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Smart Dustbins: Revolutionizing Waste Management with IoT and Automation Internet of Things (IoT) & It's Applications

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Abstract: ***The traditional waste management system is inefficient, leading to overflowing dustbins, littered streets, and environmental pollution. This paper presents "Smart Dustbin," an innovative IoT-based solution that revolutionizes waste management. Equipped with sensors, GPS, and Wi-Fi connectivity, Smart Dustbin monitors waste levels, composition, and location in real-time. The system sends alerts to concern authorities when dustbins needs to be empty, optimizing collection routes and reducing waste disposal costs. Additionally, Smart Dustbin provides valuable insights into waste generation patterns, enabling data-driven decision-making for sustainable waste management practices. Our prototype demonstrates significant improvements in waste collection efficiency, reduced labour costs, and enhanced community cleanliness. This paper discusses the design, development, and deployment of Smart Dustbin, highlighting its potential to transform urban waste management.***
Keywords: IoT, Smart Dustbin, Motors, Waste Management, Arduino, Sensors.

I. INTRODUCTION

Effective waste management solutions are more important than ever in a time when urbanization is growing quickly, and environmental sustainability is becoming more important. Overflowing bins, ineffective routing, and insufficient data for collection schedule optimization are just a few of the issues that traditional waste collection systems frequently face. These issues harm the environment and strain municipal resources in addition to having an impact on how clean cities are. Among the many industries that the Internet of Things (IoT) has the potential to totally transform waste management. We are developed "smart" solutions to solve these problems by incorporating IoT technology into waste collection systems.One can observe trash cans being overfilled and trash spilling out of them everywhere. Because so many insects and mosquitoes breed on it, this causes a variety of diseases. Management of Solid waste is a major issue in urban areas. Therefore, a smart dustbin is a technology that may either completely eliminate or significantly reduce this issue.

II. LITERATURE SURVEY

Sr.No.	Authors Name	Methodology	Purpose	Improvement	Limitations
1	Ameya Angadi 2020	Microcontrollers, Ultrasonic sensor, SG90 Servo motor.	Design for contactless disposal.	The system allows by customization by adjusting sensor distance and lid open time.	Sensor Accuracy, Limited Scalability.
2	Naresh R. 2021	Sim800L GSM, Ultrasonic sensors, SG90 Servo motor.	Design smart dustbin for an eco-friendly environment.	Developed an IoT-enabled smart dustbin with a messaging alert system to notify authority.	Environmental Factors, Data security.
3	Abhishek Kumar 2022	Wi-Fi Module (ESP8266), MG90s Servo Motor.	Design dustbin to improve waste management using automation.	Optimize collection routes.	Regular Maintenance, High Initial setup cost.
4	Raghavendra S. 2023	Arduino UNO R3, Ultrasonic Sensor, Servo Motor, SIM800 GSM	Design Smart Waste management system using IoT.	Adds Cloud computing, Data Analytics, Machine Learning Algorithms.	Limited area network, Frequent battery recharging.

A. *Circuit Diagram*

The smart dustbin circuit consists of an Arduino Uno, an ultrasonic sensor for waste level detection, second ultrasonic sensor for touchless operation, and a GSM module for SMS alerts. A 16x2 LCD display shows status, while red/green LEDs indicate bin levels. The system is powered by a 2Amp Adapter, with a PCB for component connections.

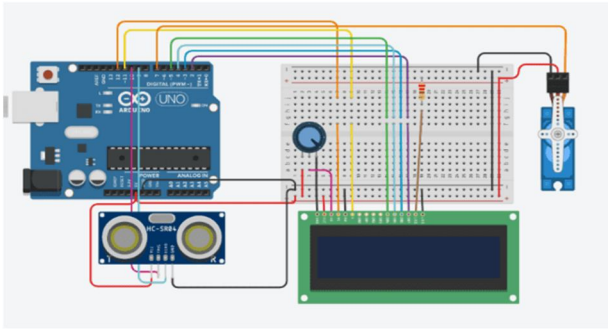

Figure.1 Circuit Diagram

B. *Hardware Components*

1) Arduino Uno Board: The brain of the system, responsible for processing data from sensors and sending commands to the GSM module and LCD display.

