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IOT Based Smart Waste Management System Using Arduino

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ABSTRACT— Our research, titled "IoT-based Smart Waste Management System using Arduino," is driven by the primary goal of contributing to the Swacch Bharat Abhiyan initiated by our Honorable Prime Minister, Shri. Narendra Modi. Leveraging advancements in emerging technologies, we focused on implementing a smart system for waste management, specifically targeting waste bins and their contents. In our research, we employed Internet of Things (IoT) principles to develop a fully functional model. The core of our working model is an Arduino microcontroller, integrated with ultrasonic sensors and motors within the dustbins. The objective is to address the importance of maintaining cleanliness in waste disposal areas, as poorly managed bins can lead to an unhealthy environment and contribute to various pollutants that adversely affect public health.Our innovative solution incorporates ultrasonic sensors, servo motors, and battery jumper cables. Once the hardware and software connections are established, the smart dustbin program is activated. The dustbin lid intelligently responds to the user's presence, waiting for them to approach before opening for trash disposal. The ultrasonic sensors detect the user, prompting the servo motor to lift the lid. After the user disposes of the trash, the lid automatically closes. This technology not only promotes health and hygiene from a societal perspective but also aims to be economically accessible to a wide range of users. Our vision is to make this smart waste management solution inclusive, benefiting people from all walks of life.

KEYWORDS: Arduino UNO, Dustbins, Ultrasonic Sensors, Servo Motors, Jumper Wires, IoT, Circuit, etc.

I. INTRODUCTION

India's population growth rate is rising rapidly, garbage is increasing, and environmental problems are increasing. A dustbin is a container used to collect garbage or store recyclable or non-recyclable, degradable and non-degradable items. It is usually used in homes and offices, but when it is full, there will be no one to clean it, and garbage will spill out. Areas surrounding litter can also contribute to elevated pollution levels. Air pollution from dustbin produce bacteria and viruses that can cause life-threatening diseases in humans. For this reason, we have developed a smart dustbin equipped with the ultrasonic sensor ARDUINO UNO. It detects objects thrown into the dustbin and opens the lid with the help of a motor. This is an IOT based research & project that brings new smart and clean way. It's a good device to clean your home, as nearly every descendant of the house has soiled it and littered it on a large scale via electronics, wrappers, and other things. And intelligent dustbins are attractive and kid-friendly, helping you keep your home clean. Applies to different types of waste. The dustbin opens the lid when someone/object is nearby, waits a certain amount of time, and then closes automatically. Here, the lid is closed when not in use and opened only when needed.

II. LITERATURE SURVEY

1. Permana et al. (2023) [1] introduce an integrated waste management system with IoT-based centralized control for the purpose of developing a Smart Eco Campus at Telkom University. The research focuses on enhancing waste management practices on the campus by utilizing IoT technology and centralized control mechanisms.
The study highlights the integration of IoT devices and centralized control to monitor, manage, and optimize waste collection and disposal. By implementing this integrated system, Telkom University aims to create a sustainable and environmentally friendly campus environment. The paper provides technical insights into the implementation of this system and its potential to transform waste management within an educational institution. Published in the International Journal of Energy Economics and Policy, this research underscores the importance of IoT technology and centralized control in achieving the goal of a Smart Eco Campus.

2. Karthik, M., Sreevidya et al. (2023) [2] proposed an innovative waste management solution using IoT technology. The system addresses the problem of overflowing public trash cans in urban areas. The key components of the proposed system include ultrasonic sensors, embedded devices, and a central web server. The system offers real-time monitoring of trash can fill levels, allowing for efficient waste collection. When a trash can reaches a preset fill level, automatic alerts are sent to bin collectors via their mobile phones. This prompt action ensures that the city remains clean and free from overflowing trash. The proposed system aims to enhance cleanliness, reduce environmental contamination, improve public health, and minimize the negative impact of waste accumulation. By leveraging IoT technology, it offers a cost-effective and scalable solution for modernizing waste management practices in urban environments.

