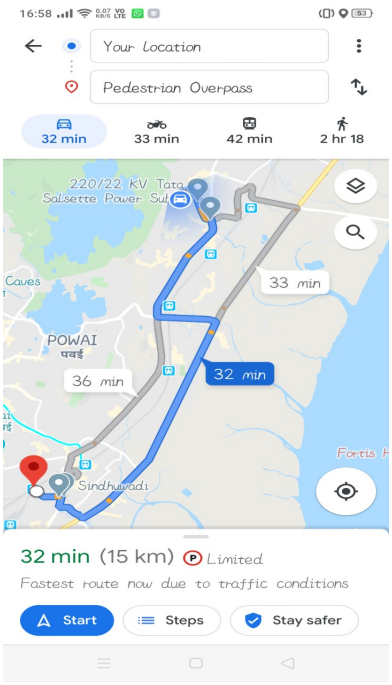

Fig. 5. Route

Sr.No.	Waste Material	Dry	Metal	Wet
1	Battery	No	Yes	No
2	Vegetables	No	No	Yes
3	Paper	Yes	No	No
4	Thermocol	Yes	No	No
5	Fruits	No	No	Yes
6	Card board	Yes	No	No
7	Wet paper	No	No	Yes
8	Scissor	No	Yes	No
9	Silicon Cover	Yes	No	No
10	Glass	Yes	No	No
11	Wet Cups	Yes	No	No
12	Plastic	Yes	No	No
13	Cotton	Yes	No	No
14	Wet Cotton	Yes	No	No
15	Steel	No	Yes	No

TABLE I
EXPECTED WASTE SEGREGATION RESULTS

empty the bin through application.

(iii)An optimized route will be shown to the garbage collector in order to save time and fuel.

(iv)The application will direct the user to the nearest bin which is full.

Sr.No.	Waste Material	Dry	Metal	Wet
1	Battery	No	Yes	No
2	Vegetables	No	No	Yes
3	Paper	Yes	No	No
4	Thermocol	Yes	No	No
5	Fruits	No	No	Yes
6	Card board	Yes	No	No
7	Wet paper	No	No	Yes
8	Scissor	No	Yes	No
9	Silicon Cover	Yes	No	No
10	Glass	Yes	No	No
11	Wet Cups	No	No	Yes
12	Plastic	Yes	No	No
13	Cotton	Yes	No	No
14	Wet Cotton	No	No	Yes
15	Steel	No	Yes	No

TABLE II
ACTUAL WASTE SEGREGATION RESULTS

VI. CONCLUSION

The proposed system will provide effective and user friendly solution for waste segregation and management using IOT and Android technologies. This system will automate and optimize the whole waste management process thus achieving higher hygiene standards and less manual interaction. The system will not be using complex algorithm thus reducing computation power and improving the speed of the backend process. Our solution aims at helping the country for its growth and build a sense of responsibilities in the citizens.

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