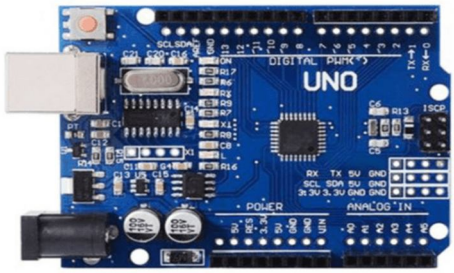

Figure.2.1: Arduino Uno

2) GSM Module: Responsible for sending SMS notifications to a predefined number when motion is detected or when the waste level reaches a certain threshold.

Figure.2.2: GSM Module

3) Ultrasonic Sensor: Measures the distance of the waste level in the dustbin and sends the data to the Arduino board.

Figure.2.3: Ultrasonic Sensor

4) LCD Display: The LCD display shows the waste level percentage, dustbin status (open/closed), and SMS notification status.

Figure.2.4: LCD Display

5) Servo motor :The servo motor opens and closes the dustbin lid.

Figure.2.5: Servo motor

C. Flowchart

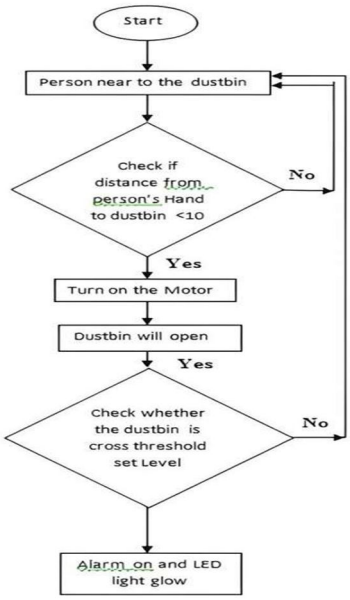

Figure.3: Flowchart

D. Advantages

Improved Public Health: By reducing waste overflow, smart dustbins contribute to a cleaner environment and better public health.
Cost-Effective: Arduino boards are relatively inexpensive, making them a budget-friendly option for developing smart systems.
Increased Hygiene: The lid opens automatically when needed, minimizing direct contact with waste and reducing the risk of disease transmission.
Customizable: Arduino allows for easy modification and customization to suit specific needs and requirements.
Optimized Waste Collection: By monitoring fill levels and waste generation patterns, smart dustbins can help optimize waste collection routes.

E. Limitations

Maintenance and Repair: Smart dustbins require regular maintenance and repair, which can be time-consuming and costly.
Power Supply: Smart dustbins need a reliable power supply, which can be a limitation in areas with frequent power outages.
Connectivity Issues: Smart dustbins require stable internet connectivity, which can be a limitation in areas with poor network coverage.
Data Security: Smart dustbins collect data, which can be vulnerable to cyber-attacks and data breaches.
Weather Resistance: Smart dustbins must be weather-resistant, which can add complexity and cost to the design.

F. Applications

Airports and Railway Stations: These locations often have significant amounts of waste generated by travelers. Smart dustbins help to reduce overflow and maintain cleanliness.
Hospitals and Clinics: In healthcare settings, smart dustbins can improve the management of both general and hazardous waste, enhancing safety and operational efficiency.
Universities and Schools: Smart dustbins in educational settings help manage waste produced by students and staff.
Smart Cities: In smart cities, residential areas may use smart dustbins to integrate waste management.
Industrial Sites: Smart dustbins can help to manage waste in industrial sites.

G. Problem Causes due to Scattered Dustbins

Environmental Pollution: Littered dustbins contribute to soil, air, and water pollution, harming ecosystems and wildlife.
Health Risks: Exposed waste attracts pests, spreading diseases like malaria, dengue, and cholera.
aste Management Challenges: Disorganized waste collection leads to inefficient disposal, overfilled landfills and increased greenhouse gas emissions.
Climate Change: Improper waste disposal contributes to climate change by releasing methane and other harmful gases.