3. Rahmanifar et al. (2023) [3] tackle the Vehicle Routing Problem (VRP) in the context of an IoT-based waste

management system, highlighting the use of heuristic approaches. Their research aims to optimize the route planning for waste collection vehicles in a smart waste management system. The study focuses on the integration of IoT technology to monitor and collect waste efficiently. IoT devices provide real-time data about waste levels and locations. The authors discuss the vehicle routing problem and propose heuristic methods to enhance route planning, ultimately reducing operational costs and environmental impact.

4. Saha et al. (2023) [4] introduce an IoT-based smart waste management system designed to tackle the unique challenges posed by the COVID-19 pandemic. Their research focuses on leveraging Internet of Things (IoT) technology to enhance waste management efficiency in this context. By integrating IoT devices and sensors, they enable real-time data collection, improving waste monitoring and collection processes. This approach helps ensure a safer and more effective waste disposal system during a public health crisis.

5. Abdullah et al. (2022) [5] present an innovative IoT-based waste management system designed for both formal and informal public areas in Mecca. Their study explores the integration of the Internet of Things (IoT) technology to improve waste management in this significant location. The research emphasizes the versatility of IoT in addressing waste management challenges. By utilizing IoT devices and sensors, the system enables real-time data collection and monitoring of waste in various public spaces, including formal and informal areas. This real-time data acquisition enhances the efficiency of waste collection and disposal, optimizing the overall waste management process.

6. Prakash, S. P. et al. (2022) [6] explore an IoT-based solid waste management system employing smart dustbins to enhance urban waste collection and management efficiency. The paper likely details the development and implementation of this system, integrating electronic components like Arduino, Servo Motor, and Ultrasonic Sensor. The IoT-based smart dustbins, known for their effectiveness, utilize sensors to trigger lid opening upon detecting human presence or waste, optimizing waste collection and contributing to cleaner urban environments compared to traditional methods.

7. Salehi-Amiri et al. (2022) [7] introduce a two-stage, sustainable, and IoT-based waste management system to optimize processes. The initial stage focuses on waste separation at the source to enhance recyclability and reduce landfill burden. The second stage utilizes IoT technology for effective waste monitoring and management. Real-time data collection with IoT devices and sensors enables optimized waste collection and disposal. The paper details the technical aspects, highlighting potential efficiency and sustainability improvements.

8. Uganya, G. et al. (2022) [8] explores an innovative approach to waste prediction by integrating machine learning algorithms with an Internet of Things (IoT)-based intelligent waste management system. The objective is to enhance waste collection and management processes in urban areas through predictive analytics. This methodology likely involves leveraging historical data and patterns related to waste generation using machine learning algorithms, enabling the system to forecast future waste generation trends. The IoT component includes sensors in waste bins to monitor fill levels and wireless communication for data transmission to a central platform.

9. Wijanarko et al. (2022) [9] emphasize the implementation of Measurement System Analysis (MSA) in an IoT-based waste management system to ensure precise data collection. Integrating IoT technology for monitoring waste-related data, MSA techniques are applied for rigorous measurement and analysis processes. This approach guarantees the accuracy and reliability of the collected data, reinforcing the dependability of the IoT-based waste management system for informed decision-making.

10. Ghahramani et al. (2022) [10] present an innovative IoT-based route recommendation approach for intelligent waste management. The study integrates IoT technology for real-time waste data monitoring, utilizing device-generated information on waste levels and locations to recommend optimal collection routes. This system reduces operational costs and enhances environmental sustainability by optimizing waste collection processes, offering an efficient and data-driven solution to improve overall waste management efficiency.

11. Khan, R. et al. (2021) [11] showcase an IoT-based smart waste management system ensuring prompt collection at maximum fill levels. The system generates accurate reports, significantly boosting operational efficiency and aligning with sustainable waste management practices. Addressing landfill hazards, the system optimizes waste collection, treatment, and real-time tracking of garbage trucks, enhancing route optimization and overall efficiency while saving costs and time.

