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Smart Automated Dustbin using Bin-Level and Distance Monitoring

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Abstract*:* In this project, smart technologies are demonstrated as an effective way to tackle real-world problems and promote sustainable development. It is designed to provide a convenient and hygienic solution for waste disposal using Arduino Uno, servo motor, and ultrasonic sensor. With its automatic operation and the ability to be activated through hand gestures, the system is user-friendly and efficient. Detecting a user's presence, the ultrasonic sensor sends a signal to the Arduino Uno board, which activates the servo motor to open the dustbin lid. As a result, the risk of contamination is reduced, because the waste can be disposed of without being touched by the dustbin. Cleanliness and hygiene are improved in household and public areas with the use of the system, since it is cost-effective and easily implemented.

Keywords: *Automated Dustbin, Ultrasonic waves, Arduino, Gesture, Wifi Module, Waste management*

1. Introduction

The smart dustbin system viewpoints as a testament to innovation and progress [1]. It represents a revolutionary departure from conventional waste disposal practices and hinges on the amalgamation of various hardware components [2]. At its heart lies the ultrasonic sensor, a technological marvel that serves as the dustbin's discerning eye, meticulously quantifying the garbage within [3]. This sensor operates in harmony with a gesture sensor, an equally impressive piece of technology, which detects hand movements to facilitate the graceful opening of the dustbin's lid [3].

Facilitating this seamless dance of technology is the servo motor, intricately attached to the lid. It acts as the animated arm of the dustbin, orchestrated by the sensor's cues, gracefully opening and closing in perfect harmony [4]. Yet, the symphony of this system does not merely rely on mechanical prowess. It necessitates the integration of a power supply, a Wi-Fi module, and a microcontroller, forming the system's central nervous system. This triumvirate of components functions as the brain, ensuring that every operation is executed with precision [5].

Once the physical components are seamlessly assembled, the critical next step involves crafting the microcontroller's code. This code is the system's soul, its guiding force, dictating how sensors interact, how the servo motor executes lid movements, and when to raise an alert if the bin nears fullness [6]. It is the algorithmic brilliance that breathes life into the hardware.

Testing the system is a pivotal phase, vital to validate its accuracy and effectiveness [7]. The ultrasonic sensor undergoes rigorous examination to ensure its ability to accurately measure the garbage level within the dustbin [8][9]. Additionally, the sensor's proficiency in gauging distances and its ability to command the servo motor to perform lid actions are tested extensively [10].

The smart dustbin system represents an ingenious and pragmatic solution to the challenges of waste disposal. When meticulously implemented and rigorously tested, it offers a multitude of advantages for households and public areas alike. These benefits encompass elevated hygiene standards, reduced contamination risks, and a notable contribution to environmental sustainability. The smart dustbin system, with its fusion of hardware and software, signifies a promising stride towards a more efficient and responsible future in waste management.

2. Literature Review

The proposed device [11] utilizes an ultrasonic sensor to monitor waste levels and an IR sensor to detect individuals, opening the bin's door via a DC motor. It includes an Arduino UNO microcontroller, GPS module, and Wi-Fi module to transmit data to a server for tracking and analysis. The LED lights indicate the bin's status, and the data is stored in an archive accessible on the web server. This IoT-integrated gadget has the potential to effectively manage waste, with the microcontroller processing volume and location data to inform waste management decisions. The proposed IoT-based smart waste management system [12] uses sensors to monitor the waste level in urban area dustbins and an android app to provide location-based

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information to drivers for garbage collection. The system notifies higher officials to track the employees and is powered by solar panels. The solution uses ZigBee with sensors and modules to collect and transmit data over an ad-hoc network. The collected data is stored in the cloud and used for dynamic supervision of the garbage collection mechanism.

The growing urbanization and population underline the necessity for an effective waste management system. The authors examine several strategies and tools for putting into practise smart rubbish systems, including infrared sensors, ultrasonic sensors, and machine learning algorithms [13]. The report also looks at numerous case studies of smart waste systems that have been implemented in other nations, highlighting their characteristics, benefits, and drawbacks. The writers also go through problems and difficulties with implementing smart rubbish systems, such as cost, power usage, and data security. The discussion of potential future research areas for IoT-based smart waste systems closes the study. For academics and practitioners interested in creating effective and sustainable waste management systems utilizing IoT-based technology, this review offers useful insights.

