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Arduino-Based Smart Dustbin with Ultrasonic Sensor for Efficient Waste Management

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Abstract

The invention of the Arduino-based smart dustbin equipped with several sensors aims to improve waste management system efficiency by automating and user-friendly processes. The goal of this project is to create a smart dustbin that can automatically open its lid when someone approaches, monitor and tell the user about the trash level, weigh the waste, and detect dangerous gases to maintain a safe atmosphere. The integration of these functionalities is intended to promote hygiene, increase trash collection efficiency, and improve safety. The scope of this project encompasses the design, development, and testing of a smart dustbin using various sensors including an ultrasonic sensor, IR sensor, load cell sensor, and MQ-2 air quality sensor. The system is also integrated with the Blynk app, allowing users to receive real-time notifications. The project is intended for usage in both household and small commercial settings. The experimental findings showed that the ultrasonic sensor reliably recognized the presence of people within a 30 cm range, effectively actuating the lid. The IR sensor accurately monitored trash levels and successfully provided notifications. The load cell sensor gave accurate weight measurements with minimum error, while the MQ-2 air quality sensor detected dangerous chemicals and activated the alert as planned. The Arduino-based smart dustbin successfully integrates several sensors, resulting in an automated and intelligent trash management solution.

1. Introduction

Trash disposal has become a major concern and a focal point for public attention, with effective waste management being crucial for environmental sustainability. Early waste sorting can enhance production and improve waste management efficiency. According to estimates (Maalouf et al.,2022), municipal solid waste is expected to increase to 2.89–4.54 billion tones by 2050, a 26%–45% increase compared to 2019. Researchers such as (Kasat et al.,2023, Mahmood et al., 2019) have focused on the challenges of mobility and transportation in solid waste management, highlighting the burden on municipal laborers who must frequently check if dustbins are full. This labor-intensive process necessitates an innovative approach, and the use of Arduino technology offers a promising solution. Arduino is an open-source electronics platform that simplifies the creation of interactive projects by integrating sensors, actuators, and other components, making it an ideal tool for developing an advanced waste management system.

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Improper monitoring of waste in dustbins can lead to the proliferation of bacteria, viruses, and other harmful pathogens, spread by insects such as flies, mosquitoes, and ants. Overloaded dustbins contribute to unsanitary conditions, impacting public health in cities, communities, homes, colleges, and public spaces (Keramitsoglou et al., 2018). Users typically have to manually open the lids of trash bins, exposing themselves to germs and dirt. Additionally, waste materials like plastic bottles, glass bottles, and empty cans can emit unpleasant odors or harmful gases if left unattended for too long. This underscores the need for an automated waste management system that can mitigate these health risks and improve hygiene standards (Saha et al., 2017).

Furthermore, the hospitality business, which includes hotels and restaurants, faces considerable issues in maintaining cleanliness and hygiene due to the large amounts of trash generated on a daily basis. Traditional waste management procedures are frequently ineffective in such environments, resulting in overflowing bins, unpleasant aromas, and increased health hazards for both workers and guests. A smart dustbin can help with these difficulties by offering real-time monitoring and automatic waste handling, ensuring that dumpsters are emptied quickly and hygienically (Geethamani et al., 2021). This solution can enhance the overall guest experience, protect the establishment's reputation, and ensure compliance with strict health and safety laws. Integrating smart dustbins into hotel spaces can improve operational efficiency and create a healthier, more pleasant environment for all.

This research project seeks to achieve the following objectives. Firstly, the objective to develop a smart dustbin with ultrasonic sensor for efficient waste management. The next step involves implement the proposed systems in actual that can measure weight of waste and air quality in the vicinity. Finally, the aim is to evaluate the performance of the developed system.

