Biomedical Waste Segregation and Management

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Abstract— Hospitals have been producing waste on a very large scale. The corresponding waste is of many types like wet, dry, metallic, and so on. So, segregation of waste becomes a prominent factor since segregating waste at the dumping ground is burdensome and usually ineffective. This paper aims to design such a model for the segregation of waste in mainly 3 categories such as non-metallic dry, non-metallic wet, and metallic waste. The proposed system contains three stages followed by the detection of waste, segregation of waste, and real-time monitoring of data related to the dustbin's waste level. The electronic model for the segregation includes various sensors and ESP32 microcontroller as well as a conveyer belt on which object will be placed. After the process of segregation, the data regarding the garbage level in dustbins is sent over the internet to the Thingspeak cloud and is stored there. And as a result, if any dustbin crosses the threshold limit, the corresponding action, as well as the corresponding dustbin's garbage level, will be reflected in the designed GUI (Graphical User Interface) and adding to that, an alert email will be sent. The main objective of the proposed system is to reduce human intervention in the process of segregation of waste while ensuring proper segregation of waste with minimal effort. So, it is regarded as an IoT-based automatic waste segregator system.

Keywords -- Conveyer belt, ESP32, GUI, IoT, Segregation, Thingspeak

I. INTRODUCTION

The basic principle of good Bio-Medical waste practice is based on the concept of 3Rs, namely, reduce, recycle, and reuse. The Automatic waste management and segregation system use the concept of IoT, with an embedded system to segregate and monitor the level of the bin[1]. The status of bins is sent to concerned authorities to evacuate the bins. This system reduces human intervention, interaction and also reduces the consumption of time and cost. The project aims in reducing the waste at hospital level. Production of hazardous wastes out of hospitals are immeasurable. Rag pickers separate most of the wastes which are done by people at present. Nowadays, harmful hospital wastes and containers containing disposed pus, needles, glucose drip bottles, plastic papers and bandages are segregated by hand so that this would lead to adverse chronic health effects like tuberculosis, cancer and infectious diseases[2]. People could experience decreased standard of living, decreased longevity and after effects to generation of children born to such affected parents. The automation of biomedical waste segregation that is caused by the hospitals, an automated waste segregator is suggested[3]. When the medical waste is detected, the conveyor belt starts to move by the external motor. The waste is the transferred to the sensing unit and classifier unit. Ultrasonic sensors are used to monitor the bins that are placed inside the bins, it also spots the level of waste[4]. The segregation of medical waste is done automatically using numerous sensors in an effort to avoid the diseases which could spread in hospitals and to lower manual process[5]. This could help in persuading multiple aspects like

- To make use of technology to help make a cleaner and healthier environment.
- To ensure each waste item is collected and treated in accordance with regulations for each type of waste[6].
- To avoid illegal reuse of pharmaceuticals.
- To calculate the total waste generated per day by a hospital[7].
- To prevent waste mixture in the general municipal waste stream.
- To identify and segregate the waste[8].

II. METHODOLOGY

In order to achieve the aim of the project, it was necessary to carry out intense literature survey of the existing technologies and identify the research gaps. The solution to the gaps identified along with the final research objective should also be explored. The proposed system and subsystems are explained below:

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A. *Proposed System*

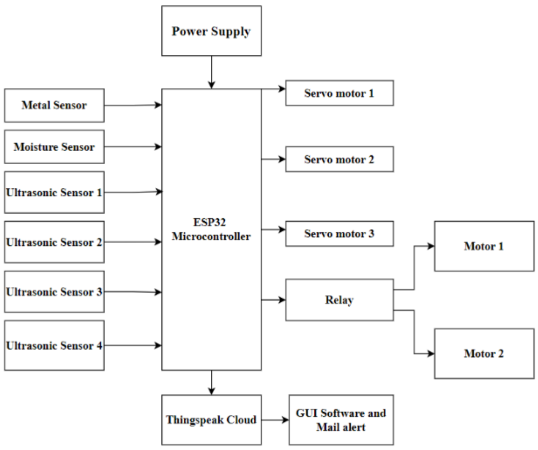

Figure 1. System Block Diagram

The project is divided into two parts.