In order to solve the rising waste management issue in metropolitan areas, the [14] article presents the design and execution of a smart dustbin system utilizing an Arduino Uno board and several sensors. The study emphasizes the difficulties caused by rising waste output and population, which results in clogged trash cans and unclean environments. The suggested smart trashcan system has sensors to keep track of the rubbish level and notify the appropriate authorities through GSM and GPRS when the threshold level is reached. The usage of externally fixed LEDs to display the state of the trash can is also covered in the article. In order to create communication between the dustbins and offer a smart system, elements like mapping and connection are also employed. The study underlines how the application of this system might foster a healthy society and lessen public and official irresponsibility. Overall, this study shows the potential of IoT technology in addressing environmental issues and offers a workable answer for waste management issues in metropolitan settings. This research paper (Kalyan et al., 2021) [15] presents a smart dustbin system that uses ultrasonic sensors to detect the level of waste in the dustbin. The system comprises a microcontroller that controls the sensors and notifies the authorities when the dustbin is full. The authors have also proposed a mobile application that can be used to monitor the status of the dustbin in real-time. The system has shown promising results in terms of accuracy and cost-effectiveness. This research paper (Purohit et al., 2020) [16] proposes a smart dustbin system that uses image processing to detect the level of waste in the dustbin. The system comprises a camera that captures images of the dustbin and a microcontroller that processes the images to determine the level of waste. The authors have also used machine learning algorithms to predict the level of waste based on the historical data. The proposed system has shown promising results in terms of accuracy and efficiency.

This paper [17] presents a smart dustbin monitoring system using IoT that utilizes Arduino and a LAN server to monitor and manage waste bins. The system provides real-time monitoring of waste level and notifies the garbage collector when it reaches a certain threshold. The paper mentions ethernet shield technology by which the dustbin is connected to computers/laptops using IOT technology. The proposed system also uses ultrasonic sensors to monitor the level of dust in the dustbin and denote whether it is empty/full or partially full. This approach differs from other approaches as it uses an ethernet shield and can be monitored by any device with an IP. The paper proposes [18] a Smart Dual Dustbin Model for waste management in smart cities. The model consists of two dustbins, one for wet waste and one for dry waste, equipped with sensors that monitor the level of waste in each bin. The data from the sensors is transmitted to a central monitoring system, which uses machine learning algorithms to predict the amount of waste generated and to optimize waste collection routes. The proposed model has been evaluated through experiments and simulations, which demonstrate its effectiveness in reducing the cost and time required for waste collection, while also improving the overall efficiency of waste management in smart cities. The authors suggest that the proposed model can be further enhanced through the integration of additional sensors and the use of more advanced machine learning algorithms.

The framework developed by Prof R.M. Sahu et. al. [19] involves placing a camera and load cell sensor at each garbage collection point. The camera continuously captures snapshots of the trash can, while the load cell sensor measures the weight of the garbage. By comparing the outputs of the camera and the load cell sensor using a microcontroller, the level of garbage in the can and its weight can be determined. The system then processes this information and checks whether the threshold level has been exceeded or not. While this method is easy to use, it may not be economically reliable. Meghana and her team proposed a system [20] that utilizes an infrared (IR) sensor to detect the level of garbage in a bin. The IR sensor emits light that is invisible to the naked eye, but can be detected by electronic components. The sensor is composed of an IR transmitter and an IR receiver, and is capable of determining the level of garbage in the bin and providing an output accordingly. Once the garbage level reaches a pre-set threshold, an LED located at the bin starts blinking. Clicking on the blinking LED opens a display that shows the location of the bin, its status, data and time of filling, mobile number, and the text to be sent to the concerned person. However,

this system does not ensure that the garbage is collected and transported, which may incur additional costs.

3. Methodology

Create the smart dustbin by putting the hardware pieces together. To gauge the amount of garbage inside, put the ultrasonic sensor at the top of the trash can. In order to detect hand motions that can be used to open the dustbin lid, place the gesture sensor close to the lid. To enable the trash can lid to open and close in response to input from the gesture sensor, attach the servo motor to the lid. Next, attach the power supply and microcontroller to the sensors and motor. The microcontroller's code must then be written after the hardware has been put together. The code should contain instructions for reading data from the gesture and ultrasonic sensors, operating the servo motor to open and close the lid [21]. Test the ultrasonic sensor to make sure it can detect the amount of trash inside the trash can with accuracy. The ultrasonic sensor should then be put to the test to make sure it can distance and command the servo motor to open and close the lid.