2. System Development

Fig. 1 shows the block diagram of the Arduino based smart dustbin with ultrasonic sensor. The system is divided into two parts, first phase of the system concentrates on sensor functioning, with the goal of creating a safe environment for humans. This part is like an observant monitor, keeping the environment clean and healthy for the owner by monitoring air quality, weight of trash and level of trash. The second part of the system coordinates data transfer, acting as a conduit between the environment and the owner. As the recipient of this data transmission, the Blynk application is essential to providing the owner with up-to-date information about the level trash inside the smart dustbin. The Blynk app gives the owner more control over the present conditions by providing a thorough overview through the alert displayed in the Blynk application in specific conditions.

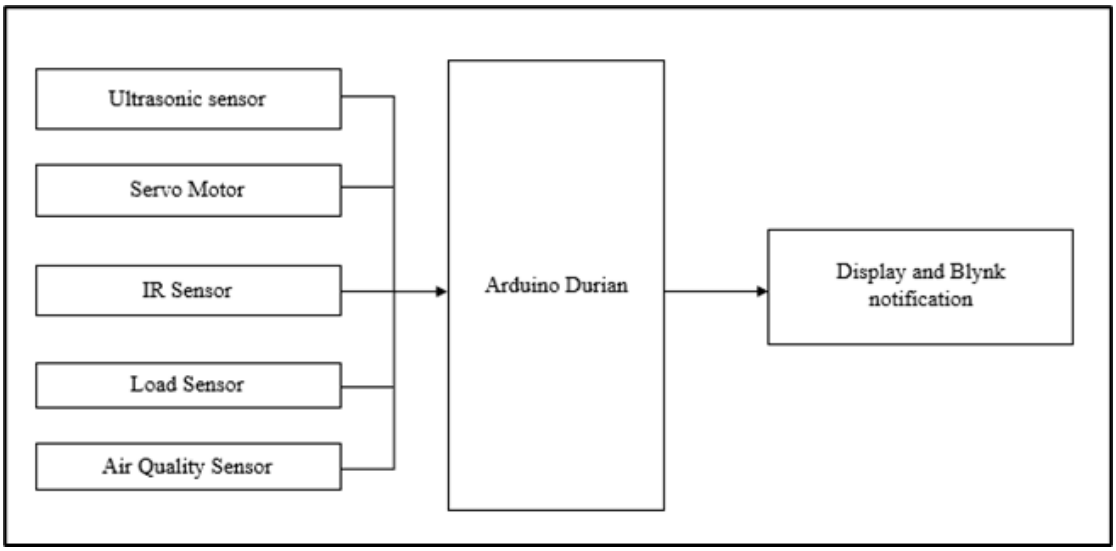

Fig. 1 *Block Diagram of system*

Fig. 2 shows the flowchart of the system. It starts when the ultrasonic detects a person, the motor is turned on, and the dustbin lid opens automatically. Data on the trash level can be read using the IR sensor to check the trash level. When the trash level reaches full, the owner gets a notification via mobile phone. At the same time, the value of trash weight will be displayed on the LCD. Meanwhile, the gas detector system will keep monitoring the air quality, but when the air quality is high, a buzzer is turned on to alert users. Lastly, the sensor will check the quality of the air again to confirm the air is in good condition.