H. Evaluation Results of the Smart Dustbin

To evaluate the application of smart dustbins in the campus environment, questionnaires were distributed to 50 respondents consisting of lecturers, students, and academic staff at Government Polytechnic Gadchiroli. The distribution of data on the results of respondents' responses to the evaluation of implementing smart dustbins is presented in the form of a bar chart in Figure. 4.
Then the lowest usage is in Day 3 and 4, namely, there is a shortage of Power Supply in smart dustbin. The rest of the respondents are satisfied with the presence of this smart dustbin to reduce laziness, increase awareness of environmental cleanliness, and of course reduce waste circulation carelessly.
Furthermore, it can be confirmed that the average results obtained from the evaluation of the implementation of these smart dustbins are at 87.80% which states that they strongly agree with the existence of this smart dustbins, they are very enthusiastic in using the trash and providing benefits. schedules, reducing fuel consumption and emissions.

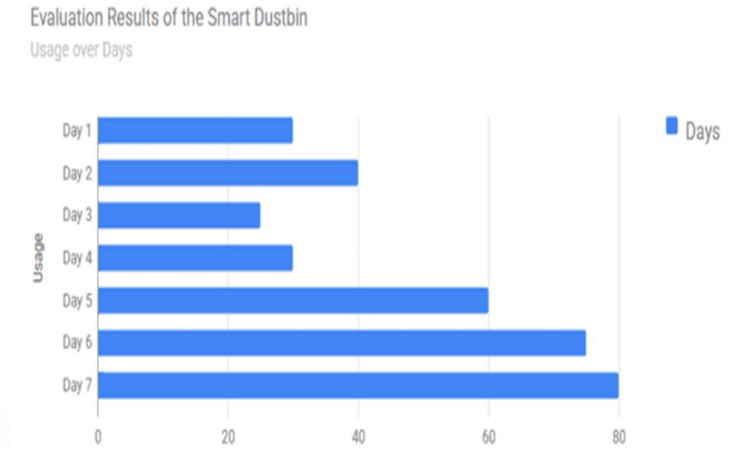

Figure.4: Evaluation Results

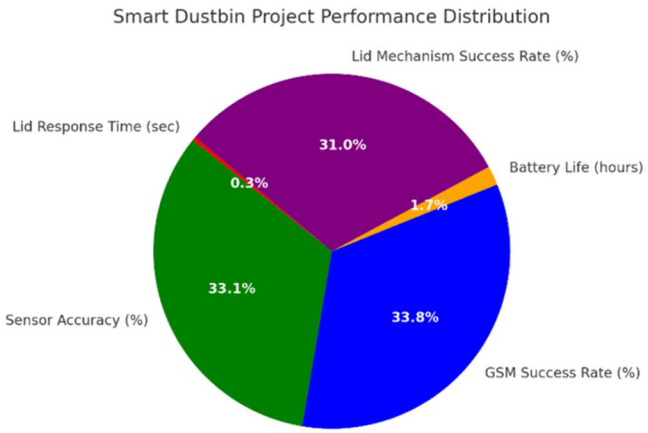

Figure.5: Smart Dustbin Performance Pie-Chart

1) Lid Opening Response Time (1 second)

The dustbin lid opens within 1 second after detecting waste, which is a fast response. This ensures smooth user interaction. Further improvements could be made by optimizing motor speed and sensor processing.

2) Sensor Accuracy (95%)

The sensors detect objects with 95% accuracy, which is highly reliable. Occasional errors might occur due to environmental factors like dust, lighting, or interference. Regular sensor cleaning and recalibration can help maintain high accuracy.

3) GSM Message Success Rate (97%)

The GSM module successfully sends messages 97% of the time, which means the system effectively communicates when the bin is full.

4) Battery Life (5 hours)

The system runs for 5 hours on a full charge, which is decent. To improve battery life, power optimization techniques such as using low-power modes in Arduino and efficient motor usage can be implemented.

5) Lid Mechanism Success Rate (89%)

The lid operates correctly 89% of the time, which is good but has some room for improvement. Occasional failures could be due to mechanical issues, motor wear, or sensor misalignment.