1. Segregation

In segregation part the biomedical waste from the hospital is dumped on the conveyor belt. On detection of the waste, the conveyor belt will start to move. The waste is passed through different sensors;
1. Metal detector
2. Moisture sensor

Segregation is done on the basis of Metallic waste, Non-metallic wet waste and Non-metallic dry waste.

2. Management

In management part, once the dustbin gets 60% full, a notification is sent on the mobile phone using IOT indicating that the dustbin needs to be replaced with empty bin and also the notification will include the weight of the waste generated to keep the record[9]. Once the entire waste is segregated then it can be sent for treatment and disposal[10].

The system uses ESP32 microcontroller. The conveyor is operated using two DC geared motors. When a waste is placed on the conveyor it is sensed by the metal sensor. If it is a metallic waste it is pushed into the first bin using the first servo linear actuator. If it is a non-metallic waste the conveyor takes it to the moisture sensor. If it is wet waste it is pushed into second bin using second servo linear actuator. At last, if it does not qualify for both metallic and non-metallic wet waste then it is pushed int o third bin of non-metallic dry waste using the third linear actuator. Track of the dustbins is kept by ultrasonic sensors which activates the mail module and sends a mail if the threshold of dustbin crosses 60%. A GUI based system is developed using Python for monitoring of complete system which shows current level of all dustbins.

So, firstly ESP32 micro controller is the heart of the entire system. Then two geared dc motors of 10 rpm are used for the operation of conveyer belt. So conveyer belt will now start to move and it will be in the same state until the detected object is placed on it and that object approaches to corresponding linear actuator. When the object comes closer to the linear actuator the belt will be stopped to provide better pushing mechanism to the object. Now we will detect the waste through two different sensors present outside the conveyer setup and then place that waste on the conveyer belt. Suppose we placed metallic waste on metal sensor and it gets detected and after that we will place it on the conveyer belt. Now onwards there are 3 linear actuators for the three different categories of waste. The placed metallic waste on belt will now be pushed by the linear actuator associated with it. The pushing mechanism of actuator is based on the ultrasonic sensor present at the extreme of conveyer setup. This ultrasonic sensor will continuously track the distance of waste on the conveyer belt. The three threshold distances for three actuators are set already and when the waste crosses that threshold distance the actuator will push the object into bin. Now we will get back to our consideration of metallic object. When it is placed on belt its corresponding actuator will push it into respective bin after detection. The same mechanism is followed by all three categories of waste. Further ultrasonic sensors present in three bins will find the percentage of waste level and the same data is transferred to cloud through the WiFi module present in microcontroller. With the help of this data, the alerting actions will take place through the graphical user interface and mail alert. The same data from cloud will be reflected in user interface and correspondingly, mail alert will get activate if any of the dustbin exceeds the threshold limit.

III. FLOWCHART

Figure 2. Flowchart

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Figure 2. shows the flow of work or the algorithm of the whole system.

IV. SYSTEM DETAILS

A. *Electronic model*

In electronic model, ESP32 microcontroller is the heart of the entire system. Metal sensor and Moisture sensor are used for the detection of metallic objects and non-metallic wet objects placed on the conveyer belt respectively. After the detection of waste materials by these two sensors, the corresponding wastes will get pushed into corresponding bins by their respective linear actuators. And the third category i.e., non-metallic dry objects are getting separated(segregated) without any involvement of sensor which means that when a non-metallic dry object is placed on the conveyer belt, it won't get detected by any of the two sensors present in the system. So, by default it will be pushed into respective bin by its corresponding linear actuator. Servo motor (MG995) is responsible for the linear motion of linear actuator. The pushing mechanism of all the three linear actuators is based upon the ultrasonic sensor present at the extreme of the system setup (outside of the conveyer belt). Ultrasonic sensor present over the extreme end will constantly compute the distance of the object placed on the conveyer belt and once it gets detected and when it crosses the threshold distance set already (in the code) from the ultrasonic sensor, the linear actuator assigned to corresponding waste type will be informed by microcontroller to start the pushing action of object on the conveyer belt into respective bin. The threshold distances for all three linear actuators are predefined. Figure 3 below shows the actual model for the sorting.

