International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 03 Issue: 04 April 2025
Page No: 1355-1360
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2025.0193

Automated Smart Dustbin with Solar Powered and Iot Applications

C Vibin Stalin[1], B J Buvanesh[2], V Radhakrishnan[3], R J Prithik raj[4]
[1]Assistant Professor, Dept. of Mechatronics, Paavai Engineering College., Namakkal, Tamil Nadu, India.
[2,3,4]UG Scholar, Dept. of Mechatronics, Paavai Engineering College, Namakkal, Tamil Nadu, India.
Emails: *stalinjose173@gmail.com[1], buvaneshrao999@gmail.com[2], radhakrishnanbem2021@gmail.com[3], prithik003@gmail.com[4]*

Abstract
Urban development has led to increased waste generation, putting pressure on existing waste collection infrastructure. This paper proposes a solution using IoT and solar energy: the IoT-based solar-powered smart dustbin. This system enhances efficiency and sustainability in waste collection processes in urban areas. The smart dustbin monitors garbage levels continuously using two ultrasonic sensors—one for the lid and another for waste levels. When the waste exceeds a threshold, it automatically sends real-time alerts to municipal authorities. Once fully occupied, the bin remains closed to prevent overflow and dumping issues, adopting a proactive approach to improve cleanliness and sanitation. Additional features include GPS for locating dustbins, a camera for preventing the disposal of living beings (via image processing), and smoke sensors to detect fire incidents caused by electrical waste or chemical reactions. Powered by solar energy, the system operates sustainably, reducing carbon footprint and costs. IoT integration allows for remote monitoring across multiple locations, enabling municipal authorities to access real-time data, schedule garbage collection, and monitor system performance through a centralized dashboard. This improves operational efficiency, optimizes resource allocation, and supports proactive maintenance.
Keywords: *Ultrasonic sensor, Smoke sensor, Image Processing, GPS, IoT*

1. Introduction
In rapidly urbanizing world, the efficient management of waste has become a critical challenge. Traditional waste management systems often face issues such as overflowing bins, delayed collection, and unsanitary conditions. To address these problems, the advent of Internet of Things (IoT) and renewable energy technologies has paved the way for innovative solutions. This project introduces an "Automated Smart Dustbin with Solar Power and IoT Applications.", designed to revolutionize waste management practices. By integrating IoT sensors and solar power, this smart dustbin can monitor its fill level, send real-time alerts to authorities, and automatically compact waste to maximize capacity. Solar panels provide a sustainable and eco-friendly power source, reducing reliance on grid electricity. Additionally, the IoT connectivity enables remote monitoring and control, allowing for efficient waste collection and optimized routes. This project aims to contribute to a cleaner and more sustainable environment by promoting efficient waste management, reducing manual labor, and minimizing the environmental impact of waste disposal. Automations gained more importance in the modern era since it requires less cost to operate than a human labor to do the same task. Now a day's industry is turning towards computer- based monitoring of tasks mainly due to the need for the increased productivity and delivery of the final products with maximum quality. In the era of rapid technological advancements, the concept of smart cities is gaining significant traction. These cities aim to integrate technology into urban infrastructure to enhance efficiency, sustainability, and quality of life. One such innovative application is the Internet of Things (IoT)-based smart dustbin. This groundbreaking technology leverages the power of IoT to revolutionize waste management practices. Traditional waste management systems often face numerous challenges, including:

- Manual waste collection can be time-consuming and labor-intensive.

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 03 Issue: 04 April 2025
Page No: 1355-1360
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2025.0193

- Overfilled bins can lead to unsanitary conditions and attract pests.
- It's difficult to track waste levels and optimize collection routes. [1]
- Improper waste disposal can harm the environment and contribute to pollution.

IoT-Based Smart Dustbin: A Solution, to address these challenges, IoT-based smart dustbins offer a promising solution. These intelligent devices are equipped with sensors, microcontrollers, and wireless communication modules that enable them to.

- Real-time monitoring of waste levels helps optimize collection schedules.
- When bins reach capacity, alerts can be sent to waste management authorities. Also when living things dumped the alert is sent.
- Advanced sensors can differentiate between various waste types, facilitating efficient recycling.
- Data collected by the smart dustbins can be analyzed to identify trends and improve waste management strategies.
- Remote access to the system allows for efficient monitoring and control of the entire waste management process.

