Smart Dustbin With Integrated Bomb Detection System

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Abstract- *The rapid urbanization and increasing population in metropolitan cities have intensified the challenges of waste management. Traditional waste disposal systems often fail to address the critical issues of efficiency, segregation, and monitoring. The proposed Smart Dustbin project aims to integrate advanced technologies to create a sustainable and efficient waste management solution tailored for high-traffic areas like metro stations, railway stations, etc. This smart dustbin incorporates a NodeMCU microcontroller for IoT integration, a servo motor, RFID reader, GSM module, IR sensor, and a metal detection system based on conductivity.*

The system works as follows: when a user approaches, they authenticate using an RFID card. Waste is then placed on a plate attached to a servo motor. The system detects whether the waste is metallic or non-metallic. Non-metallic waste is deposited into the bin by rotating the servo motor, while metallic waste triggers an alert sent to the authorities via GSM, ensuring proper disposal or recycling. Additionally, an IR sensor monitors the fill level of the dustbin, sending an alert when the bin is full. This innovative design not only automates waste segregation but also enhances operational efficiency by notifying authorities about critical events such as bin overflow or inappropriate waste disposal.

By integrating IoT with efficient waste segregation mechanisms, this project aims to revolutionize waste management in metro stations, promoting environmental sustainability and hygiene

Keywords- Metal Detection, RFID Card Reader, GSM

I. INTRODUCTION

The Smart Dustbin with Integrated Bomb Detection System is an innovative solution aimed at enhancing waste management and security in high-risk areas, particularly metro stations. The system utilizes RFID (Radio-Frequency Identification) technology to facilitate automatic identification and tracking of waste materials. RFID tags embedded in waste containers are scanned by an MFRC522 reader installed in the dustbin, enabling seamless monitoring without the need for direct line-of-sight, unlike traditional barcode systems. This project to further improve user experience and hygiene, the system incorporates an ultrasonic sensor that detects user proximity and automatically opens the dustbin lid via an SG09 servo motor. Additionally, it monitors the fill level of the bin and communicates this information to a Node MCU microcontroller, which manages operations such as closing the lid or sending alerts when the bin is full.

II. LITERATURE SURVEY

Literature Survey is most important step in the software development process. Before developing of development of intelligent safety systems, it is necessary to determine the time factor, economy and company strength. Once these things are satisfied, the next step is to determine which operating system and language can be used in developing the system.

[1] IEEE Xplore, 2023 – Intelligent Waste Segregation Using Smart IoT-Based Dustbin

In this work by PragunJaswal et al., a smart dustbin capable of distinguishing between dry and wet waste was proposed using IoT sensors. It aimed to reduce human involvement and ensure timely garbage disposal through real-time monitoring and notifications. The system demonstrated efficient waste segregation in both urban and rural settings. However, it was limited to basic waste types and did not account for hazardous or recyclable materials, which restricts its broader application in complex environments.

[2] IEEE Xplore, 2023 – Smart IoT-Based Dustbin and Waste Monitoring System

PalomiGawali and her team developed an IoT-driven waste bin equipped with ultrasonic sensors and NodeMCU. The system sent alerts when bins were nearly full (85–90%), helping reduce overflow in cities. While practical and cost-effective, it lacked waste segregation capabilities and long-term data analytics. Moreover, its dependence on constant internet connectivity and accurate sensor calibration posed constraints in real-world deployment.

[3] IEEE Xplore, 2023 – IoT-Based Smart Dustbin for Effective Waste Management

Peng Pan et al. presented a smart bin that went beyond simple monitoring by including sensors to detect moisture and weight. Notifications were pushed via a mobile app, enabling real-time tracking. Though useful in analyzing waste patterns, the system did not handle segregation. It also required internet connectivity and periodic sensor maintenance, limiting its use in underdeveloped areas.

[4] IEEE Xplore, 2022 – Smart Garbage Monitoring System Using GSM

B. Rubini and colleagues proposed a cost-efficient GSM-based waste monitoring system to prevent bin overflows. Ultrasonic sensors were used to detect bin fill levels, and alerts were sent via SMS. Despite being easy to implement, the system lacked classification capabilities and faced limitations such as sensor inaccuracies, GSM delays, and power dependencies, making it more suitable for basic monitoring tasks.

[5] IEEE Xplore, 2020 – A Cloud-Based Smart Recycling Bin for In-house Waste Classification

NikolaosBaras and team introduced a machine learning-powered recycling bin that could classify waste into recyclable and non-recyclable categories. It used cloud storage for data analysis and delivered classification accuracy of 93.4%. However, high implementation costs, reliance on internet access, and potential privacy concerns due to cloud data were noted as major drawbacks, making the system better suited for industrial or high-budget applications.

III. METHODOLOGY

The Smart Dustbin with Integrated Bomb Detection System follows a multi-phase methodology integrating embedded systems, IoT communication, user authentication, and material classification technologies to enhance public safety and waste management efficiency. The system is built on a NodeMCU microcontroller, supported by various sensors and modules to aautomate waste segregation and detect potential threats.