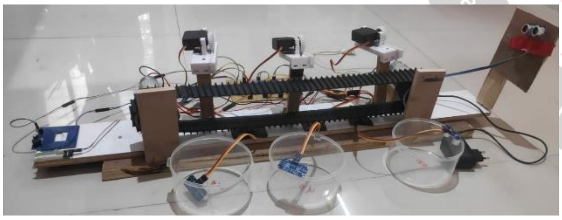

Figure 3. Electronic system

B. *Data storage at Thingspeak cloud*

After the process of segregation, the ultrasonic sensors located inside the three different dustbins will determine the percentage of waste filled in the dustbin and the corresponding data will be fetched to Thingspeak cloud over the internet with the help of in-built Wi-Fi module positioned inside the ESP32 microcontroller. In Thingspeak cloud's channel, there are four fields out of which three fields display the amount of waste filled inside the three different bins whereas fourth field will fluctuate from 0 to 1. If any of the three bins exceeds the 60% threshold then the value of fourth field will be 1 otherwise it will be 0. In the Figure 4a, the bin status is below threshold and in the Figure 4b, the bin status is above the threshold. The first four images are a pair of Figure 4a and the other four images are associated with Figure 4b denoting bin 1, bin 2 ,bin 3, overall status respectively.

Figure 4a. When bin status is below threshold

Figure 4b. When bin status is above threshold

C. *Graphical User Interface*

The designed graphical user interface with the help of Python will receive the data from cloud by accessing it and display the same data of three dustbins. The fourth stream in interface will be decided by percentage of bin filled. In other words, it will be a status displaying normal when any of the dustbin has not exceeded the threshold limit and alert will be displayed in case of any dustbin crosses the 60% limit.

D. *Email alert system*

The alert system is centered on the email followed by which Gmail will be delivered to the registered user showing the message as DUSTBIN FULL ALERT. The mail alert will only take place when any of the dustbin surpasses the 60%

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limit. In short, the alert action will occur when the status field in graphical user interface will be set to alert.

