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Waste Classification System using Smart Sensors

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Abstract

An innovative approach to revolutionize waste management through the integration of advanced sensor technology and intelligent algorithms is proposed. Effective waste segregation is crucial in addressing the current needs. The main objective is to develop an efficient waste segregation system using various sensors to segregate degradable, non-recyclable, bio-medical waste, and organic-waste. A MCU unit with various types of sensors is used for segregation. A DC motor with conveyor belt is used to transfer wastes to respective bins, while an I2C connector with an LCD display is used to indicate the types of waste and whether the bin is filled or not. This research holds the potential to significantly mitigate environmental degradation and contribute to building a cleaner and more sustainable future. Based on the system's performance, it can be extended to automated smart city waste management, and the skimming of crude-oil from ocean water.

Keywords: Solid Waste Management, Degradable, Waste Segregation, Sustainable, Automated Smart City

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1. Introduction

A key technique for effectively managing and recycling waste materials is garbage segregation, also known as waste sorting or waste separation. At the point of disposal, it involves the systematic separation of various waste types according to their composition and potential for recycling. This process reduces pollution in the environment, conserves resources, and promotes environmentally friendly waste management techniques. Communities can improve recycling efficiency, minimize the amount of waste dumped in landfills, and even generate energy from organic waste through anaerobic digestion or composting by sorting garbage into categories like organic, recyclable, and non-recyclable. Furthermore, garbage segregation is essential in encouraging people to adopt eco-friendly practices in their daily lives and for raising public awareness of environmental conservation. While communities persist in battling the difficulties associated with waste management.

Every day, we generate massive amounts of garbage, placing a strain on landfills and polluting our environment. Fortunately, there's a simple yet powerful solution – waste segregation. Waste segregation is the practice of separating different types of waste materials at the source, typically in our homes or workplaces. This means sorting items like food scraps, paper products, plastic containers, and metal cans into designated bins. By separating waste, we unlock a range of benefits that will be explored in detail throughout the following pages.

This approach promotes a healthy planet and a sustainable future. By exploring the world of waste segregation, we'll uncover how it contributes to a cleaner environment, reduces reliance on landfills, and conserves precious resources.. We'll also explore the economic benefits of recycling and how proper waste management fosters a more responsible and sustainable society. The proposed system, utilizing Arduino Nano and sensors, takes initiative to reduce confusion in waste management by automatically segregating different types of waste. The developed system paves the way for a cleaner and more sustainable environment

2. Literature Review

2.1 Current Challenges in Waste Management

Waste management has become a critical global issue due to the increasing volume of waste generated daily. Various studies have highlighted the challenges posed by inadequate

waste management practices, including environmental pollution, depletion of natural resources, and public health risks [1-3].

2.2 Integration of Sensor Technology in Waste Management

Recent advancements in sensor technology have opened up new possibilities for enhancing waste management processes. Studies have explored the application of smart sensors for real-time monitoring of waste generation, facilitating [4,5]

2.3 Intelligent Algorithms for Waste Sorting

Intelligent algorithms play a crucial role in automating waste sorting processes and improving classification accuracy. Research conducted by researchers demonstrates the effectiveness of machine learning algorithms in identifying and sorting all types of waste materials based on their physical and chemical properties. [6]

2.4 Benefits of Automated Waste Sorting Systems

Implementing automated waste sorting systems offers advantages, including increased recycling rates, reduced contamination, and enhanced resource recovery. Studies highlight the environmental and economic benefits associated with deploying intelligent waste sorting technologies. [7,8]

2.5 Potential Environmental and Societal Impacts

By revolutionizing waste management practices through the integration of advanced sensor technology and intelligent algorithms, there is a potential to mitigate environmental degradation and promote sustainable development. Studies by Wang et al. [13] discusses the anticipated environmental and societal impacts of adopting automated waste sorting systems.

3. Existing System [9-14]

- **Manual Sorting:** This is the most traditional method of garbage segregation, and it involves people sorting waste into different bins according to its type (e.g., paper, plastic, metal, glass, food scraps). This method is labour- intensive and can be inaccurate, but it is still widely used.

- **Dual-stream Recycling:** This system uses two separate bins for recyclables and non-recyclables. This is a more efficient way to collect recyclables, but it still requires people to sort their waste correctly.
- **Multi-stream Recycling:** This system uses multiple bins for various types of recyclables, such as paper, plastic, metal, and glass. This is the most efficient way to collect recyclables, but it requires more education and effort from residents.
- **Automated Sorting:** This system uses machines to sort waste into different categories. These machines can use a variety of sensors, such as cameras and lasers, to identify various types of materials. Automated sorting systems are becoming increasingly common, but they can be expensive to install and operate.