The system architecture of the Smart Dustbin with Integrated Bomb Detection System, as depicted in the figure 1, is centered around the ESP8266 microcontroller, which acts as the brain of the system, coordinating data flow and operations. The architecture is modular and integrates multiple components for efficient functionality:

- **RFID Module:**The RFID module authenticates users by reading RFID tags during waste disposal. It ensures that only authorized individuals can use the bin, enhancing traceability, preventing misuse, and adding a security layer to public waste management systems.
- **IR Sensor:**The IR sensor monitors the dustbin's fill level by detecting the distance to the waste surface. When the bin reaches capacity, it alerts the system to notify authorities, ensuring timely collection and preventing overflow in public areas.
- **Metal Detection Module:**This module identifies metallic objects in waste using conductivity-based sensing. If metal is detected, the system halts operation and sends an alert, helping prevent disposal of hazardous or explosive items in high-security or public locations.
- **ESP8266 Microcontroller:**The ESP8266 microcontroller acts as the system's brain, processing data from sensors and managing actions like user verification, motor control, and alert transmission. It supports efficient, coordinated operation of all smart dustbin components with optional IoT integration.
- **Servo Motor:**The servo motor automates waste handling by rotating to deposit non-metallic waste into the bin. It enables hands-free, hygienic disposal and resets after each operation, supporting smooth, accurate, and reliable mechanical motion for the system.
- **GSM Module:**The GSM module provides real-time communication by sending SMS and calls to alert authorities. It notifies about bin overflow or metal detection, ensuring immediate response to maintenance or security threats in public areas.
- **Power Supply (Battery and Solar Panel):**The system uses a rechargeable battery for consistent operation and can integrate solar panels for eco-friendly charging. This sustainable setup ensures functionality during power outages and supports green energy initiatives in smart city infrastructure.
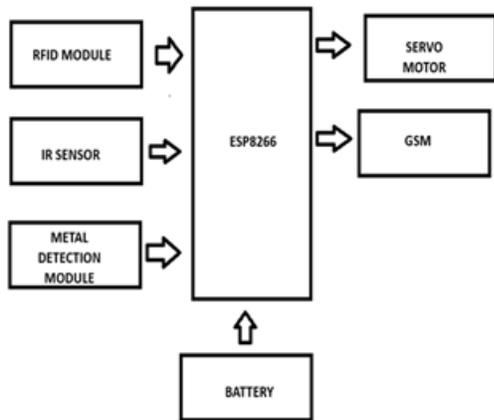
Figure1: System architecture of Smart Dustbin with Integrated Bomb Detection System.

IV. SNAPSHOTS

Snapshot 1: The system is initialized by powering on the circuit, illuminating all the connected LEDs, and confirming that each component, including sensors and actuators, is ready for operation. The system awaits input for waste classification.

Snapshot 2: Non-metallic waste is placed on the lid, and the system's sensors begin the process of analyzing the material. This interaction activates the preliminary detection phase, ensuring the waste type is correctly identified before proceeding.

Snapshot 3: The user authenticates their access by tapping an RFID card against the system. This ensures that only authorized personnel can interact with the waste disposal mechanism, adding a layer of security to the operation.

Snapshot 4: Upon successful authentication, the system's mechanism opens the lid, allowing the non-metallic waste to be deposited into the bin. The system simultaneously updates its records to log the transaction.

Snapshot 5: The system identifies metallic waste through its detection sensors. Immediately, a phone call is made to notify the concerned authority.

Snapshot 6: In addition to the phone call, the system sends an SMS notification to the authority with details about the detection of metallic waste. This redundancy ensures effective communication and action, emphasizing the system's reliability in waste management.

V. CONCLUSION

The Smart Dustbin demonstrates a transformative approach to waste management in hightraffic areas such as metro stations. By leveraging IoT technologies and embedded systems,it automates processes like waste segregation, real-time monitoring, and alerting, thusaddressing critical inefficiencies of traditional waste disposal systems. The incorporation ofRFID authentication ensures controlled waste disposal, while the conductivity-based metaldetection enables precise segregation of metallic and non-metallic waste. Additionally, realtime monitoring using IR sensors and GSM alerts enhances the operational efficiency ofwaste collection, preventing bin overflow and ensuring timely interventions.This system not only promotes hygiene and cleanliness in metro stations but also encouragesrecycling by isolating recyclable metallic waste for proper handling. Furthermore, the IoTintegration allows seamless communication between the dustbin and authorities, ensuringeffective management of critical events. By addressing the limitations of conventionalmethods, the Smart Dustbin provides a practical, scalable, and sustainable solution to thegrowing waste management challenges in urban environments. Overall, it aligns with thebroader goals of smart city initiatives by fostering environmental sustainability, resourceefficiency, and public hygiene.

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