III. RESULT

Figure.6: Human Detection

Figure.7: Waste Level Indication

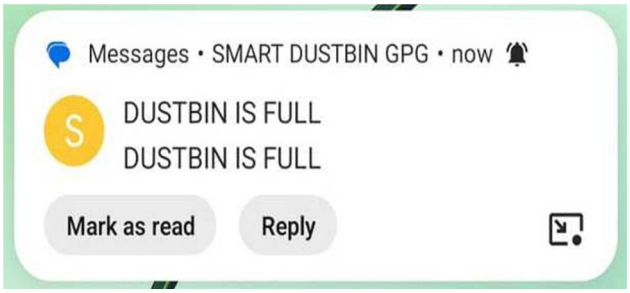

Figure.8: Notification of Dustbin

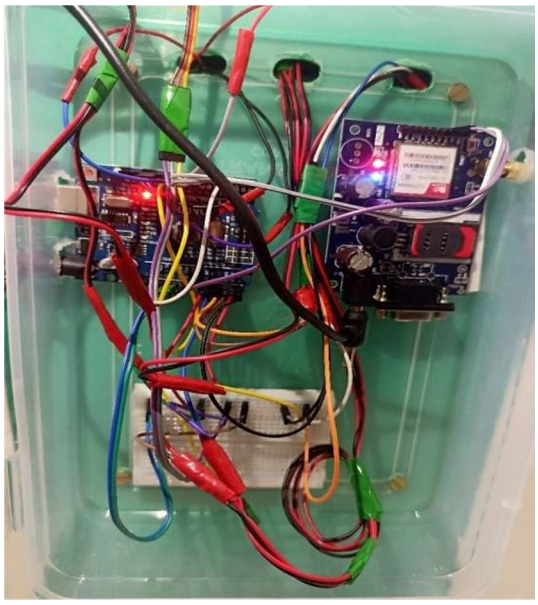

Figure.9: Hardware Setup

IV. METHODOLOGY

The IoT-based smart dustbin operates using a combination of various sensors and actuators to automate waste management tasks and improve user convenience. The first ultrasonic sensor is used for human presence detection. When a person approaches the dustbin, the sensor detects their presence by measuring the distance to the object. Once human presence is confirmed, the servo motor is triggered to automatically open the dustbin lid, allowing for touch-free waste disposal. After the user has disposed of the waste, the lid closes automatically once no motion is detected.

The second ultrasonic sensor is placed inside the dustbin for waste level detection. This sensor continuously monitors the level of waste inside the bin by calculating the distance from the sensor to the top of the waste pile. Based on the data, the microcontroller determines how full the bin is. If the bin reaches a certain threshold (e.g., 80% full).

The system triggers a buzzer module to sound an alert, notifying the user that the dustbin is full and needs to be emptied.

The LCD display provides real-time feedback to the user by showing important information such as the current waste level, whether the lid is open or closed, and whether the dustbin is full or not. This ensures that users have immediate access to the status of the bin without needing to open it.

The system also uses a set of LED indicators for additional visual feedback. A red/green blinking LED is used to indicate the status of the lid. The LED blinks when the lid is open and remains steady when the lid is closed. A blue LED lights up when the dustbin is not full, indicating that the bin is ready for use. When the bin is full, the red LED turns on, signalling that it is time for the bin to be emptied.

Lastly, a GSM900A module is integrated into the system to send a text message to the designated authority or waste management personnel when the dustbin reaches full capacity. The GSM module sends an SMS alert, informing them that the bin needs to be emptied.

V. CONCLUSION

The Arduino-based smart dustbin is a significant improvement over previously developed models, offering enhanced efficiency, automation, and sustainability in waste management. Unlike older smart dustbins that relied on basic motion sensors for lid automation, our system integrates advanced ultrasonic sensors to detect waste levels accurately and send real-time notifications when the bin reaches capacity. This prevents overflow and ensures timely waste disposal. Additionally, real-time monitoring and IoT connectivity allow users to track waste levels remotely, optimizing waste collection routes and schedules. Unlike traditional models that required frequent manual checks, our smart dustbin reduces unnecessary trips, saving time, fuel, and resources.

Moreover, our dustbin improves public health and safety by minimizing direct human contact with waste, addressing concerns related to hygiene and odour issues often associated with traditional bins.