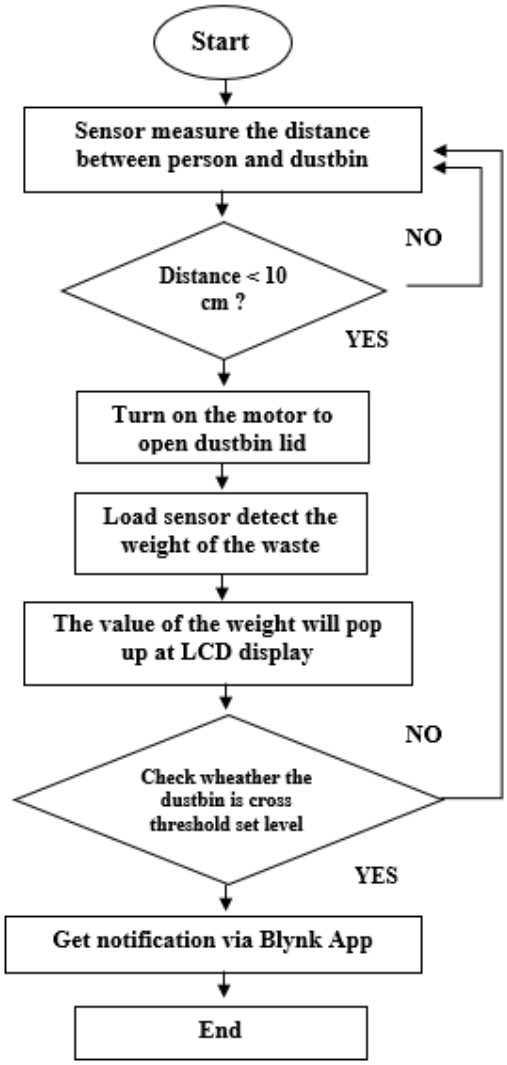

Fig. 2 Flowchart of system

3. Results and Discussion

The hardware for Arduino-based smart dustbin with ultrasonic sensor for efficient waste management as shown in Fig. 3(a) and Fig. 3(b) was developed according to the illustrated block diagram in Fig. 1 where all the electronic components are interconnected with each other. The activation which includes the device initialization and the Wi-Fi connection will be done before it enters the functionality of the smart dustbin system as shown in Fig. 4(a).

(a) **(b)**

Fig. 3 *(a) Outer view of the hardware; (b) Side view of the hardware*

The ultrasonic was placed in the initial position, as depicted in Fig. 4(b). After that, the ultrasonic system can be used to detect the distance between humans and the smart dustbin. The servo motor turned on when the ultrasonic sensor detected an obstacle. As shown in Fig. 5(a), the lid automatically lifted up.

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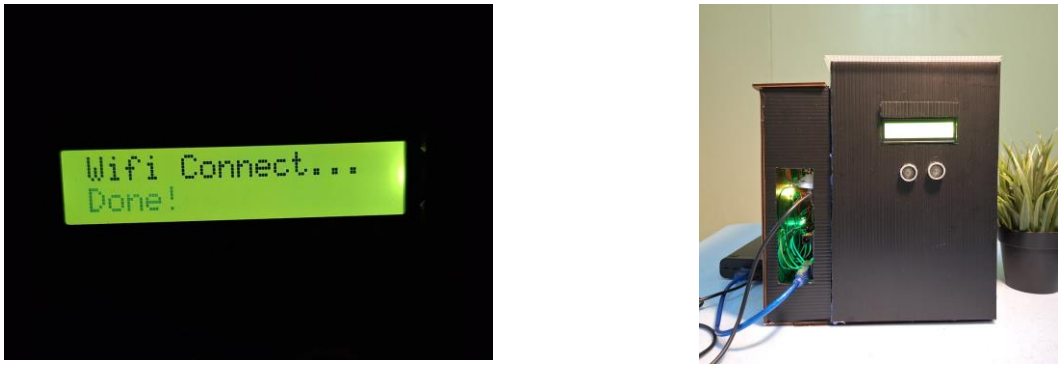

(a) **(b)**

Fig 4 *(a) Smart dustbin activated; (b) Ultrasonic sensor*

Besides, the value of trash weight was displayed on the LCD, as shown in Fig. 5(b). In addition, the air quality sensors placed on smart dustbins can detect and measure the concentration of various pollutants in the air, such as carbon monoxide (CO), nitrogen dioxide (NO2), ammonia (NH3), and sulfur dioxide (SO2). These sensors can provide real-time data on air quality, which can be used to monitor and improve the overall air quality in a given area. To keep the user well informed, all the controls in the smart dustbin will be able to send updated notifications through the Blynk platform (refer to Fig. 6). The user will be able to receive a notification regarding the status of the trash level to ensure they have the information wherever and whenever they want.

