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2ND INTERNATIONAL SCIENCE,
ENGINEERING AND TECHNOLOGY
COLLOQUIUM



THE POWER OF SCIENTIFIC INNOVATION

INTELLIGENT SOLUTIONS FOR A
SUSTAINABLE WORLD

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PREFACE

Welcome to the 2nd International Science, Engineering and Technology Colloquium 2025 (ISETC 2025)!

It is with great pleasure that we present this year's colloquium, a distinguished gathering of scholars, researchers, and professionals dedicated to the advancement of applied sciences. Held virtually on 9th July 2025, ISETC 2025 serves as a platform to highlight cutting-edge research, foster meaningful networking, encourage collaborations, and explore innovative solutions to global challenges.

This year's theme, "The Power of Scientific Innovation: Intelligent Solutions for a Sustainable World" highlights our shared goal to solve global challenges through applied science. It celebrates innovation as a key to building a more sustainable and resilient future. We're proud to feature keynote speakers and presenters who bring fresh insights, bold ideas, and breakthroughs shaping tomorrow's world.

We would like to extend our heartfelt appreciation to the Faculty of Applied Sciences, Universiti Teknologi MARA, Perak Branch, Tapah Campus, for their outstanding support and assistance throughout the planning and execution of the event. Their dedication has been instrumental to the success of this colloquium. We would like to sincerely thank all participants and researchers for their valuable contributions. We also appreciate the reviewers for their careful evaluations and helpful feedback. Your hard work and support mean a lot to us.

As editors, we are proud to present this collection of proceedings. It is an honour to bring together the interesting and meaningful work of our speakers and authors. We hope the ideas shared will lead to new discoveries, encourage more research, and help solve global challenges through science and innovation.

Warm regards,

Dr. Emi Norzehan Mohamad Mahbob

Dr. Saiyidah Nafisah Hashim

Ms. Lili Widarti Zainuddin

Ms. Nurul Nazwa Mohammad

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ISETC 2025 Proceedings Editors

IOT-ENABLED SMART DUSTBIN FOR REAL-TIME WASTE MONITORING AND SCALABLE HYGIENE MANAGEMENT IN FACILITIES

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Abstract: This study presents the design and implementation of an IoT-enabled smart dustbin system to improve waste monitoring and hygiene in large facilities. The system uses an ESP32 microcontroller, ultrasonic sensors to detect bin fill levels and user presence, a servomotor for automatic lid control, and tri-color LEDs to display the current bin status. Real-time data is sent to the Blynk mobile app, allowing maintenance teams to receive immediate alerts when the bin is nearly full or full. The system was tested through both simulation and physical hardware implementation, showing reliable sensor readings, accurate response to motion and fill levels, and effective mobile integration. The results confirm the system's potential to reduce manual bin checks, support timely waste collection, and promote cleaner environments. For future improvement, features such as solar power integration, centralized monitoring for multiple bins, and automated waste locking when full are recommended to enhance energy efficiency and scalability in smart infrastructure applications.

Keywords: *Automated, IoT, real-time, ESP32*

INTRODUCTION

Efficient waste management is a major challenge in indoor and outdoor environments, particularly in high-traffic areas such as offices, hospitals, schools, and public spaces. Traditional collection methods, which rely on manual checks and fixed schedules, are often inefficient and lead to issues like overflowing bins, delayed response, and higher operational costs. To address these challenges, smarter, automated solutions are needed.

Recent studies have explored the use of Internet of Things (IoT) technology to improve waste collection through real-time monitoring and remote alerts. Systems using ultrasonic sensors and microcontrollers have shown promise in detecting fill levels and notifying maintenance teams via platforms like Blynk (Acharya et al., 2022; Lincy & Sasikala, 2021; Muley, 2018). Some designs have also added features like lid automation and waste segregation (Nevon Projects, 2024; Rupesh et al., 2022). However, many are limited to specific environments and lack flexibility for broader use.

