

Design and Implementation of Smart Dustbins: Segregation, Monitoring and Notification Capabilities

Sameer Chavan¹, Mayur Mhaske², Pranav Somavanshi³, Viraj Shinde⁴, Avishkar Rathod⁵ and Dr. Pallavi Deshpande⁶

¹Vishwakarma Institute of Information Technology
Email: sameer.22311008@viit.ac.in

²⁻⁶Department of Electronics engineering, Pune, India
Email: {mayur.22310903, pranav.22310809, viraj.22310834, avishkar.22310769, pallavi.deshpande}@viit.ac.in

Abstract—This paper proposes a model for automation of the waste management and segregation systems by developing smart dustbins as a solution for monitoring, and segregating the waste materials at early stages of garbage collection, which will indeed help to reduce the stress on existing systems and improving the efficiency of work. This project makes use of various sensors such as ultrasonic sensor which continuously monitor the level of the garbage in bins, IR sensor for hands-free opening and closing of the lid of dustbin, soil moisture sensor for segregation, etc. Arduino uno board with a microcontroller which connects all these components together and makes the whole system functional, and an esp8266 Wi-Fi module, which here is used to send reports of the usage and also notify about the status of level of dustbins to related authority. This system send a message directly to the receiver, via various means, along with the location of the dustbin. The results on implementation of the system were positive and with further improvements, it can prove to be a valuable addition to the existing systems of waste management.

Index Terms—Ultrasonic sensor, IR sensor, Arduino uno, esp8266 module, Automation, Smart dustbins, Soil moisture sensors.

I. INTRODUCTION

Continuously growing from the last few decades, the population of India and now reached the huge number of 1.43 billion people. Surpassing China, India will now become the most populated country in the world. With such increasing number of population every year, the rate at which waste materials are being generated in our country has also increased rapidly. Combined with the growing degree of urbanization, India's daily municipal waste production has also increased. The current collection methods does not allow the local municipal authority to know the status of the garbage bin either full or empty. This practice of garbage collection become irregular and not relevant, once the increasing of state's population. Also, it does not have a systematic schedule to collect every type of garbage, the overloaded garbage will attract animals and insects. A solution is needed to all such problems, and smart waste management systems can be the next step in improving waste management and segregation methods, and introducing waste monitoring methods. This paper proposes a model with simple method of waste segregation and monitoring.

By integrating Internet of Things (IoT) technology, sensors, and data transmission systems, these smart bins can

automatically segregate waste into different categories, monitor bin levels, and notify waste management authorities in real-time. Although the project explained in this paper is an IoT based smart dustbin, creating a network of such bins can lead to creation of a system for waste management.

II. LITERATURE SURVEY

There has been a great deal of study done on waste monitoring and collection. A few of the well-known works that are connected to this suggested system are covered here.

Shubha et al. (2023) present a smart waste management system that automates the segregation of waste into metal and non-metal categories and sanitizes it using ultraviolet (UV) light to prevent the spread of infections. A UV-C ultraviolet light LED strip is used to disinfect the surface of the dustbin, while metal and gas sensors are utilized for segregation and toxicity monitoring [1]

Sharma et al. (2023) utilize a different approach for waste segregation by implementing an IoT-based system that leverages a machine learning model. The system is designed to recognize garbage images captured by an OpenCV camera and automatically sort them into categories, thereby reducing the need for manual sorting and improving recycling efficiency [2].

Wu et al. (2022) propose a dustbin tracking system that integrates a GPS framework for tracking dustbins based on their locations. This system facilitates the collection of materials without any hassle or chaos and also proposes the development of a mobile app to make this tracking system accessible [3].

Sharma et al. (2020) and Thirumugam et al. (2023) both explore the use of servo motors and IR sensors in combination with IoT to automate waste segregation and sanitization. Their systems rely on Arduino and WIFI-enabled boards to send and receive data over cloud platforms, allowing for real-time control of devices. These papers inspired further optimization and design restructuring of the system [4] [5].