(a) **(b)**

Fig 5 *(a) Lid open; (b)Value of trash weight and air quality*

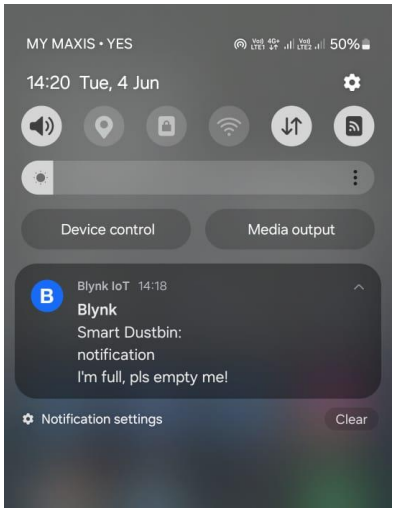

Fig 6 *Notification for trash level*

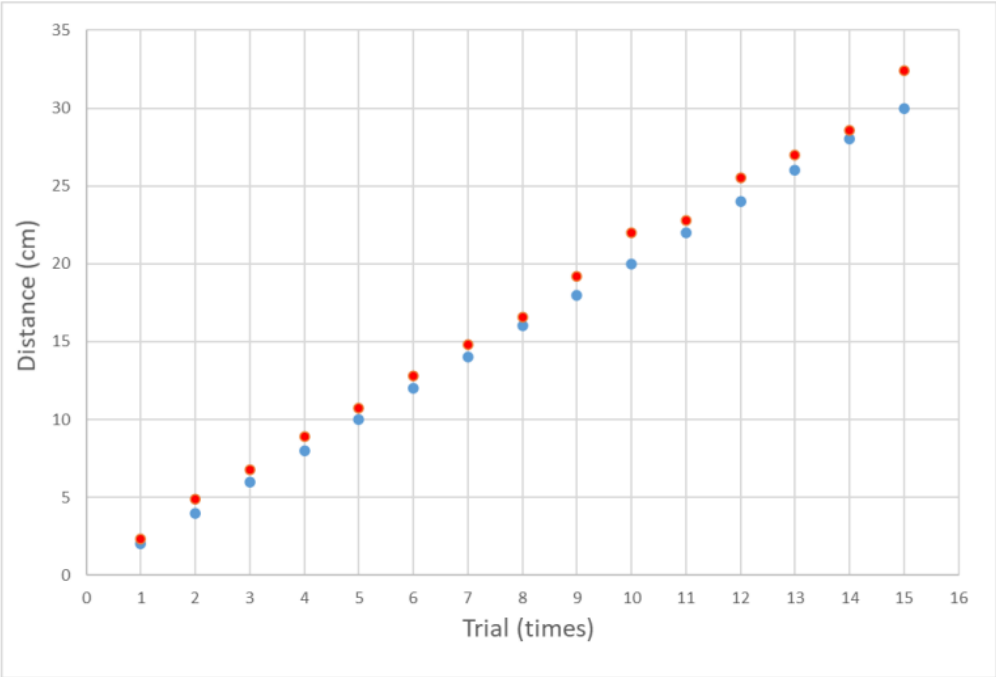

Fig. 7 *Recorded data of measured and actual distance*

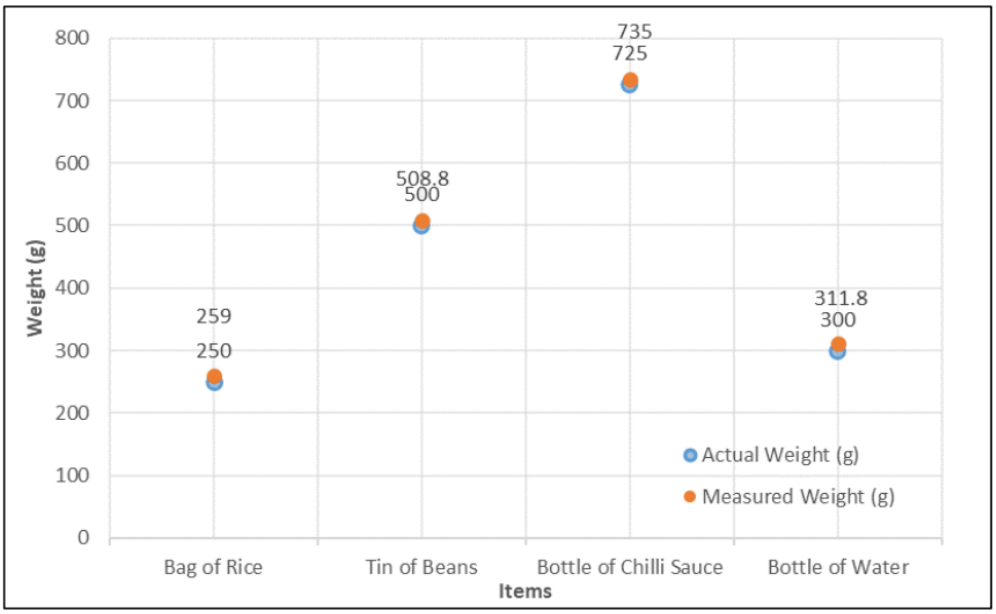

Fig. 8 *Recorded data of measured and actual weight*

Data collection and system performance via obtaining information from ultrasonic. The main objective of the experiment is to prove that the ultrasonic sensor can trigger the lid to open when someone is near. The materials selected for the analysis were cardboard as a obstacle. The values "Measured Distance" and "Actual Distance" on a centimeter scale supplied information on the sensor's performance across the chosen materials. The experiment takes 15 times with an interval of 2 cm and is measured up to a distance of 30 cm. Fig. 7 display a plot graph recorded value of actual distance, with x-axis are labeled as trial (times) and y-axis are labeled as distance (cm). The ultrasonic sensor gives consistent and linear readings from 2 cm to 22 cm. However, when the experiment reaches Trial 10, the ultrasonic measurement is somewhat higher than the real distance. Environmental factors, such ambient light and impediments in the sensor's path, can sometimes alter results. To mitigate this, place the sensor in an area with minimal interference and consider adding a protective casing to shield it from direct light.

Other experiments were performed on this project utilizing a load cell sensor. In this experiment, the load cell sensor is used to determine the weight of several items, including a bottle of chili sauce, a can of beans, a

bottle of water, and a rice bag. The purpose is to evaluate the load cell sensor's accuracy and reliability in detecting net weight of various materials and accurately displaying weight data on the LCD. The weights of these goods are initially determined using a regular kitchen scale for comparative purposes. Fig. 8 shows a plot graph above compares the real weights of several things (measured using