12. Ramson et al. (2021) [12] present an IoT-based system for real-time monitoring of bin levels in solid waste management. Their research aims to enhance waste collection processes by deploying services only when bins near full capacity. The integration of IoT technology ensures continuous monitoring, optimizing efficiency, reducing operational costs, and promoting more sustainable waste management practices. The paper offers technical insights into system implementation, highlighting its potential to enhance solid waste management.

13. Shah, A. A. I. et al. (2021) [13] offer a comprehensive review of IoT-based smart waste level monitoring systems tailored for smart city applications. The paper delves into how IoT transforms waste management by monitoring and managing fill levels in urban waste bins. It covers components, technologies, system architecture, and benefits of these IoT systems, highlighting improved efficiency, cost savings, and prompt issue resolution. Challenges like sensor accuracy and data security are discussed, with practical insights from global case studies.

14. Srinivasan, P. et al. (2021) [14] introduced the concept of an IoT-based smart dustbin, which utilizes Internet of Things (IoT) technology to enhance waste management. The smart dustbin is designed to monitor its fill level continuously, and when it reaches a certain capacity, it triggers alerts or notifications. IoT-based smart dustbins incorporate electronic components like Arduino, Servo

Motor, and Ultrasonic Sensor. These components work together to create an efficient and effective waste management solution. The functioning of a smart dustbin involves an ultrasonic sensor positioned at the front of the dustbin, linked to the lid and an Arduino. When a human hand or waste is placed in front of the sensor, it detects the presence and triggers the opening of the dustbin's lid, allowing for waste disposal.

15. Anh et al. (2020) [15] introduce an innovative waste management system in a university, merging IoT and machine learning. Emphasizing optimization in academic settings, IoT devices gather real-time waste data, processed by machine learning for informed collection and disposal decisions. This integrated system enhances efficiency, reduces costs, and promotes environmental sustainability, offering valuable technical insights and practical applications for universities seeking advanced waste management solutions.

16. Ali et al. (2020) [16] present an IoT-based smart waste bin monitoring system for efficient municipal solid waste management in smart cities. The study integrates IoT technology to monitor and manage waste bins in real-time, optimizing collection schedules. This approach enhances operational efficiency and contributes to cleaner and more sustainable urban environments, offering valuable insights into the technical aspects and applicability of the system in smart city contexts.

17. Harith et al. (2020) [17] present a prototype of an IoT-based smart waste management system designed for smart city applications. The research focuses on the development of an innovative system that leverages Internet of Things (IoT) technology to optimize waste management within urban environments. The study emphasizes the integration of IoT devices to monitor and manage waste collection in real-time. This system is designed to enhance waste collection efficiency, reduce operational costs, and contribute to the creation of cleaner and more sustainable smart cities. The paper offers technical insights into the development of this prototype and its potential for enhancing waste management in urban areas.

18. Kabir et al. (2020) [18] introduce an IoT-based solar-powered smart waste management system with real-time monitoring, designed to advance smart city planning. This research focuses on combining renewable energy and IoT technology to optimize waste management in urban areas. The study emphasizes the integration of IoT devices for real-time monitoring of waste bins. What sets this system apart is its use of solar power to sustain IoT operations, reducing the environmental impact and ensuring continuous monitoring. The combination of IoT and renewable energy sources enhances efficiency and sustainability.

19. Maddileti, T. et al. (2020) [19] explore an IoT-driven smart dustbin featuring Arduino, Servo Motor, and Ultrasonic Sensor components for advanced waste disposal. The paper likely outlines the design and functionality, emphasizing the system's superiority over traditional bins. With an ultrasonic sensor connected to both the lid and Arduino microcontroller, the dustbin opens automatically upon detecting a human hand or waste. This innovative approach promises cleaner and more efficient urban environments, showcasing the potential of IoT technology in waste management.