Saxena et al. (2024) employ a GPS framework for tracking smart dustbins in smart cities, improving the efficiency of waste collection systems by facilitating real-time monitoring of waste levels and optimizing the collection routes [6].

Vasagade et al. (2017) integrate a GSM module with their smart waste management system to send alerts when waste levels reach a threshold. However, in later projects, this technique was replaced with ESP boards for more efficient data transmission. This paper also helped structure the flow of execution in the system design [7].

Rohit et al. (2018) propose a dual-dustbin system aimed at smart cities, with an emphasis on waste segregation and monitoring. Their model uses IoT technologies to track and manage waste collection in real time, making it scalable and suitable for urban environments [8].

We referred to the work of Pallavi Deshpande et al.(2019) & (2021) to guide the structure, format, and flow of this paper for conference publication. While their studies informed our organizational approach, no direct content or references were used, ensuring the originality of this work[9][10]

III. EXISTING METHODS OF WASTE MANAGEMENT

- Trommel separators: Alternatively referred to as a rotary screen, a trommel screen is a type of mechanical screening machine that finds common applications in the mineral and solid-waste processing industries. Composed of a perforated cylindrical drum usually elevated at an angle at its feed end, it allows various materials of different sizes to fall through its holes. It separates based on physical size due to the spiral motion in the rotating drum; the undersized material-small than the screen apertures-pass through the screen, while the oversized material is taken out at the other end of the drum.
- Eddy current separators: An eddy current separator (ECS) is a machine that uses a powerful magnetic field to separate non-ferrous metals from an input waste or ore stream. The device makes use of eddy currents to effect the separation. Non-ferrous metals typically separated by an ECS include aluminium, copper, and die-cast metals. In waste sorting of single-stream recycling at materials recovery facilities, ECS is used after the waste has passed through some arrangement of magnets to remove ferrous metals.
- Manual sorting: Sorting of waste materials into different types, by respective workers.
- Incineration: Incineration is a waste management method that involves combustion of waste materials. Industrial plants for incineration are referred to as waste-to-energy plants.
The main advantage of incineration is the reduction of the volume of the waste at a very high rate. But it has plenty of drawbacks, out of which the dominant one is the emission of harmful gases, smog, etc. into the air, which causes air pollution.

- Landfills: A landfill is a site for waste material disposal. It is the oldest and most common waste disposal method, although the systematic burial of waste with daily, intermediate, and final covers only began in the 1940s. Traditionally, waste was merely left in piles or thrown into pits. Some landfills serve as sites for any of the following: provisionary storage, accumulation, and transfer, or part of the operations of processing waste material, such as sorting, treatment, or recycling. Landfills, unless stabilized, may experience extreme shaking or ground liquefaction during an earthquake.

IV. PROPOSED WORK

The project proposed in this paper is about making the waste management system IoT-based and more efficient. The project is about building IoT-based and internet-enabled smart dustbins/trash cans. These bins have the ability to detect motion, monitor the status of the waste collected, collect and send real-time data to cloud platforms, as well as trigger notifications on certain conditions.

The main objectives of this project are as follows:

- Develop a smart dustbin system capable of sorting the waste material into categories using sensors.
- To achieve real-time waste level monitoring and hands-free operation.
- Implement Wi-Fi-enabled modules to send real-time data and notifications including bin location to relevant authorities, which will improve the responsiveness and effectiveness of the overall waste collection services.
- Connect multiple such dustbins to one main base to form a network that can enable better waste management and also collect data on waste production, frequency, and management across locations.

V. METHODOLOGY AND WORKING

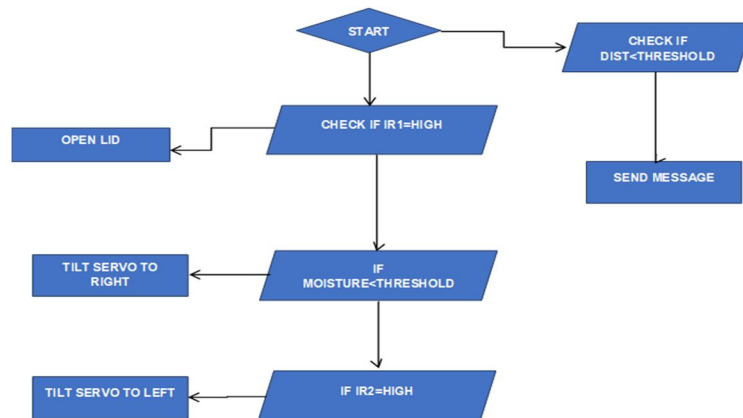


Fig. 1 Block diagram

This is the overall working of the system. Below figure explains it in form of a flow chart[Fig.1]

