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IOT-DRIVEN URBAN WASTE SEGREGATION

Bhoomika CP[*1], Deeksha A[*2], Thrisha Rai PB[*3], Mrs. Saraswathi Devadiga[*4]

[*1,2,3]Department of Computer Science, Shree Devi Institute of Technology, Mangalore, Karnataka, India.

[*4]Professor, Department of Computer Science, Shree Devi Institute of Technology, Mangalore, Karnataka, India.

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ABSTRACT

Urban India generates substantial waste annually, necessitating efficient segregation to mitigate environmental and health risks. This project presents an automated waste segregation system that categorizes waste into wet, dry, and metallic types using inductive proximity, moisture, and ultrasonic sensors. The system ensures accurate identification and disposal of waste into corresponding bins, tested successfully with various materials. Enhancements for weapon detection ensure public safety. This innovative solution, demonstrating high efficiency and low power consumption, offers a sustainable approach to waste management, promising cleaner urban environments and contributing to public health and environmental conservation.

I. INTRODUCTION

Urban India generates 62 million tons of waste annually, expected to reach 165 million tons by 2030. Overflowing bins and littered streets highlight the need for improved waste management. The waste includes harmful materials like glass, paper, metal, plastic, e-waste, and chemicals, necessitating effective segregation into dry and wet categories to reduce environmental impact and health risks.

The current waste collection system is poorly planned, often relying on informal waste pickers who lack proper training and equipment, exposing them to health hazards. Burning trash for warmth contributes to air pollution. A systematic approach to temporary storage and collection is essential. Traditional methods involving large bins and garbage trucks struggle to maintain cleanliness.

Innovative technologies present promising solutions. For instance, systems using image processing and "recyclebots" enhance waste sorting. Somu Dhana Satyamanikanta et al. developed a smart garbage monitoring system using RFID and IoT, employing sensors to measure weight and volume, alerting authorities to prevent overflow. Parveen Sultana et al. proposed displaying trash mass on a web portal, while Priyam Anilkumar Parikh et al. discussed using IR and metallic sensors for waste identification and segregation.

Adopting such innovations can improve waste sorting accuracy and efficiency, leading to sustainable waste management and cleaner urban environments.

II. LITERATURE REVIEW

A green bin model was created to segregate household waste into dry and wet categories. Three different bins are arranged in a circle, and the waste is sorted into the correct bin by a moving module. However, this system is bulky and not cost-effective.

Metallic, Wet, and Dry Waste Segregation: Another model was designed to separate waste into metallic, wet, and dry categories. It used dielectric constant values to classify the waste, but this method was not very effective. Some dry waste was incorrectly classified as wet.

Sound Resonant Frequency:

A different approach used the sound resonant frequency produced when plastic bottles and tin cans hit a galvanized iron platform. This method was successful in distinguishing and recycling these materials

Microcontroller-Based System:

A microcontroller-based system with a DC motor and conveyor belt was created to sort waste into metal, dry, and wet categories. However, it mixed biodegradable and recyclable waste in one section, which was not effective for proper segregation.

Advanced Models

Recycle bot:

A recyclebot using image processing to distinguish between recyclable and non-recyclable waste was designed. It also used ZigBee for communication. This system is complex and relies on efficient communication between modules.

IoT-Based System:

An IoT-based system was proposed for the collection and disposal of domestic waste. The main goal was to keep local areas clean, but it did not focus on segregation and recycling at the household level.

AI Deep Learning System:

An automatic waste management system using artificial intelligence and deep learning was developed to classify waste into biodegradable and non-biodegradable. The system needs thorough training to work efficiently, and its effectiveness is low if not properly trained.

III. DATA AND METHODOLOGY

3.1 Tools and Components

Inductive proximity sensor

An inductive proximity sensor is a type of sensor that uses electromagnetic radiation to detect metal targets without physical contact. It is a versatile metal sensor with a high switching rate and no moving parts, which ensures a long service life. It provides a detection range of up to 60 mm. It is commonly used in the automotive industry. Fig. 1 shows the inductive proximity sensor with a sensing range of 8 mm. It requires a minimum supply voltage of 10 volts, and the maximum frequency response is 350 Hz.