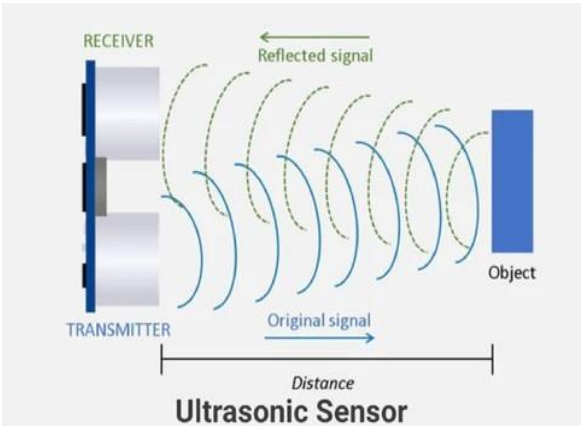

Fig.1 Ultrasound traveling

The transmitter fig.1 of the sensor transmits an ultrasonic sound [22], if there is an object in between 2 cm to 400 cm sounds waves bounce back from the surface of the object then received by the receiver of the ultrasonic sensor [23]. The distance is calculated by the time required to receive the ultrasonic sound and its speed fig. 2.

$$Distance = Time * Speed\ of\ sound / 2$$

To transmit ultrasonic sound, you need to set the trig pin as high as 10µs [24]. Then the sensor will start to send 8 burst ultrasounds 40khz. Then it will be received by the receiver and will calculate time to receive to measure the distance [25]. The distance is returned in centimetres (cm).

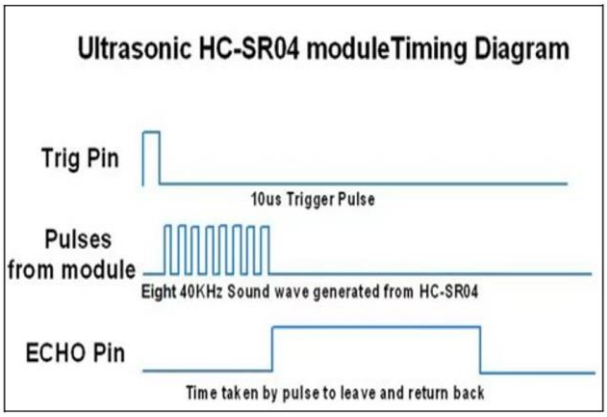

Fig.2 Working of ultrasonic

Experimental Setup

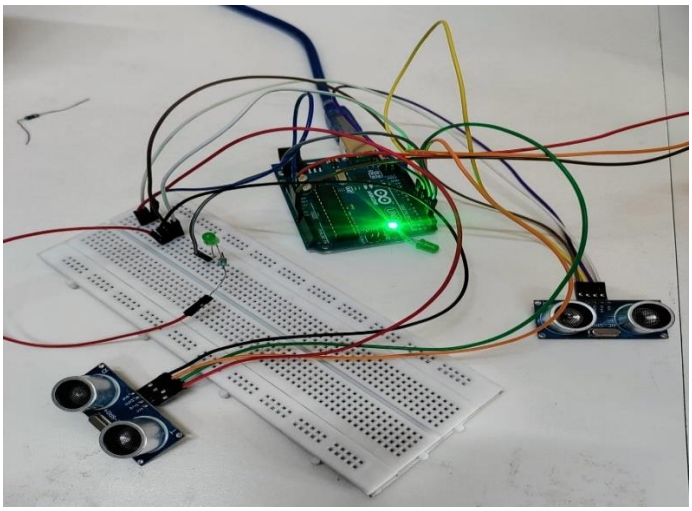

Fig.3 Circuit of System

Fig. 3 depicts the fundamental components of a smart dustbin, a revolutionary innovation in waste management. At its core is a standard trash bin that has been enhanced with integrated ultrasonic sensors. These sensors serve as the bin's discerning eyes, continuously monitoring, and measuring the levels of waste contained within the receptacle. This real-time data forms the foundation for efficient waste management, providing essential insights into when the bin requires attention. The sensory data generated by the ultrasonic sensors is a mere starting point for this intelligent system. A microcontroller, the brain of the smart dustbin, processes this information with lightning speed and precision. It not only calculates the current fill levels but also makes informed decisions about the state of the bin. For example, it can determine whether the bin is nearly full or still has ample capacity, a vital piece of information in waste management. What sets this system apart is its connectivity. Leveraging the power of Wi-Fi or Bluetooth, the microcontroller communicates this data to a mobile app or dashboard, both of which serve as the eyes and ears of the system's human operators. This remote monitoring capability is a game-changer, as it enables real-time tracking and management of waste levels. Users can

access this information from virtually anywhere, providing an unprecedented level of convenience and control.