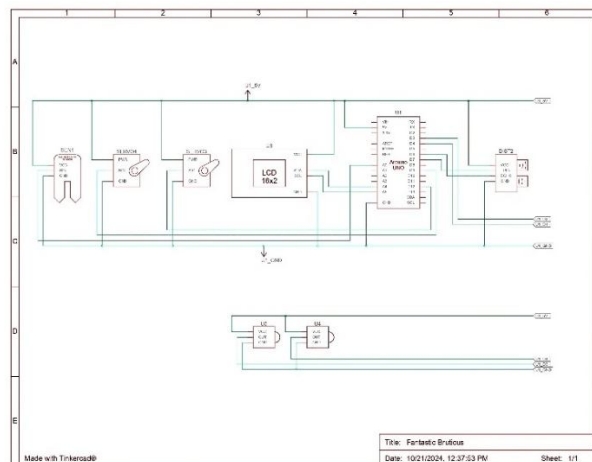


Fig. 2 Circuit diagram

[Fig.2] This figure shows the basic circuit diagram of the devices used in building the project and how they are categorized according to their roles.

The proposed project will help us automatically sort waste materials according to their type, monitor the garbage level in each compartment, and communicate with an assigned device once any bin is full. The whole design of this model mainly consists of three major parts:

- Segregation
- Monitoring
- Notification

A. Segregation

The segregation system of this model is based upon the use of moisture sensors and IR sensors. The moisture sensor is mainly used to differentiate between wet and dry waste. Once a certain moisture level, which is already set in the code, is crossed, the moisture sensor senses it as wet waste, and after that the servo, whose code is interlinked with that of the moisture sensor, tilts to a certain angle allowing the material present on the moisture sensor fall down. [Fig.4]. Sensing dry material was a challenge, as for example when a paper was kept on a moisture sensor, it did not change the moisture value. So to overcome this issue, we connected an IR sensor along with the existing components. So whenever there is dry waste material present on the moisture sensor, it will not detect it, but the IR will detect it instead which will lead to the tilting of servo motor to the opposite direction, thus segregating wet and dry waste automatically.

B. Monitoring

The ultrasonic sensors are used to monitor the level of garbage bins continuously once the system is turned on. The LCD continuously displays the status of the dustbin as per the output of ultrasonic sensors. Ultrasonic sensor consists of 4 pins namely the Trigger pin, Echo pin, VCC pin, and ground pin. Similarly, the LCD display with a built-in I2C module has 4 pins namely SDA pin, SCL pin, VCC, and ground.

The ultrasonic sensor emits a wave in fixed time intervals through the emitter, and the receiver captures the waves that come back bouncing off from some surface. The time period between the emission and reception of waves is noted and then used to find the distance of the surface from the ultrasonic sensor.

The ultrasonic sensor measures the level to which each compartment of the dustbin is filled. A threshold value is set according to the height of the compartment and once the threshold is crossed, the LCD displays the status of the dustbin as full and the opening and closing of the lid is turned off.[Fig.3] Also, the continuous status of the level of each compartment is displayed on the LCD.[Fig.5] The data collected from the ultrasonic sensor are sent over the Thingspeak cloud platform through the esp module.

This data can be used later for analysis and the usage details of the dustbin over time which can help in further improvements in the overall functioning

C. Notification

The notification section consists of an ESP8266 board, and an ultrasonic sensor, along with the use of the Thingspeak cloud platform and newly created telegram bot.

