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Smart Waste Segregator with Overflow Control Mechanism

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ABSTRACT: Waste disposal is a major issue today, with well-known negative impacts on the environment, human health, and animal life. This research proposes a low-cost automated trash segregator with an overflow management system for efficient small-scale garbage disposal. The system uses sensors to segregate waste into different categories and also detects bin capacity to prevent overflow. It is designed to be cost-effective and user-friendly, making it suitable for household and small-scale waste disposal. The system employs three sensors to segregate metallic, dry, and wet wastes that serve as the input devices connected to the Arduino microcontroller. Furthermore, three ultrasonic sensors monitor bin capacity independently. Its affordability and user-friendly design make the system well-suited for household and small-scale waste disposal. Future improvements may include integrating machine learning algorithms and internet connectivity for better monitoring and management.

1. INTRODUCTION

The of waste has garnered more attention in recent years [1]. Waste disposal practices in modest contexts, such as schools, households, and small-scale businesses, are frequently ineffective and poor in terms of waste segregation.House hold waste disposal has been the major concern of many countries all over the world. Nowadays, most garbage thrown is piled up on top and around the bins, and this may lead to the spread of various diseases. People generally dispose waste improperly because they avoid their hands to come into contact with the dirty lid of the waste bin [2]. Most common trash bins are improperly emptied, resulting in garbage overflow. Improper bin collection procedures, collection, transfer, and/or transport methods significantly impact the solid waste's properties [3]. Growing issues with the disposal of solid waste result in pollution of the air and water [4]. The environment and public health in developing nations have suffered greatly as a result of inadequate garbage management [5]

2. PROBLEM STATEMENT

It is essential for the effective management of waste produced in an area where the residents know how to separate waste into different categories. However, manual segregation methods are prone to errors and irregularities in current systems. According to a household garbage survey conducted in Oman, the country produced 1.5 million tons of waste in 2012, and by 2030, that number is predicted to rise to 1.89 million tons [6]. Oman faces several difficulties, including a deficient strategy, an imprecise master plan, an absence of particular rules and regulations, and a lack of an integrated system or facilities for efficient waste management [7].

3. BACKGROUND

The main approaches to moving the country forward in waste management are to build the necessary infrastructure, reorganize municipal garbage collection systems, and promote public awareness of waste management. To overcome these challenges, an integrated, low-cost system is proposed. This system utilizes a microcontroller-based technology and integrates sensors such as an inductive proximity sensor for metallic waste, an ultrasonic sensor for dry waste, and a rain sensor for wet waste. In addition, two servo motors are utilized to rotate the bin and open and close the lid before and after waste disposal, and three ultrasonic sensors are used to detect individual bin capacity. The objective is to develop an affordable and user-friendly solution that improves waste disposal practices in small-scale settings.

4. MATERIALS AND METHODS

The Smart Waste Segregator with Overflow Control Mechanism was proposed to automate waste segregation and overflow management for efficient small-scale waste disposal. It has three sensors to ensure accurate garbage detection and segregation: an inductive proximity sensor for metallic waste, an ultrasonic sensor for dry waste, and a rain sensor for wet waste.

Inductive proximity is used to detect metallic waste objects. The sensor generates an electromagnetic signal. Once the metallic hits the electromagnetic signal, it will produce eddy current. The eddy current as an input for the microcontroller for further processing. The ultrasonic sensor is used to calculate the distance to an object, in this case, the level of dry waste in the bin. The sensor radiates ultrasonic waves and measures the time it takes for the waves to bounce back after hitting an object. The sensor calculates the level capacity of dry waste in the bin. The rain sensor is used to detect the presence of moisture or wet waste through analog input pins. The sensor provides a numerical output signal that indicates the occurrence or nonexistence of moisture.

Servo Motor 1 is used to open the lid before waste is put into one of the bins and close it after the waste is thrown in one of the bins. Electrical signals, or pulses, are sent to the motor to control its rotation.

By controlling the number and sequence of pulses, the motor can be accurately rotated to open or close the cap as required.Servo Motor 2 is used to rotate the bins, allowing waste to be dumped in the appropriate bin. The motor receives electrical signals, or pulses, that control its rotation. By controlling the number and sequence of pulses, the motor can be accurately rotated in specific increments. This enables the bins to be positioned correctly for waste disposal based on the input received from the sensors.

The LCD is used to provide visual feedback by showing the type of waste thrown. The LCD can show different text or symbols based on the input received from the sensors. It can indicate the type of waste thrown, such as metallic waste, dry waste, or wet waste.