a regular kitchen scale) to the weights measured by the load cell sensor. The blue plot with circle markers illustrates the actual weights, whereas the red plot with cross markers represents the measured weights. The proximity of the two lines indicates the accuracy of the load cell sensor. Minor discrepancies between the actual and measured weights demonstrate the sensor's performance, with errors ranging from -5g to +10g, which falls within an acceptable accuracy range for this application. The experiment shows that the load cell sensor is dependable, producing precise weight measurements with a tiny error margin, verifying the smart dustbin system's capacity to effectively monitor trash weight.

4. Conclusion

In conclusion, the Arduino-based smart dustbin is equipped with various sensors such as an ultrasonic sensor, a TCRT5000 IR sensor, a load cell sensor and an MQ-2 air quality sensor, successfully demonstrating the integration of current technologies to improve the efficiency of waste management. Ultrasonic sensors successfully identify the user's presence causing the bin lid to open automatically and support a contactless and clean disposal approach. The performance of the IR sensor in detecting the level of trash is consistent, this can be proven by the user receiving a notification through the Blynk application when the trash can is full and ensuring prompt trash collection and preventing overflow. The load cell sensor correctly detects the weight of the waste, and the value is shown on the LCD, helping to monitor the amount of waste generated and facilitating effective waste management.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follow: ***study conception and design****: Muhamad Haikal Faisal Shaharil, Farhana Ahmad Po'ad;* ***data collection, analysis and interpretation of result:*** *Muhamad Haikal Faisal Shaharil;* ***draft manuscript preparation:*** *Muhamad Haikal Faisal Shaharil, Farhana Ahmad Po'ad. All authors reviewed the result and approved the final version of the manuscript.*

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