20. Pandey et al. (2020) [20] describe a Smart Dustbin employing Arduino, Servo Motor, and Ultrasonic Sensor for enhanced efficiency. The system functions as follows: an ultrasonic sensor, connected to an Arduino, is positioned at the front of the dustbin. When a human hand or waste is detected in its vicinity, the sensor triggers the lid to open via the servo motor, facilitating convenient waste disposal. This electronic implementation proves superior to traditional dustbins, showcasing a responsive and automated waste management approach, offering an effective and efficient solution to conventional methods.

21. Bhatt, M. C. et al. (2019) [21] proposed the problems people faced while throwing the garbage where lids are closed and their hands are full. Through this paper we have took the idea to tackle the traditional method or the normal use of Dustbin in our daily life. Each and every person in the world disposes the waste in the dustbin and if the dustbin becomes full, he empties the waste inside the bin and again uses the same Dustbin. So, we have got an idea to replace this traditional method and come up with some IOT based work.

22. Pushan (2019) [22] presents an Internet of Things (IoT) based waste management system with metering designed for application in smart village projects. The research focuses on optimizing waste management processes in rural and remote areas. The study emphasizes the integration of IoT technology for real-time waste monitoring and collection. The inclusion of metering functionalities ensures precise measurement and management of waste, allowing for efficient resource allocation and waste collection. The paper provides insights into the technical aspects and practical applications of this IoT-based system for smart village projects.

23. Ismail et al. (2019) [23] conducted a thorough literature review on IoT-based smart solid waste management systems, offering a comprehensive overview of diverse IoT technologies and their applications in enhancing waste management. Through detailed analysis, the authors identify trends, challenges, and opportunities in IoT-driven waste management. This study provides valuable insights into the current state of the field, serving as a valuable resource for researchers and practitioners involved in developing efficient and effective solid waste management solutions using IoT technology.

24. Satkar et al. (2019) [24] present a waste management system employing the Arduino Mega platform, emphasizing IoT technology to optimize solid waste management efficiency. Their focus lies in real-time waste monitoring and collection through the integration of IoT devices with Arduino Mega. The system enables precise data collection and analysis, enhancing the overall waste management process in a cost effective and scalable manner. The paper underscores the technical details, practicality, and potential widespread adoption of this Arduino Mega-based IoT solution.

25. Suryawanshi et al. (2018) [26] proposed how Arduino will be helpful in building the effective solution for a smart dustbin. It gathered data about Arduino Uno and other technicalities which will be used thereafter in the project.

The research aimed to harness the capabilities of Arduino Uno and other relevant technical elements to create an innovative system

Table 1: Literature Survey Overview

S. no	Title	Author Name	Year	Key points
1	Integrated Waste Management System with IoT-Based Centralized Control for a Smart Eco Campus at Telkom University [1]	Permana et al.	2023	The paper introduces an IoT-enabled waste management system for a Smart Eco Campus to enhance waste practices and sustainability through centralized control.
2	An IoT-Based Solution for Efficient Waste Management in Urban Areas[2]	Karthik et al.	2023	The paper outlines an IoT waste management system employing ultrasonic sensors, embedded devices, and a central web server for real-time monitoring and alerts to enhance urban cleanliness and minimize waste overflow.
3	Heuristic Approaches for Optimizing Vehicle Routing in IoT-Based Waste Management Systems[3]	Rahmanifar et al.	2023	The paper uses IoT and heuristics to improve waste collection routes and reduce costs in the context of waste management.
4	IoT-Based Smart Waste Management System for Addressing COVID-19 Pandemic Challenges [4]	Saha et al.	2023	The paper highlights an IoT waste management system using IoT devices and Arduino Uno to improve waste monitoring and collection, particularly in response to COVID-19 challenges.
5	IoT-Based Smart Dustbins for Enhanced Solid Waste Management in Urban Environments[6]	Prakash et al.	2022	The paper presents an IoT waste management system with smart dustbins, optimizing waste collection using Arduino, Servo Motor, and Ultrasonic Sensor technology for cleaner cities.
6	Waste Prediction in IoT-Based Intelligent Waste Management Using Machine Learning[8]	Uganyaet al.	2022	The paper combines machine learning and IoT in waste management to predict and optimize urban waste collection for cost savings and environmental benefits.
7	Measurement System Analysis (MSA) in IoT-Based Waste Management System Development[9]	Wijanarko et al.	2022	Highlights MSA's role in IoT-based waste management to improve data accuracy and system reliability.
8	Route Recommendation in IoT-Based Intelligent Waste Management System[10]	Ghahramani et al.	2022	Introduces an innovative IoT-based route recommendation system for efficient waste collection
9	IoT-Based Smart Waste Management System[11]	Khan, R. et al.	2021	The paper showcases an IoT smart waste management system for efficient waste collection and accurate reporting to mitigate landfill closure risks.
10	IoT-Based Monitoring System for Solid Waste Management[12]	Ramson et al.	2021	The paper introduces an IoT system for real-time waste bin monitoring to improve collection efficiency and reduce costs, emphasizing the transformative impact of IoT on waste management.