Fig 1: Inductive proximity sensor

Moisture Sensor

The moisture sensor is an analog-based sensor used to gauge the water content in the soil. When there is a shortage of water, the module outputs a high output of 10-bit ADC value; otherwise, it provides a low output. It finds applications in agricultural purposes, irrigation, and botanical gardening. It measures the dielectric permittivity of the medium surrounding it. The sensor produces a voltage that is proportional to the soil's water content and dielectric permittivity. The required operating voltage is 5V and the current required is less than 20mA. Fig. 2 shows the soil moisture sensor used in the prototype for identifying wet waste.

Fig 2: Moisture sensor

Ultrasonic Sensor

The ultrasonic sensor is an electronic device that uses ultrasonic sound waves to calculate the distance of the target object. The transmitter and receiver are its key components. These waves get reflected toward the receiver module of the sensor. By recording the amount of time passed between sending and receiving the ultrasonic pulse, the distance may be calculated. Fig. 3 depicts an ultrasonic sensor with a detection distance of 2 cm to 450 cm. It determines whether an item has been put in the bin. Its working voltage is 5 volts (DC).

Fig 3: Ultrasonic Sensor

Servo Motor

A servo motor s an electrical machine that has extremely accurate rotational capabilities. A control circuit that provides feedback on the motor shaft's current location is often incorporated in this sort of motor. This feedback enables the servo motors to rotate very precisely. A servo motor is used to rotate an object at predetermined angles or distances. It is made up of a simple motor that powers a servo mechanism. According to the PWM (Pulse Width Modulation) principle, a servo motor's rotational angle is determined by the length of the pulse that is applied to its control pin. For this project, two different models of servo motors were used, namely the MG995 and SG90. Fig. 4 is the TowerPro SG90 Micro Servo Motor, which operates at a voltage of 4.8 to 5 volts. The torque provided by the motor is 1.8 kg cm.

Fig 4: Servo Motor

3.2 Processing Unit

Arduino UNO

The Arduino UNO board, as shown in Fig. 5, is a development board on which the ATMega328P microcontroller board is mounted. Its operating voltage is 5 volts. It consists of 14 digital pins, 6 analog pins, power pins, a DC power jack, a USB jack, a 16 MHz crystal, etc. It is designed to make applications, interactive controls, or environments easily adaptive. Some of its great features include, cross-platform adaptability, it is inexpensive, open-source, easy to configure and use, etc.