Working is as follows:

- With the help of the API key to send data over the cloud platform, data about the state of the dustbin which is monitored by the ultrasonic sensor is sent to the Thingspeak cloud after a certain time interval.
- Following are the steps followed to upload data to the Thingspeak channel:
 - Create a channel.
 - Create and add a field.
 - Pick the GET data API link from the API section and edit the code of the ESP8266 board accordingly. [Fig.6]
 - Set a time-interval to send data. Minimum of 16 seconds.
 - Observe the graph[Fig.7]
- With code linking the ESP and a new telegram bot created for solely delivering messages about the level of the dustbin, a messaging system is developed.
- This bot will send a message whenever the container is filled up to a certain extent. [Fig.8]

The use of individual components in the overall project is as follows:

- Ultrasonic sensor: Ultrasonic sensors are used for monitoring the level of garbage in the dustbin compartments. When the waste reaches a pre-set threshold, the sensor signals that the compartment is full, which can be displayed on an LCD and trigger notifications to the authorities.

- IR Sensor: IR sensors are employed to detect dry waste, particularly when the moisture sensor does not detect a significant change in moisture level. They also serve the purpose of opening the lid of the dustbin when motion is detected.
- Servo motors: Servo motors are responsible for the physical movement required for the waste segregation process. Based on the input from the moisture and IR sensors, the servo motors tilt in different directions.
- LCD: The LCD displays the current status of the dustbin, such as the waste level in each compartment. It shows real-time updates on whether the bin is full or still has capacity, as per the ultrasonic sensor data.
- Moisture sensor: When the moisture sensor detects a certain moisture level, it identifies the waste as wet and triggers the servo motor to segregate the wet waste into its respective compartments. Dry waste does not trigger this sensor, so the IR sensor handles that instead.
- ESP 8266 module: The ESP8266 sends data such as waste levels to the cloud at regular intervals, and it also communicates with a Telegram bot to notify the owner when a dustbin compartment is full.
- Arduino Uno: Arduino Uno serves as the central microcontroller, managing the operation of all sensors, servo motors, and communication components.

Following are the images of actual implementations of these components in the hardware project:

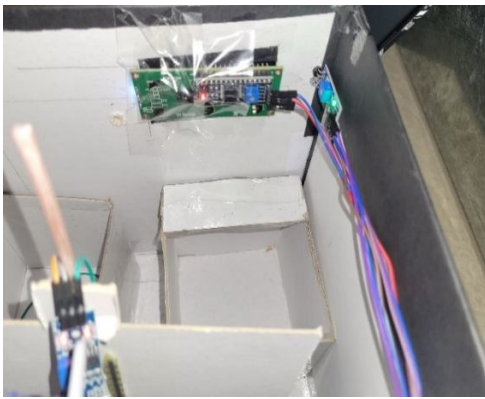


Fig. 3 Display setup

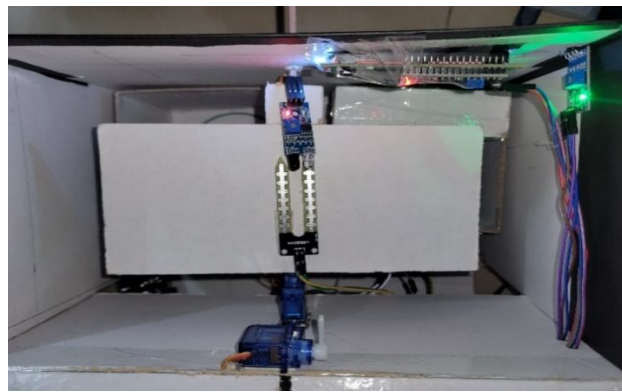


Fig. 4 Segregation setup top view



Fig. 5 Front view

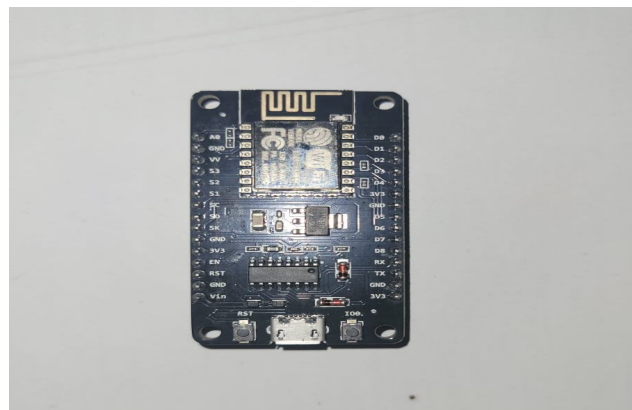


Fig. 6 ESP8266

VI. RESULTS AND DISCUSSIONS

The dustbin was used for various types of materials and the results that were observed are as follows:

TABLE I

Material	Type detected	Action
Banana peel	WET	Bin2
Paper	DRY	Bin1
Bottle	DRY	Bin1
Onion peels	WET	Bin2

Observations

- The segregation system works overall efficiently, functioning with a delay of 5 to 10 seconds.
- The message which is sent to telegram, is triggered immediately as soon as the threshold is crossed.
- The segregation part is relatively less accurate, and very less sensitive due to its slow functioning.
- The moisture sensor might fail to detect slightly wet materials or low-moisture content items, leading to occasional misclassification of wet waste as dry waste.
- The system primarily differentiates between wet and dry waste, but it cannot categorize other types of waste such as plastic, metal, or glass, which limits its functionality in comprehensive waste management systems.
- Only one object at a time can be thrown in the dustbin, which makes it difficult to be effective in day-to-day life.
- Since the system uses multiple sensors and an ESP8266 module for real-time communication, it could result in high power consumption, especially if the dustbin is deployed in areas without reliable power sources.

Following are the results of the project:

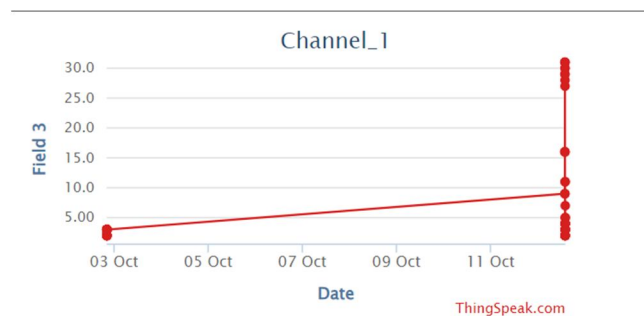


Fig. 7 Thingspeak graph



Fig. 8 Telegram notification

VII. FUTURE SCOPE

The future scope of this research regarding smart dustbin systems shows the future development that can possibly be achieved to significantly enhance the waste management system. Future studies may focus on developing some sensor technology advances like computer vision and the algorithms of machine learning, which will further improve the precision and efficiency in waste classification and segregation. Big data analytics and IoT connectivity can support real-time monitoring of waste generation trends, thereby improving the data-driven insights available from waste management authorities for optimized collection routes and schedules. Further, integration with mobile applications will make the system a more people-friendly interface, encouraging people to participate more actively and be concerned for proper waste disposal within the community. Future work in this direction could exploit sensor data to enable predictive maintenance capabilities

and predict and prevent operational issues. Finally, as this system is extended beyond the first central city applications and into rural communities, local governments, technology developers and community organizations will be vital parts of an integrated approach to the complex societal issues that arise in dealing with waste on this scale.

VIII. CONCLUSION

This research paper explicitly outlines the design of the smart dustbin system for automating urban waste management processes and notifying local authorities of the kind of waste in need of segregated collection immediately. The proposed system integrates ultrasonic, IR, and soil moisture sensors into Arduino Uno microcontrollers along with an ESP8266 WiFi module to automate the segregation of wastes through timely automatic notification. These are results that speak well to both efficiency in the collection of waste and responsible practices among the users. Well, the demonstration success of this smart dustbin seems to extend even to the wider possibility of IoT use in resolving most of the pressing environmental issues that we have. With increasingly built-up populations of urban dwellers, innovation in efficient ways of collecting this very highly ignored natural resource becomes much more pertinent in these modern times. These future improvements presented in this research work and viewed as a means of possibility to create paths for further studies, thus contributing toward sustainable urban living and enhanced environmental health.