4. Proposed System

The smart waste segregation system helps to segregate metals, biodegradable and non-biodegradable waste using efficient sensors. Automatic sorting system helps to segregate the waste flawlessly. This system automates waste separation using a conveyor belt, ultrasonic sensor, proximity sensor, soil moisture sensor, servo motor, and DC motor. The proximity sensor detects waste deposited on the conveyor belt, which sets off the system and finds metal objects. The non-biodegradable wastes are found using the ultrasonic sensor. The moisture content of the trash is measured by a soil moisture sensor. When separating organic waste from other materials, this can be useful.

Microcontroller unit is the brain of the system. It receives signals from the sensors, processes them based on pre-defined logic, and controls the servo motor accordingly. A microcontroller interprets the sensor data, categorizing the waste (e.g., organic, plastic, metal) the MCU sends a signal to the servo motor, which positions the flap or diverter to direct the waste stream into the designated bin. Finally, the DC motor propels the conveyor belt, while the servo motor precisely diverts the waste stream into designated bins based on its category. 16*2 LCD display shows waste category type and bin fullness. This approach offers improved accuracy, efficiency, and hygiene in waste management. By implementing such an automatic waste segregation system, you can significantly contribute to a cleaner and more sustainable

environment. The Figure 1 and 2 illustrates the block diagram and flow chart of the proposed system.

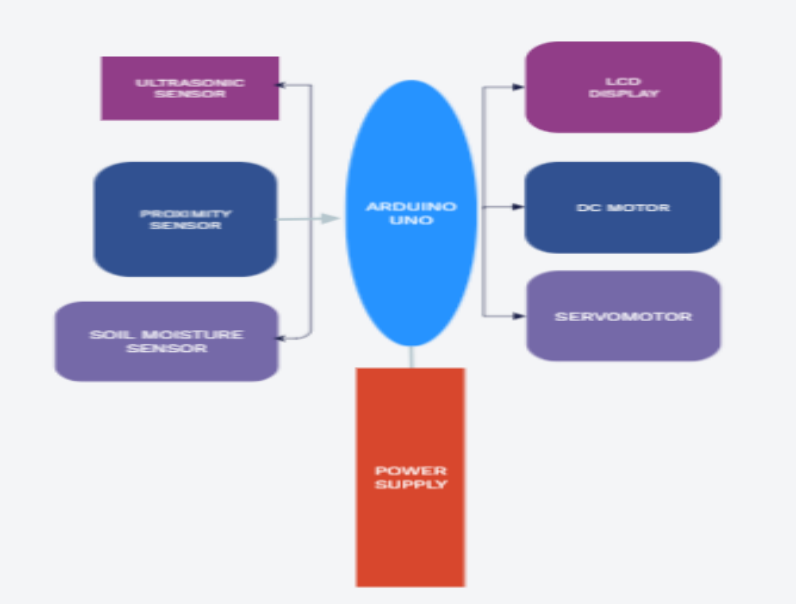


Figure 1. Block Diagram

4.1 Flow Chart

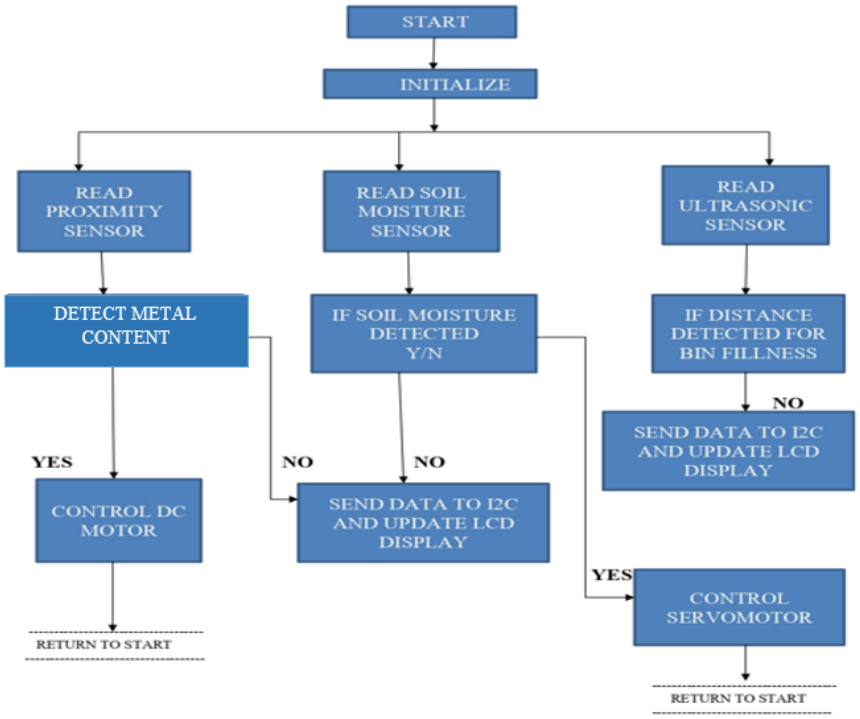


Figure 2. Flowchart

4.2 Hardware Requirements

The Table.1 shows the hardware requirements of the proposed waste segregation system.