By leveraging the power of IoT, smart dustbins can significantly improve waste management practices, reduce environmental impact, and contribute to the creation of cleaner and more sustainable cities. [2]

2. Component

2.1. Ultrasonic Sensor

An ultrasonic sensor uses high-frequency sound waves to detect objects and measure distances. It has a transmitter that emits ultrasonic waves and a receiver that detects their reflection. When the waves hit an object, they bounce back, and the sensor calculates the distance using the formula (D = \frac{T \times C}{2}), where (D) is distance, (T) is time, and (C) is the speed of sound. (Figure 1) and quality of life. One such innovative application is the Internet of Things (IoT)-based smart dustbin. This groundbreaking technology leverages the power of IoT to revolutionize waste management

Figure 1 Ultrasonic Sensor

2.2. Smoke Sensor

A smoke sensor detects smoke particles in the air, often as an indicator of fire. It works by using either an ionization chamber or a photoelectric system. The sensor triggers an alarm when it identifies abnormal smoke levels, providing an early warning.

2.3. Raspberry Pi-Pico W

It is a microcontroller board with built-in Wi-Fi, enabling wireless connectivity for IoT applications. It uses the RP2040 chip and supports programming in Micro Python or C/C++. The Pico W can connect to networks, control devices, and gather sensor data. (Figure 2)

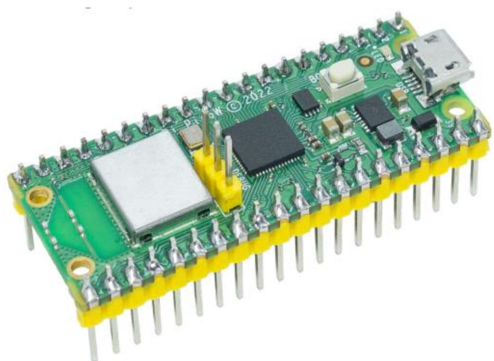

Figure 2 Raspberry Pi-Pico W

2.4. Servo Motor

It is a rotary or linear actuator that precisely controls position, speed, and acceleration. It operates using a feedback system, typically consisting of a motor, controller, and encoder. The controller sends signals to adjust the motor's position based on feedback. [3]

2.5. Accelerometer

It is used to measures acceleration forces, which may be static, like gravity, or dynamic, caused by movement. It works by detecting changes in velocity and converting them into electrical signals. (Figure 3)

Figure 3 **Accelerometer**

2.6.12 Volt Battery

It stores and supplies electrical energy using chemical reactions between its electrodes and electrolyte. It converts chemical energy into electricity. As it discharges, ions flow between the electrodes, generating voltage to run connected devices efficiently. [4]

2.7.Solar Panel

It converts sunlight into electricity using photovoltaic cells. These cells absorb sunlight, generating direct current (DC) electricity, which is then converted into alternating current (AC) by an inverter for practical use.

2.8.Buzzer

It works by converting electrical energy into sound through electromagnetic or piezoelectric principles. When voltage is applied, the internal diaphragm or coil vibrates rapidly, producing an audible tone.

2.9.Regulator Board

It stabilizes voltage and current in electronic circuits, ensuring consistent power supply. It uses components like voltage regulators, capacitors, and resistors to prevent fluctuations. [5]

2.10. Camera

It capture and digitize visual data. Light enters through the lens, focusing onto an image sensor, which converts it into electrical signals. The camera's settings optimize contrast, resolution, and clarity.

3. Working Process

3.1.Automatic Lid Open/Close

Ultrasonic sensor to detect nearby objects. When a person approaches within a set distance, the sensor sends a signal to a microcontroller, activating a servo motor to open the lid. After a short delay, the lid closes automatically.

3.2.Image Processing

Using image processing, camera capturing frames. A trained AI model detects children in real-time by analyzing visual features. If a child is detected inside the dustbin, the system triggers alerts and on buzzer in the dustbin.

Table 1 **Components Used**

Component	Quantity
Ultrasonic Sensor	2
Smoke Sensor	1
Raspberry pi-Pico W	1
Connecting wire	30
Servo Motor	1
Accelerometer	1
12 Volt Battery	1
Solar Panel	1
Buzzer	1
Dustbins	2
Regulator Board	1
Camera	1

3.3.Level Monitoring

An ultrasonic sensor monitors waste levels inside the dustbin by emitting ultrasonic waves and measuring the distance to the waste. When the waste reaches a preset threshold level, the sensor signals a microcontroller to trigger automated alerts, such as notifications.

3.4.Smoke Detection

A smoke sensor detects smoke in the dustbin by analyzing air quality and identifying hazardous particles. If smoke exceeds a preset threshold, the sensor signals a microcontroller to trigger automated alerts, such as alarms and notifications.