The inclusion of data-driven waste analysis enhances user engagement, enabling informed decision-making for better waste management. While previous smart dustbins lacked intelligent waste classification, our model has the potential for AI-powered waste segregation, further improving recycling efforts. Future enhancements, such as solar-powered operation and integration with municipal waste systems, will continue to enhance its capabilities.

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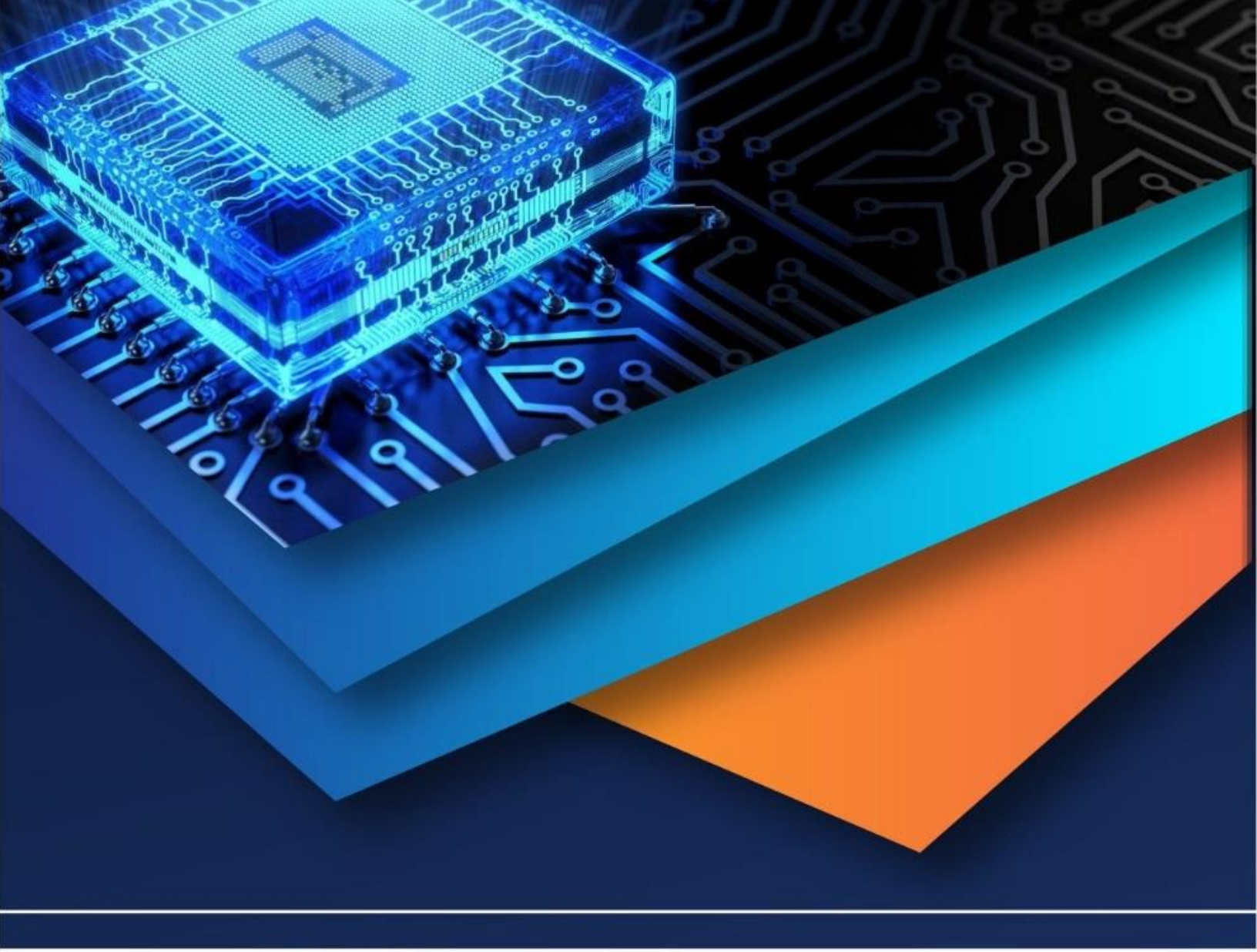

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