Table 1. Hardware Requirements

Arduino Controller	The microcontroller unit interprets the sensor data, categorizes the waste accordingly, and sends signals to the servo motor for precise diversion directing waste to designated bins or respective containers.
Proximity Sensor	Capacitive proximity sensors are used for non-contact detection of both metallic and nonmetallic objects such as liquid, plastic, paper and more.
Soil Moisture Sensor	Based on the moisture content present in the object, a moisture sensor will detect the type of waste. The waste is then segregated and sent to the appropriate bin.
Ultrasonic Sensor	A robust sensor is placed in waste bins and containers to measure the fill level, regardless of the contents deposited inside.
Direct Current (DC) Motor	It is used to run the conveyor belt to transfer the segregated waste to the respective bins.
I2C Connector and Lcd Display	It is used to display the types of waste and the status of the bin, indicating whether it is full or empty.

4.3 Software Requirements

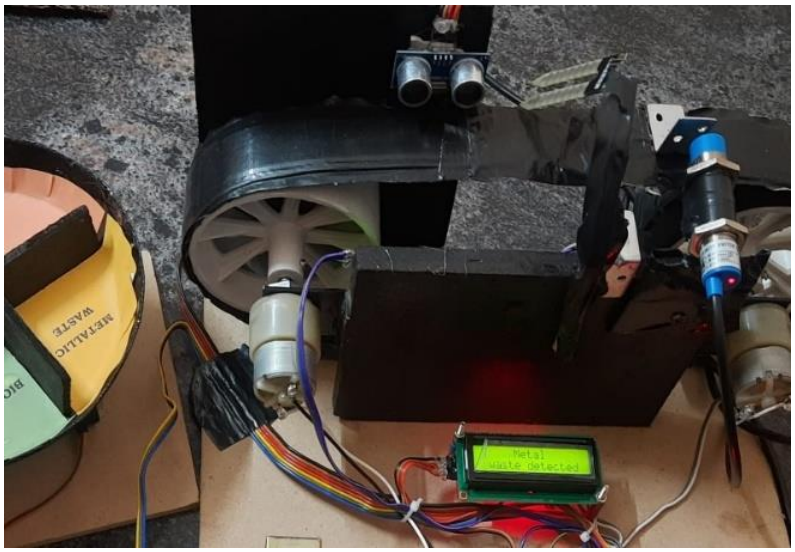
- **Arduino IDE-** Arduino IDE provides a user-friendly platform for writing and uploading code to the Arduino board, facilitating the integration of various sensors and components.

- **Language –** The Embedded C programming language allows for precise control and optimization of system operations. Through Embedded C, the system's functionalities are programmed to ensure efficient waste segregation based on sensor inputs. The programming is designed to handle waste management through accurate waste

classification, as well as the control of peripheral devices such as the DC motor and LCD display.

5. Results and Discussion

(a)



(b)

Figure 3. (a) Hardware Setup, (b) Metal Waste Detected

Lastly, garbage that is metal, non-metal, and biodegradable is separated into appropriate bins, and an ultrasonic sensor is used to determine whether the bins are full The hardware setup

is illustrated in Figure.3. Therefore, it is simple to separate the various types of waste from the trash by applying the above-proposed method. The types of garbage separated in the bin will be displayed on the LCD.

This automatic waste segregation system utilizing ultrasonic, proximity, and soil moisture sensors alongside a servo motor, DC motor, and conveyor belt offers a sophisticated solution for efficient waste management. By combining sensor data and pre-programmed logic, the system accurately sorts waste into designated bins, improving accuracy and hygiene compared to manual methods. This not only saves time and manpower but also promotes proper recycling practices, contributing to a more sustainable environment. LCD displays can enhance user experience and overall system efficiency.

The system enhances operational efficiency by drastically reducing sorting time and effort through fast and accurate waste classification. Its advanced smart sensors ensure high accuracy in waste categorization, minimizing errors and contamination. Complete automation eliminates manual sorting, reducing labor costs and ensuring consistent sorting results.

5.1 Future scope

The future holds immense system's ability to distinguish between a wider range of waste materials like different types of plastics, metals, and paper, which can be enhanced. Real-time communication with recycling facilities can optimize waste collection routes and ensure proper recycling of segregated materials. Automatic waste segregation systems integrated into smart homes and city waste management infrastructure, fostering a more sustainable future. These advancements promise a future where waste segregation becomes effortless, contributing significantly to environmental conservation and responsible resource management.

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