3.5.Finding Location & Position

GPS module tracks the dustbin's location, enabling precise monitoring and management. An accelerometer detects sudden movements or tilts, signaling a potential fall. When a fall occurs, the system triggers automated alerts, such as notifications and alarms. [6]

3.6.Charging Method

A solar panel mounted on the dustbin converts sunlight into electricity That energy is stored in a rechargeable battery for continuous usage.

4. Methodology

The dustbin structure is fabricated using durable materials like stainless steel or high-grade plastic to withstand environmental conditions and usage. Hinges are integrated for smooth lid operation. Two ultrasonic sensors are fixed strategically: one at the lid for automated opening/closing, and another inside the dustbin to monitor garbage levels continuously. The GPS module is securely mounted within the structure for location tracking, while the camera is installed externally to capture images for processing and safety monitoring. The smoke sensor is embedded within the dustbin interior to detect hazardous smoke levels, ensuring early fire incident warnings. [7] A solar panel is mounted on the dustbin's surface, connected to a rechargeable battery for efficient power supply to all electronic components. An Arduino or similar microcontroller is connected to the sensors, camera, GPS, and solar panel to manage data collection, processing, and communication IoT software is developed and integrated into the microcontroller to enable real-time data transmission to a centralized dashboard for monitoring and alerts. The entire system is tested and calibrated for accuracy, ensuring proper functionality of sensors, smooth lid operation, and reliable alert generation.

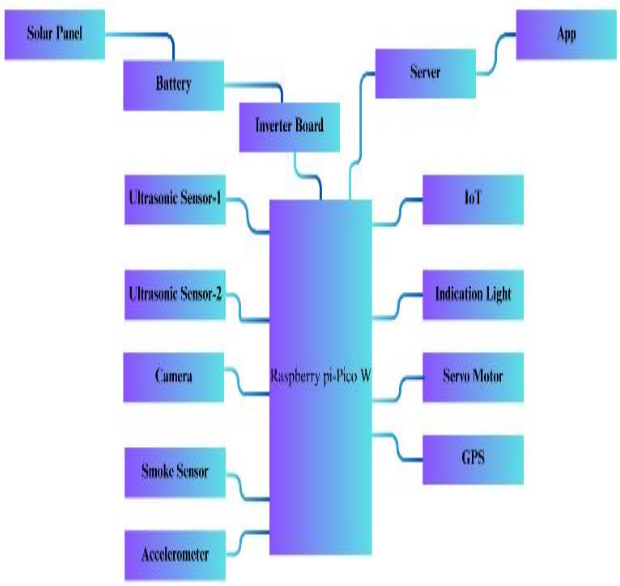

Figure 4 Methodology of Process

5. Results and Discussion

5.1. Results

The IoT-based solar-powered smart dustbin system addresses urban waste collection challenges by enhancing efficiency and sustainability. Equipped with ultrasonic sensors, it monitors garbage levels in real-time and alerts municipal authorities when waste exceeds thresholds, ensuring cleanliness and preventing overflow. GPS integration aids in locating bins, while cameras with image processing prevent the disposal of living beings. Smoke sensors detect fire incidents caused by electrical or chemical reactions, enhancing safety. Powered by renewable solar energy, the system minimizes carbon footprints and operational costs. Its IoT-enabled centralized dashboard facilitates real-time monitoring, resource allocation, optimized garbage collection schedules, and performance tracking. These features significantly improve sanitation and operational efficiency while promoting environmental sustainability. This innovative system offers a scalable, eco-friendly solution for modernizing waste management infrastructure in urban areas. By combining IoT and renewable energy, it supports the development of smarter and greener cities.

5.2. Discussion

Urban development has significantly increased waste generation, challenging traditional waste collection systems. This growing pressure highlights the need for smart, technology-driven solutions to ensure effective waste management in urban environments. [8] The proposed IoT-based smart dustbin demonstrates an innovative approach to addressing these challenges by leveraging automation and advanced sensors for enhanced functionality. Real-time monitoring of garbage levels through ultrasonic sensors ensures that waste collection schedules can be optimized, reducing over-dumping and overflow issues that harm public sanitation. The incorporation of GPS technology allows precise tracking of dustbin locations, facilitating better planning and resource allocation for municipal authorities. Image processing effectively prevents the unethical and unsafe disposal of living beings, reflecting the system's commitment to ethical waste management practices. Smoke detection through integrated sensors offers proactive fire prevention measures, tackling safety concerns related to hazardous waste materials and chemical reactions. The utilization of solar energy for power supply aligns with sustainable development goals, reducing reliance on traditional energy sources while minimizing operational costs and environmental impact. The centralized dashboard enhances decision-making by streamlining data analysis, scheduling, and maintenance, ensuring operational efficiency and long-term reliability. The proactive approach of the system fosters improved sanitation standards, contributing to healthier urban environments while addressing hygiene challenges. [9] The research highlights the scalability of this smart dustbin solution, suggesting that it can adapt to diverse urban settings for widespread implementation. Overall, the interpretation of findings confirms that the proposed IoT-based solar-powered smart dustbin successfully addresses key waste management challenges, offering a sustainable and technologically advanced solution for urban infrastructure.