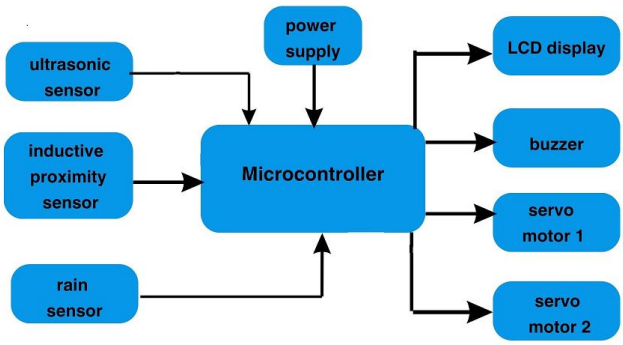

Figure 1. Block Diagram of Smart Waste Segregator

The sensors can identify whether or not a specific bin is full by comparing the distance data with a predetermined threshold. The three ultrasonic sensors are used to detect the capacity levels of the separate bins. Each ultrasonic sensor emits ultrasonic waves and measures the time taken for the waves to bounce back from the bin's surface. Based on the time taken, the sensors calculate the distance to the bin's surface. By comparing the distance measurements with a predefined threshold, the sensors can determine if a particular bin is full or not. The output of these sensors would be digital signals indicating whether each bin is full or not.

The buzzer is used to notify that a certain bin is full when activated. The buzzer generates a high-frequency sound when any of the ultrasonic sensors detects a bin full of waste. Until the garbage within the bin is cleared, the buzzer will keep beeping. Generally, the combination of these sensors, the Arduino Uno microcontroller, the servo motor, the LCD, and the buzzers allows the automated segregation and management of different types of waste, as well as the detection of full bins for efficient small-scale waste disposal.