ACKNOWLEDGMENT

We would like to express our gratitude to Dr. Pallavi Deshpande mam for her valuable guidance and support throughout the project. Her insights and suggestions helped us in shaping the direction of this project. We are sincerely thankful for her encouragement and support.

REFERENCES

- [1] G. Shubha, V. Dalal, R. T S, and R. C E, "Smart Dustbin Model for WasteManagement," 2023 IEEE North Karnataka Subsection Flagship International Conference (NKCon), Belagavi, India, 2023, pp. 1-4, doi: 10.1109/NKCon59507.2023.10396474.
- [2] K. Sharma, M. S. Naruka, R. Singh, G. Nijhawan, R. Chandrashekar and B. S. Kumar, "IoT Based Smart Dustbin with Waste Segregation," 2023 International Conference on Power Energy, Environment & Intelligent Control (PEEIC), Greater Noida, India, 2023, pp. 791-794, doi: 10.1109/PEEIC59336.2023.10450355.
- [3] H. Wu, H. Zhang, J. Liang, Z. Yang and X. Wang, "Design of New Intelligent Dustbin for Garbage Classification based on Machine Learning," 2022 International Joint Conference on Information and Communication Engineering (JCICE), Seoul, Korea, Republic of, 2022, pp. 171-176, doi: 10.1109/JCICE56791.2022.00044
- [4] P. Sharma, P. Kumar, R. Nigam and K. Singh, "Automatic Waste Segregating and Self Sanitizing Dustbin," 2020 2nd International Conference on Advances in Computing, Communication Control and Networking (ICACCCN), Greater Noida, India, 2020, pp. 368-372, doi: 10.1109/ICACCCN51052.2020.9362729.
- [5] P. Thirumugam, D. Herath and S. Amarasooriya, "Smart Dustbin and Garbage Monitoring System Using Internet of Things," 2023 5th International Conference on Advancements in Computing (ICAC), Colombo, Sri Lanka, 2023, pp. 857-861, doi: 10.1109/ICAC60630.2023.10417205.
- [6] K. Saxena, S. Yadav, V. Shukla and A. Awliya, "Smart Cities Using GPS to Find the Location of Smart Dustbin," 2024 International Conference on Communication, Computer Sciences and Engineering (IC3SE), Gautam Buddha Nagar, India, 2024, pp. 1887-1891, doi: 10.1109/IC3SE62002.2024.10592986.
- [7] T. S. Vasagade, S. S. Tamboli and A. D. Shinde, "Dynamic solid waste collection and management system based on sensors, elevator and GSM," 2017 International Conference on Inventive Communication and Computational Technologies (ICICCT), Coimbatore, India, 2017, pp. 263-267, doi: 10.1109/ICICCT.2017.7975200.
- [8] G. S. Rohit, M. B. Chandra, S. Saha and D. Das, "Smart Dual Dustbin Model for Waste Management in Smart Cities," 2018 3rd International Conference for Convergence in Technology (I2CT), Pune, India, 2018, pp. 1-5, doi: 10.1109/I2CT.2018.8529600.
- [9] P. D. Deshpande, P. Mukherji, and A. S. Tavildar, "Accuracy enhancement of biometric recognition using iterative weights optimization algorithm," EURASIP Journal on Information Security, vol. 2019, no. 6, pp. 1– 14, 2019, doi: 10.1186/s13635-019-0084-6.
- [10] International Journal of Computing and Digital Systems ISSN (2210-142X) Int. J. Com. Dig. Sys. 10 No.1 (Aug-2021) E-mail: archana.ratnaparakhi@viit.ac.in pallavi.deshpande@viit.ac.in gauri.ghule@viit.ac.in in <http://journals.uob.edu.bh> A Framework for Segmentation and Classification of Arrhythmia Using Novel Bidirectional LSTM Network Archana Ratnaparkhi1, Pallavi Deshpande1 and Gauri Ghule1