V. RESULT AND CONCLUSION

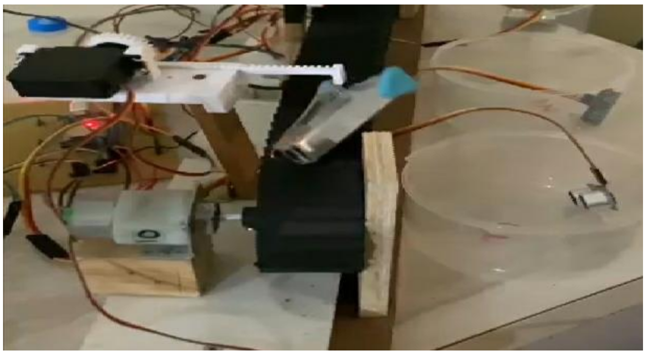

Figure 5. Metal waste being getting pushed

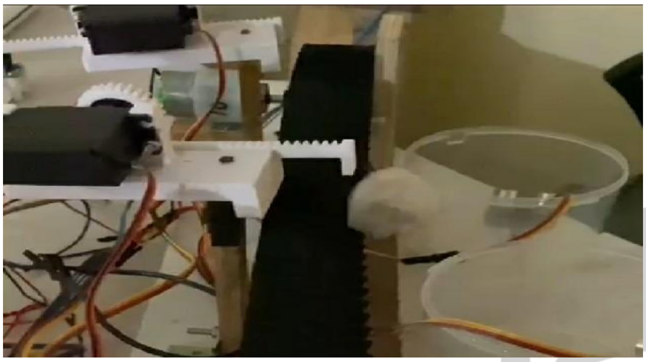

Figure 6. Wet waste being getting pushed

Figure 7. Dry waste being getting pushed

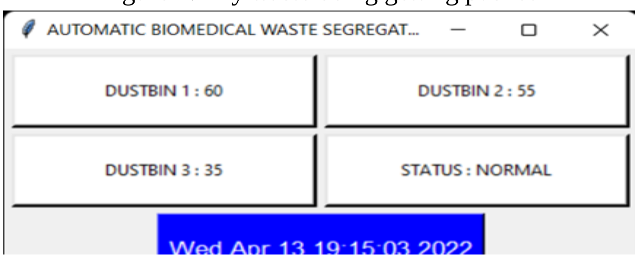

Figure 8. When status is normal

Figure 9. When status is alert

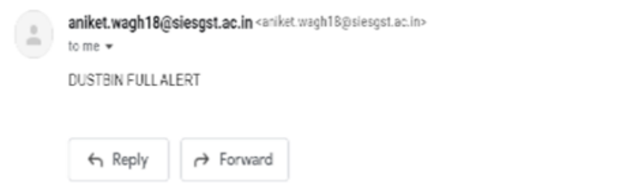

Figure 10. Received mail about alert

As visible in the above figures 5,6 and 7, the three different categories of waste i.e., metallic, non-metallic wet, non-metallic dry are getting sorted with the help of pushing mechanism we have used. After sensing and detecting the type of waste, the linear actuators assigned to corresponding category are pushing the object placed on conveyer belt into the desired dustbins. The data of dustbin is getting transferred to the cloud and the same data is being shown in the graphical user interface. In the Figure 8, the status is normal as any of the dustbin haven't crossed the 60% limit whereas Figure 9 shows the alert status as one of the dustbin has crossed 60% limit. Figure 10 illustrates the alerting action via mail. The mail action has taken place as dustbin crossed the limit. The objects(wastes) will be detected first by keeping them on corresponding sensors. After it, the object will now be placed on conveyer belt for segregation purpose. Now, if it is metallic waste then linear actuator associated with that specific waste will start its pushing mechanism with the help of ultrasonic sensor located at the end of the system which will calculate the distance of the object and once that object crosses that threshold distance, actuator will move linearly(straight) and pushes that object in bin associated with metallic waste. As the object approaches the linear actuator and when it will come in that actuator's radar, conveyer belt will be stopped by the relay for providing efficient pushing mechanism. Appropriate time delay is given to all the actuators so as to have the synchronization between the coming waste and pushing action. The same flow of working is applicable for remaining categories i.e. non metallic wet waste and non metallic dry waste. The segregation of all the three categories has been achieved successfully as the microcontroller gives corresponding commands to individual components properly and also receives the inputs from sensors rightly.

After achieving the goal of segregation, the management part is mainly based on Thingspeak cloud and the mail alert system followed by the GUI development by python. The data related to bin's garbage level will be fetched to Thingspeak cloud and based on empty level (60%) that means any of the dustbin crosses 60% limit, the corresponding field in the Thingspeak cloud will be set to 1 otherwise 0. The fetching of data from bins to cloud is achieved successfully.

The graphical user interface is also developed wherein the same data present in the cloud will be imported from the

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cloud displaying the same four sections as that of Thingspeak cloud. In Anaconda prompt, the python executable file is executed and then the developed graphical user interface will appear on the screen showing the data discussed above. Now, the status field in graphical user interface will be set to normal if the corresponding field in the cloud will be 0. If the corresponding field in the cloud will be 1 then the status field in graphical user interface will be alert. In this way, both the cases are achieved properly.

The alert system is centered on the email followed by which Gmail will be delivered to the registered user showing the message as DUSTBIN FULL ALERT. The mail alert will only take place when any of the dustbin surpasses the 60% limit. In short, the alert action will occur when the status field in graphical user interface will be set to alert. The email alert action has also been observed with success.

So, the designed automated system outlined above provides cost effective, low time consuming and technically simple approach for differentiating the waste. This system makes effective use of available technologies, making the model more user-friendly and efficient. Thus, with almost negligible human involvement the system works with minimal efforts. In this way, the main objective of the project has been achieved successfully.

VI. FUTURE SCOPE

There are various improvements that can be made to this project in the future. The waste produced can be segregated into more categories than wet, dry, and metal using more and different types of sensors. This will result in better segregation of the waste and efficient disposal. Secondly, the waste discarded can be sent for the extraction or recovered in an effective way. The energy produced from these resources can be converted into usable heat or as fuel for different purposes. The large-scale introduction of this automatic waste management and disposal system in villages, hospitals, schools, or remote areas will provide solutions to various problems such as diseases, unhygienic, uncleanliness, etc. A prediction system can be introduced which will analyze the given data and then predict the variations in the amount of waste produced and also adjust the timing of its management. The proposed system can be used as a small unit or part of a large enhanced system.

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