Fig. 4 and 5 introduce another critical aspect of the smart dustbin: automation. Actuators, such as servo motors, can be seamlessly integrated into the system. These actuators are responsible for one of the most visible and practical aspects of the smart dustbin: lid operation. Depending on the fill levels calculated by the microcontroller, these actuators can automatically open or close the bin's lid. This automation ensures that the dustbin remains covered when not in use, minimizing odour and preventing pests from accessing the waste. When the bin approaches its capacity, the lid can automatically open, facilitating easy disposal. It's a simple yet highly effective way to optimize waste management and maintain hygiene.

Fig. 3, 4, and 5 collectively illustrate the brilliance of the smart dustbin system. It combines sophisticated sensors, powerful microcontrollers, and seamless connectivity to revolutionize waste management. The automated lid operation adds a layer of practicality that enhances both convenience and hygiene. This innovative approach has the potential to transform waste disposal in households, public spaces, and beyond, making it not only more efficient but also more environmentally responsible.

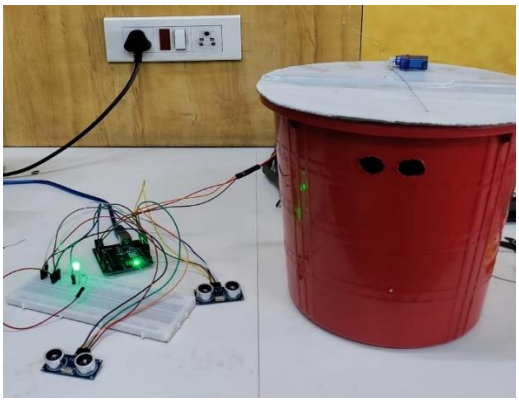

Fig.4 Smart dustbin

Fig.5 Smart dustbin when hand in range

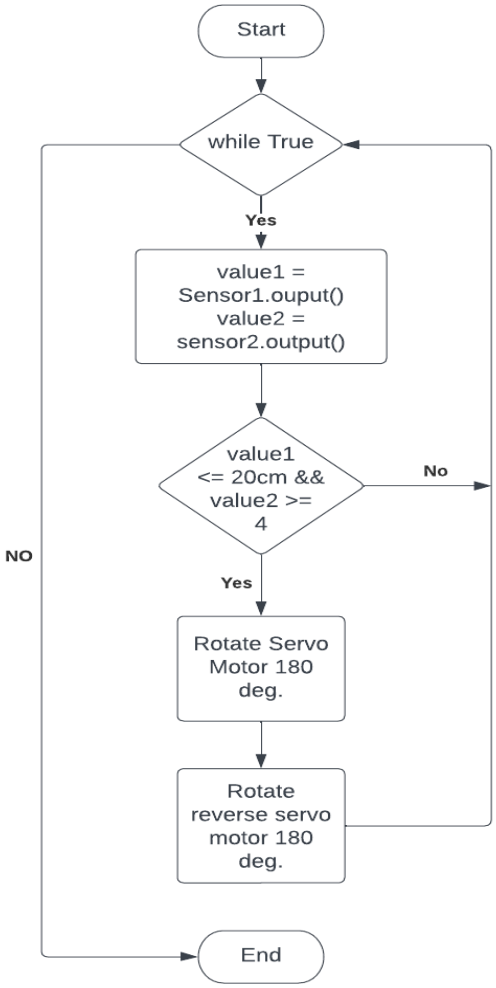

Fig.6 Flow chart

The "Initial State" of the flowchart fig.6 demonstrating how a smart trash can works shows that it is empty and that all monitoring systems are in standby. The microcontroller analyzes the data from the ultrasonic sensors that are continuously monitoring the garbage level inside the bin to determine the fill level. Comparing the fill level to a predetermined threshold value is an important step. The system keeps watching if the trash can is not yet full. When the bin is full, however, the flowchart moves on to the "Actuation" stage. Actuators such servo motors are used to open the dustbin's lid automatically in this instance, making it easier to dispose of trash. The lid is shut after the garbage has been removed, and the system returns to the "Initial State," prepared to watch and repeat the procedure for efficient waste management.