Conclusion

The study has confirmed that urban development has led to a significant increase in waste generation, pressuring traditional waste collection systems. Analysis highlights that existing infrastructures are inadequate to manage the growing urban waste effectively. The IoT-based solar-powered smart dustbin addresses these challenges by ensuring efficient monitoring and disposal of waste. Results confirm that the use of ultrasonic sensors effectively manages lid movement and garbage level monitoring, preventing over-dumping and overflow. GPS functionality has been validated for precise tracking of dustbin locations, aiding efficient waste collection. Image processing proves to be a reliable method for detecting and preventing dumping of living beings, promoting ethical disposal practices. Smoke detection capability addresses safety concerns by enabling early warning systems for fire hazards. Solar power utilization ensures uninterrupted operation while reducing carbon footprints, confirming its sustainable design. IoT integration successfully enables real-time monitoring, allowing for proactive waste collection and maintenance. Centralized dashboards provide municipal authorities with actionable insights, enhancing resource allocation and scheduling. The combined functionality of all components confirms the system's ability to improve urban sanitation and cleanliness. In conclusion, the smart dustbin system effectively overcomes the analyzed challenges, providing a scalable and sustainable solution for modern waste management needs. [10]

Acknowledgement

The research work was supported by my guide Mr. C. Vibin Stalin, Assistant Professor. Special thanks to Dr .D.R.P. Rajarathnam, Professor and Head from Paavai Engineering College, Namakkal, India, for their valuable help.

Reference

[1]. Ashutosh Goel, MeenaKumari, Ayus Khaiwal, 2456-4184, "Smart Dustbin Management System Using IoT and Blynk App", International Journal of Novel Research and Development (IJNRD), Vol.9, pp-438-441, 2024.

[2]. Jaya Priya. P, Dharani. B, Kiruthigaa.V,1583-6258, "IoT Based Smart Dustbin", Annals of the Romanian Society for Cell Biology (ARSCB), Vol.25, pp-7834-7840, 2021.

[3]. Mamta Pandey, Anamika Gowala, Mrinal Goswami, Chinmoy Saika,2582-3930, "Smart Dustbin Using Arduino", International Journal of Scientific Research in Engineering and Management (IJSREM), Vol.04, pp-1-5, 2020.

[4]. Neha Shinde, Pratiksha Gaikwad, Akshata Ochal, Sanjeevani Singate,2582-7421, "IoT Based Smart Garbage Management System (Swachh Bharat Initiative), International Journal of Research Publication and Reviews (IJRPR), Vol.4, pp-5392-5398, 2023.

[5]. Poonguzhali. A, Soundarya. R, Priyanka. N, Pavithra.M,2394-6849, "Smart Garbage Detection System Using IoT Through Mobile App", International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE), Vol.5, pp-29-34, 2018.

[6]. Ruchitha, E. Varshini, R. Syed Saif Ali,2278-

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 03 Issue: 04 April 2025
Page No: 1355-1360
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2025.0193

0181, “Smart Dustbin Monitoring System Using Arduino UNO”, International Journal of Engineering Research and Technology (IJERT)Vol.12, pp-76-80, 2023.

[7]. Sayali Sonde, Rupesh More, Dipesh Bopche,2456-8880, “Smart Dustbin Using Arduino”, Iconic Research and Engineering Journals (IREJ), Vol.5, pp-243-248, 2022.

[8]. Telugu Maddileti, Harish Kurakula,227-8616, “IoT Based Smart Dustbin”, International Journal of Scientific & Technology Research (IJSTR), Vol.9, pp-1297-1302, 2020.

[9]. Varun Chaudhary, Rohit Kumar, Anil Rajput, Manvendra Singh,2395-0072, “Smart Dustbin”, International Research Journal of Engineering and Technology (IRJET), Vol.06, pp-7647-7651, 2019.

[10]. Varsha. S. Rajana, P. Sherin Eliyas,1742-6596, “IoT Based Smart Garbage Collection Using RFID and Sensors”, Iraqi Academy Syndicate International Conference for Pure and Applied Sciences (IASICPA), Vol.10, pp-1-6, 2021.