III. OBJECTIVES

Objective 1:

Develop durable and user-friendly dustbins to encourage proper waste disposal and reduce littering.

Objective 2:

Integrate IoT technology for real-time monitoring and efficient waste management, including automated alerts for full bins.

Objective 3:

Implement automatic lid systems on dustbins to address health concerns and promote hygiene.

***Objective 4*:**

Enhance urban aesthetics with aesthetically pleasing dustbin designs that blend seamlessly with the environment.

Objective 5:

Evaluate the system's effectiveness in reducing litter, improving waste collection efficiency, and enhancing overall cleanliness in urban areas through collaboration with local authorities and public awareness campaigns.

IV. PROPOSED WORK

- Bins equipped with ultrasonic sensors, GSM, GPS, and similar technology for data collection.
- Data transmitted to a centralized database for storage and management.
- Database keeps records of both empty and full bins.
- Authorized users' information is registered in the system.
- End-users receive notifications about the nearest available empty bins and directions to reach them.
- Authorized personnel are alerted about full bins and their specific locations.
- This system enhances waste management efficiency and user convenience.

V. METHODOLOGY

The waste containers transmit signals when they reach a capacity of over eighty or ninety percent, signaling that they require emptying. These signals are then transmitted through the mobile communications network to an internet-based software application utilized by the waste management company. Within the software, the equipment's capacity is displayed, serving as a basis for optimizing the waste collection route. Garbage trucks are directed only to those containers that genuinely need to be emptied. A robust ultrasonic sensor is installed in the waste container, capable of detecting the fill level regardless of the deposited material. The entire system comprises an ultrasonic sensor, Arduino Board, GSM Module, Bread Board, and Power Supply (Battery). The sensor is securely attached to the breadboard, and the connection between the Arduino board and the sensor is established using connecting wires. The operational program is then loaded onto the Arduino board. Additionally, the GSM module is connected to the same Arduino board with the help of wires. Power is supplied to the system through a battery.