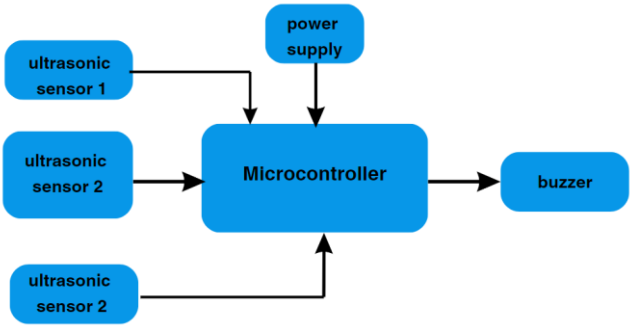

Figure 2. Block Diagram of Overflow Control Mechanism

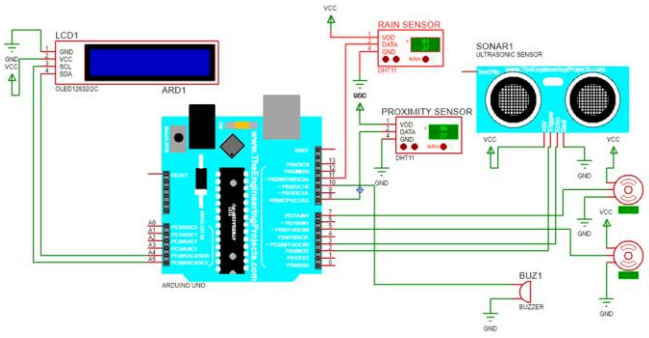

Figure 3. Wiring Diagram of Waste Segregator

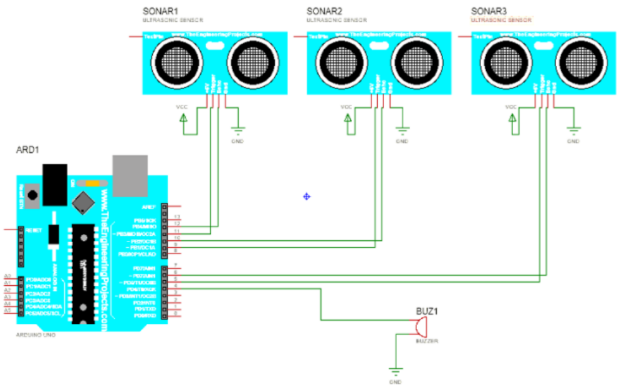

Figure 4. Wiring Diagram of Overflow Control

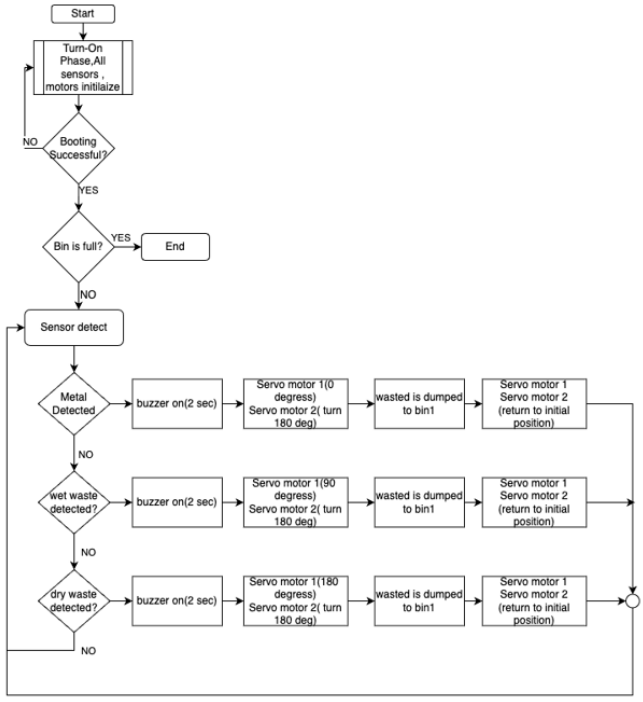

Figure 5. System Flowchart

The block diagram of the waste segregator has the capability of separating the metallic, dry, and wet wastes upon dropping them into the trash bin. The program was first simulated in a virtual environment built on the C++ programming language within the Arduino Integrated Development Environment (IDE). Second, the researcher built the actual smart waste segregator with an overflow control mechanism by building a circuit utilizing the ultrasonic sensor, inductive proximity, and rain sensors as input devices. The Arduino Uno is the microcontroller used in this project.

The trigger and echo pins of the first ultrasonic sensor are connected to pins 2 and 3 of the Arduino microcontroller. The data pin of the inductive proximity sensor is connected to pin 8, while the data pin of the rain sensor is connected to pin 11. The ultrasonic sensors use high-frequency sound waves (ultrasonic waves) to detect objects. The ultrasonic wave sensor monitors the time for waves to return after striking an item. This time delay is used to calculate the distance to the object. In this circuit, the ultrasonic sensor provides accurate distance measurements for dry waste objects.

The proximity sensor detects metallic objects through the electromagnetic induction principle. The electromagnetic field generated by this sensor drives conductive objects to induce eddy currents that vary the

sensor's output when the object comes into contact with the field.
During the actual testing, the bin is initially closed. The researchers tested the functionality of the two servo motors by connecting them to the Arduino Uno board and assessing their respective operations. The first servo motor was used for the opening and closing of the lid before and after waste was placed in the bins. The motor's response ensured reliable and accurate lid movements. Once the input sensors detect an object, the trash lid will open. The servo motor 1 is connected to the pin 5 of the Arduino Uno. The researchers programmed and controlled the second servo motor to facilitate the rotation of the bins. They assessed the motor's performance in terms of rotational smoothness, speed, and reliability. The servo motor 2 is connected to pin 7 of the Arduino Uno board.

Both servo motors operated effectively as intended. The rotation motor successfully rotated the bins, while the lid motor reliably rotated the specified bins inside the big waste bins, and the identified garbage will be thrown into specific bin opening and closing actions. The researchers noted any irregular movements, noise, or misalignments and made necessary adjustments to optimize the motors' performance.

They programmed the Arduino to display waste types and bin capacity status on the LCD. They also incorporated the buzzer to sound an alarm when required. The LCD accurately displays the waste types and bin capacity status. The buzzers provided the intended audible indication. The buzzer alerts if there is a system error. The researchers verified the readability of the displays and the audibility of the buzzers. The Arduino's pin 10 is connected to the buzzer.

The overflow control mechanism is shown in Figure 2. There are three ultrasonic sensors connected to each bin. The sensor detects the height or content of the waste in each bin. The trigger pins are connected to pins 5, 9, and 11 of the Arduino, and the echo pins are connected to pins 6, 10, and 12, respectively. Once the bin is full, the buzzer will sound to notify the person in charge that the corresponding bin is full. At this point, no matter if a person would like to drop or throw garbage, the bin will not open anymore. This will prevent overflow.

In addition to the actual testing that was done, the researchers included capabilities including debug output via the serial monitor, LED indicators for sensor activation, and a diagnostic mode to watch the system's behavior in real time to make testing easier. These functions facilitate the detection and resolution of any problems that arise during testing, guaranteeing a thorough assessment of the final system's performance in comparison to the intended requirements

5. CONCLUSION

Waste management and segregation have long been issues that have affected a significant amount of the environment. When used correctly, modern technology makes trash management simpler [8]. The smart waste segregator with overflow control management offers a practical way to dispose of large amounts of garbage in an efficient manner. It is an inexpensive, user-friendly way to set up a household segregation system so that materials can be sent straight to the processing center. The success of this project is crucial to creating a clean and healthy environment. It can be used for both outdoor and indoor applications. The project will improve the waste management system and remove the necessity for physical contact with waste bins. Though the prototype revealed affirmative results, further work, testing, and user feedback are necessary to ensure that it is reliable, useful, and beneficial. However, the successful development of the design paves the door for future improvements in waste management technology and exhibits the potential of the smart waste segregator with overflow control mechanism system in supporting effective small-scale waste disposal. Future improvements may include integrating machine learning algorithms and internet connectivity for better monitoring and management.

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