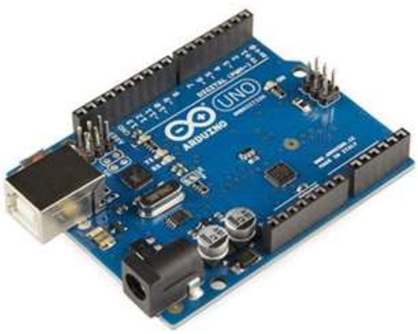

Fig 5: Arduino UNO

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System Architecture

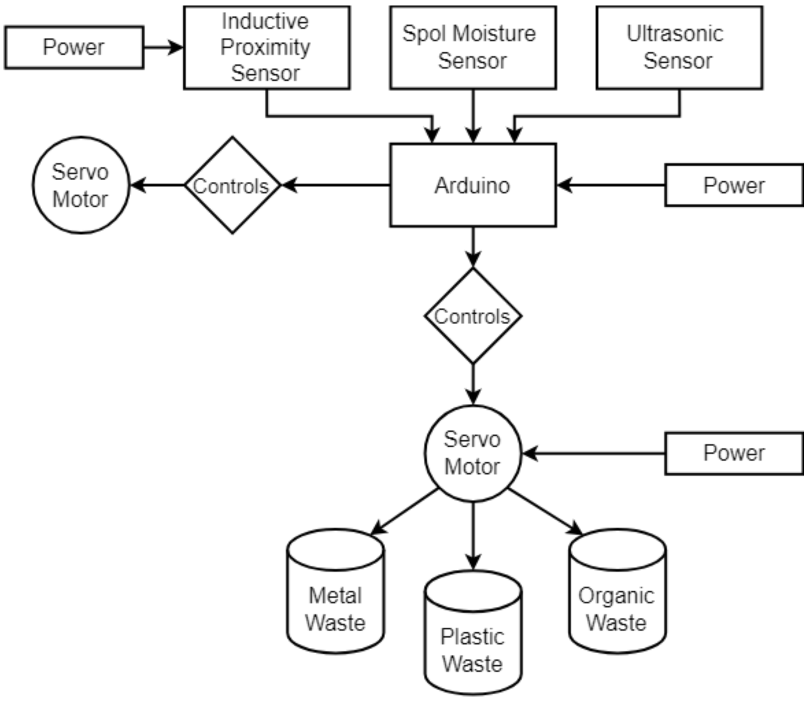

Figure 6: System Architecture

IV. WORKING

An ultrasonic sensor attached to a vertical panel detects when garbage is thrown in by a user. Once trash is detected, two other sensors, an inductive proximity sensor, and a soil moisture sensor, are activated.

Waste Detection:

When the waste item is dropped into the container, it lands on the soil moisture sensor at the bottom. This sensor measures the water content in the waste. The inductive proximity sensor checks if the item is metallic.

Waste Classification:

Based on the moisture content and metallic properties, the waste is classified into three categories:

Wet Waste*: If the moisture level is above 5%, the waste is classified as wet.

Metallic Waste*: If the item is metallic, it is classified as metallic waste.

Dry Waste*: If the moisture level is below 5%, the waste is classified as dry.

Dustbin Arrangement:

The system has a circular base with a servo motor at the bottom. Three dustbins are placed at specific angles:

0° for dry waste

90° for wet waste

180° for metallic waste.

Waste Disposal:

After classification, the base adjusts so the correct dustbin is positioned below the panel. A flap at the base of the panel, controlled by a servo motor, opens to drop the waste into the corresponding bin.

Power Supply:

The system operates with an external voltage supply of 7 volts. This setup enables effective waste management and segregation using IoT technology.

V. RESULT ANALYSIS

The proposed model consists of all the components shown in Figures

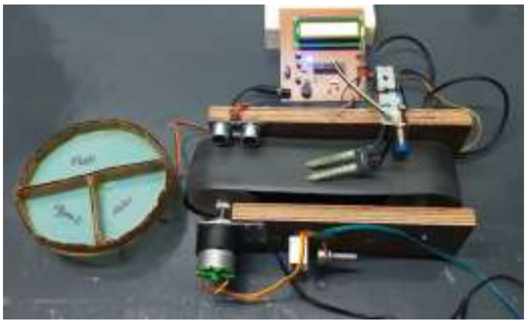

Fig 7: Hardware Model of the Project

It requires a power supply to work properly, but it consumes very little power and classifies waste efficiently.

First, the system detects the presence of an object and sorts it into predefined categories. An ultrasonic sensor detects trash on the surface of a flap. The system was tested with various waste items like banana peels, moist tissue paper, wet cloth, lemons, dry cloth, cardboard, paper, and plastic. Wet waste, such as banana peels and wet cloth, was detected using a moisture sensor, which is set to a minimum moisture content of 5%. This value can be adjusted as needed. Dry waste includes items like dry cloth and cardboard.

For metallic waste, such as aluminum sheets, tin can lid, and keys, an inductive sensor is used. The sensors correctly identify the type of garbage, and the waste is dropped into the appropriate container.

When an object is classified, the base of the model rotates to place the trash in the correct bin. This model works well for both categorizing and placing garbage into bins. It can be used in public places or transportation hubs to help prevent trash from accumulating and creating an unhealthy environment.

VI. CONCLUSION

In conclusion, effective waste segregation is crucial for maintaining a clean and healthy environment. By accurately classifying and sorting waste into wet, dry, and metallic categories, we can enhance recycling efforts, reduce landfill waste, and minimize environmental pollution. Implementing automated waste segregation systems, such as the model discussed, can significantly improve efficiency and accuracy in public spaces and transportation hubs. This not only helps in maintaining cleanliness but also promotes sustainable waste management practices. As we continue to innovate and refine these technologies, the impact on environmental conservation and public health will be profoundly positive.

VII. FUTURE SCOPE

The future scope of waste segregation is promising with advancements in technology like automated systems becoming more efficient and widespread in smart cities. Further improvements in sensor technology and AI will enhance sorting accuracy and recycling rates. Public support for these systems is growing due to increasing environmental awareness, promising cleaner cities and a healthier planet. Integrating weapon and dangerous tool detection into metal waste segregation systems enhances public safety through advanced sensors and real-time alerts to authorities.

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