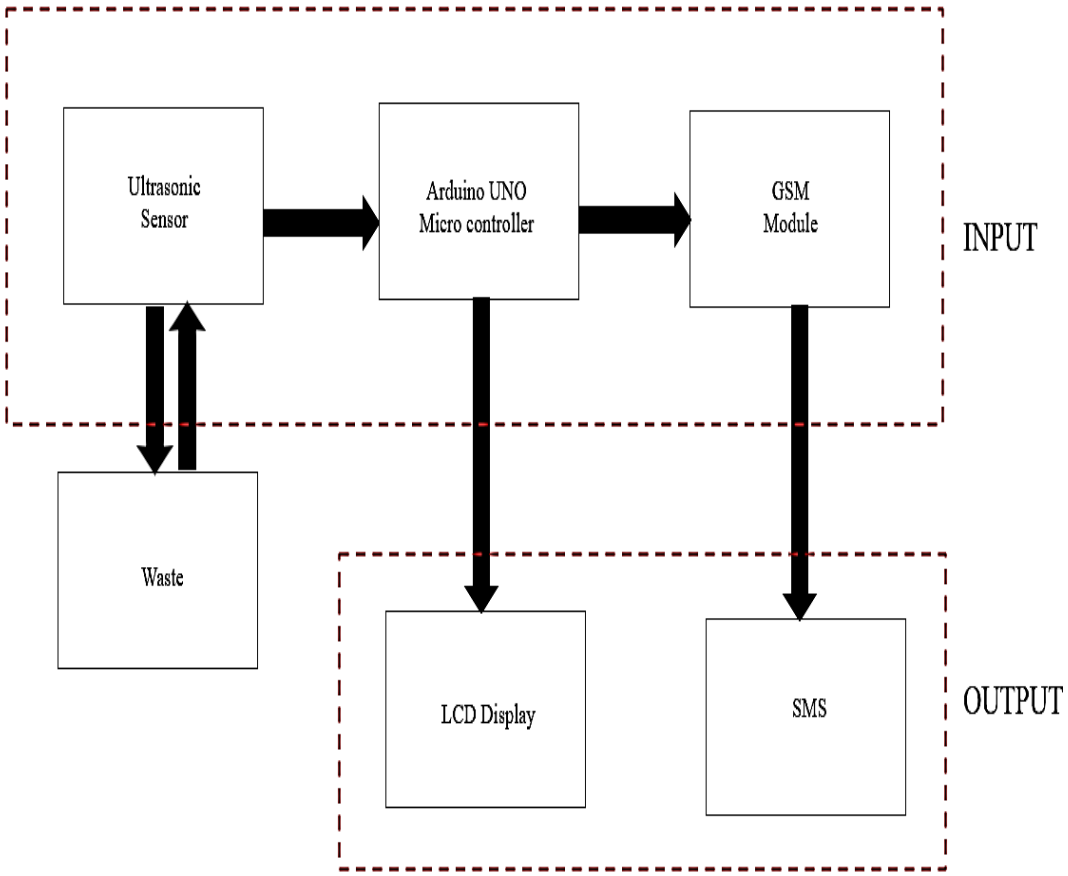

Figure 1: Block Diagram

VI. CONCLUSION

In our quest to usher in a cleaner and more efficient era, the introduction of the smart dustbin stands as a significant milestone. This innovative solution surpasses conventional dustbins by seamlessly integrating garbage compaction and state-of-the-art smart trashcan monitoring technologies, featuring cutting-edge components like Arduino. The result is a system that not only compacts trash but also offers remote access to vital smart dustbin data for decision-makers, transforming waste management into a data-driven, intelligent process. Looking ahead, the system's potential for improvement remains boundless. Future upgrades may encompass real-time monitoring with precise timestamps and sophisticated waste collection scheduling, ensuring that waste is managed with utmost efficiency and timeliness. Our objectives are clear: to reduce costs, optimize resources, and enhance the overall efficiency of smart dustbins. Furthermore, this system goes beyond mere functionality. It incorporates automated lids to bolster hygiene and cleanliness, thus addressing a crucial aspect of public health. In essence, it promotes responsible waste management while fostering a culture of cleanliness and well-being. As we embark on this innovative journey, our vision is to create a cleaner, healthier, and more efficient urban environment, successfully tackling the challenges posed by inefficient waste collection practices.

CONFLICT OF INTERREST

The authors declare that they have no conflict of interest

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Unnati Agarwal, an undergraduate researcher, web developer, data analyst at Galgotias College of Engineering and Technology. With leadership qualities and a commitment to positive impact, Unnati contributes to projects like Government Swacch Bharat Mission Project and the National Toycathon. Her diverse experience includes internships in web development, marketing and content writing, alongside notable achievements like ranking globally in the NASA Space Apps Challenge. Proficient in C, C++, Python, and Full Stack Development, Unnati's skills extend to data analysis tools like Excel, Tableau, and PowerBI. Active in club leadership as General Secretary at CSE Department and Secretary at Rotaract Club, she demonstrate a dedication to community engagement and development.