This paper presents an IoT-based smart dustbin system designed for both indoor and outdoor applications. It uses an ESP32 microcontroller, ultrasonic sensors for motion and fill-level detection, a servo motor for lid control, and LED indicators for status display. Real-time data is sent to the Blynk app to notify users when the bin is nearly or full.

The system was developed using Wokwi simulation and later tested through a working hardware prototype. Results showed accurate sensor performance, smooth operation, and reliable alert delivery, making the system a practical and scalable solution for modern waste management.

MATERIALS AND METHODS

Figure 1 shows the block diagram of the smart dustbin system, illustrating how each component interacts. The system uses two ultrasonic sensors—one to detect motion near the bin and the other to measure the trash level inside. When motion is detected within a certain range, the ESP32 microcontroller activates a servo motor to automatically open the lid.

The ESP32 functions as the main control unit. It reads data from the sensors to determine whether the bin is empty, almost full, or full. Based on this data, it controls three LED indicators: green for low fill level, yellow for almost full, and red for full. The ESP32 is also connected to the Blynk platform via Wi-Fi, allowing real-time monitoring through a mobile app. The app displays the current fill level and sends alerts when the bin needs to be emptied. After assembling all components—ESP32, sensors, servo motor, and LEDs—into the dustbin, the system is tested to ensure smooth integration and proper communication between the hardware and mobile interface.

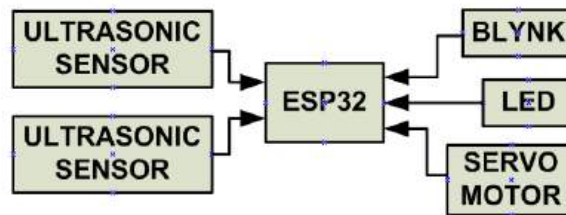


Figure 1. A block diagram represents the functional components of the smart dustbin system

Figure 2 illustrates the operational flow of the smart dustbin system, which functions through a sequential process involving motion detection, fill-level monitoring, and automated alert generation. The system begins by continuously scanning for user presence using an ultrasonic proximity sensor. When motion is detected within 20 cm, the system interprets it as user intent and responds by activating a servo motor to automatically open the lid.

Once the lid is opened, the second ultrasonic sensor measures the distance to the top of the trash inside the bin to determine its current fill level. Based on this measurement, the system classifies the bin into one of three states. If the fill level is 23 cm or more, the bin is considered full. In this case, the red LED turns on, the green and yellow LEDs remain off, and a "DUSTBIN FULL" notification is sent to the Blynk mobile application. If the fill level is between 19 cm and 23 cm, the system recognizes that the bin is almost full. The yellow LED is activated, while the red and green LEDs remain off, and a "DUSTBIN ALMOST FULL" alert is sent to the app. If the fill level is below 19 cm, the bin is regarded as having a low volume of waste. The green LED is turned on, and no alerts are generated, as no immediate action is required.

This automated decision-making process ensures that the system operates efficiently by accurately identifying the bin's status, reducing the need for manual inspections, and supporting timely waste collection. It contributes to maintaining hygiene and optimizing waste management in both indoor and outdoor environments.