4. Results and Discussions

This table 1 stores the information collected by sensors for bins. It also includes bin door status (open or closed), whether the bins are full (Yes) or not (No), and depth and distance readings from ultrasonic sensors. The information points to the possibility of real-time bin condition monitoring, possibly for garbage management or storage

management.

Table 1: Bin Status and Sensor Readings

Sr. No.	Ultrasonic sensor (distance)	Ultrasonic sensor (depth)	BinDoor (open/ close)	BinFull (Yes/ No)
1	10	30	open	No
2	24	2	close	Yes
3	18	10	open	No
4	25	4	open	Yes
5	29	10	close	No
6	15	3	open	No
7	15	3	open	No
8	40	20	close	No

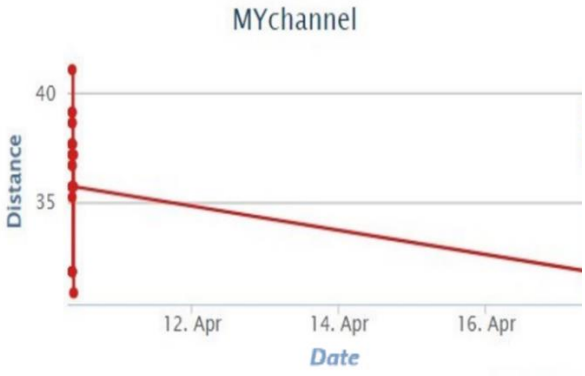

Fig.7 Ultrasonic sensor 1(distance)

Each data point (1–8) is displayed on the x-axis fig.7, while the values for the ultrasonic sensor (distance) are displayed on the y-axis. The segments of the line are colored to indicate the status of the BinDoor (Open/Close). Segments within each line denote whether the bin is full (Yes) or not (No). This facilitates trend identification by visualizing distance, door status, and bin fullness for each data point.

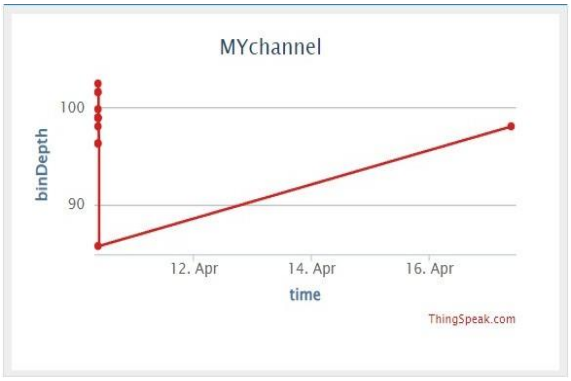

Fig.8 Ultrasonic sensor 2(depth)

This graph fig. 8 would offer a visual representation of depth measurements, bin door status, and bin fullness for each data point, simplifying the identification of patterns and trends in the data.

5. Conclusion

The smart dustbin system presents a unique and efficient solution to the traditional method of waste disposal. By utilizing sensors, a servo motor, and a microcontroller, the system can detect the amount of garbage and open the lid through gesture recognition, promoting hygiene and reducing the risk of contamination and improved cleanliness, sustainability, and reduced environmental impact. One of the most significant advantages of the smart dustbin system is its ability to promote cleanliness and sustainability. With the system in place, the garbage is deposited correctly, minimizing the risk of littering and pollution. This technology also reduces the need for manual intervention, saving time and reducing labor costs. Moreover, it helps to conserve resources by promoting recycling, which is critical in the fight against climate change. Overall, this technology showcases the potential of innovation in addressing real-world problems and promoting a better future for all.

6. Future Scope

This system uses ultrasonic sensors to detect depth of the garbage present in the dustbin and to open the lid of the dustbin when the object is in a range. So it opens the lid when any kind of object comes in the range, an additional camera can be used to detect an object present in the range is a human body part, only in that situation the lid should open. User friendly UI can be developed to preview detailed information of the dustbin such as depth level, last date of opening, etc. This approach will enhance the facility provided by the current system.

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