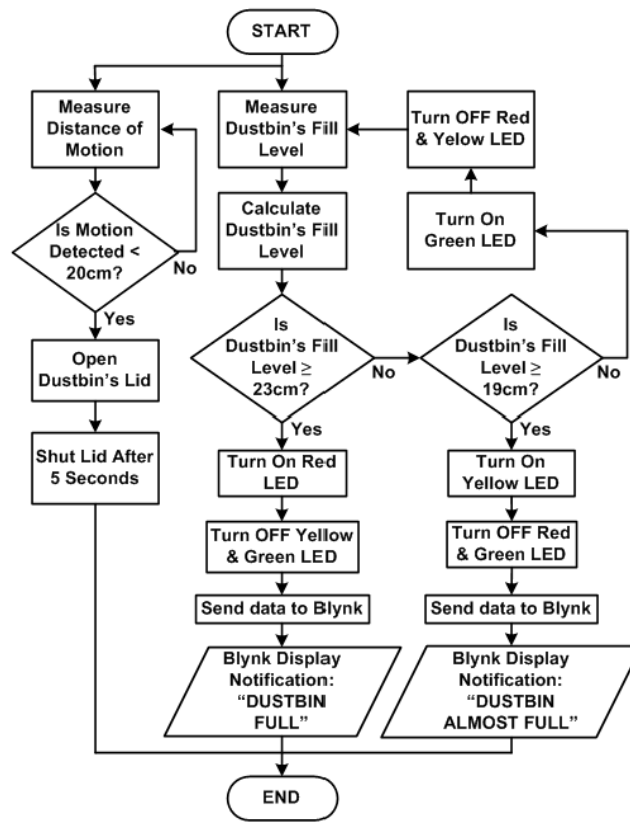


Figure 2. Flowchart illustrates the operational logic of the smart dustbin system

RESULTS AND DISCUSSION

After the software was validated, the system was assembled as a working prototype using a custom-designed PCB. Hardware testing was carried out to check the real-time performance of the sensors, servo motor, LED indicators, and their communication with the Blynk mobile app.

During the tests, the ultrasonic motion sensor consistently detected human presence within a 20 cm range, triggering the servo motor to open the lid automatically. This touchless feature supports better hygiene. The lid then closed on its own after a 5-second delay or when no motion was detected, confirming the servo responded correctly and at the intended timing.

The fill-level ultrasonic sensor performed well, accurately distinguishing between low, almost full, and full bin levels. When the trash level exceeded 23 cm, the red LED turned on, and a "Dustbin Full" alert was sent to the Blynk app, as shown in Figures 3 and 4. For levels between 19 and 23 cm, the yellow LED was activated, and an "Almost Full" notification was triggered. If the level was below 19 cm, only the green LED lit up, and no alerts were issued, as expected. The LED indicators were bright, responsive, and easy to read. The system smoothly transitioned between bin statuses with no noticeable delay, and all actions—sensor readings, LED changes, and mobile alerts—were well synchronized. The ESP32 microcontroller maintained stable Wi-Fi connectivity throughout testing, ensuring reliable data updates to the Blynk platform.

These results confirm the system's strong performance in real-world conditions, with accurate sensing, reliable communication, and consistent functionality. The prototype is well-suited for use in various environments, including offices, schools, shopping centers, and healthcare facilities.



Figure 3. Hardware prototype in operation showing red LED activation on the smart dustbin, triggered by full bin detection



Figure 4. The Blynk app alert via the smartphone, triggered by full bin detection

CONCLUSIONS

This study demonstrated that an IoT-enabled smart dustbin system can effectively automate waste monitoring and improve hygiene in both indoor and outdoor settings. The system's accurate motion and fill-level detection, reliable wireless alerts via the Blynk platform, and responsive LED indicators confirmed its ability to reduce manual checks and support timely waste collection. These results suggest that low-cost components, when integrated with real-time monitoring and automation, can deliver scalable and efficient solutions for smart waste management.

However, the system's performance may vary in outdoor conditions due to environmental factors such as rain or inconsistent Wi-Fi signals, which can affect sensor accuracy and data transmission. Despite these limitations, the project has practical value for facilities like offices, hospitals, and public spaces, and supports broader goals in smart infrastructure. Future improvements could include solar power integration, lid-locking for full bins, and centralized dashboards for managing multiple units. Adding waste-type detection may further align the system with sustainability and recycling initiatives.

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Kelulusan daripada pihak tuan dalam perkara ini amat dihargai.

Sekian, terima kasih.

"BERKHIDMAT UNTUK NEGARA"

Saya yang menjalankan amanah,

Setuju.

27.1.2023

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