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Automatic Waste Segregator using Arduino Uno with Wet, Metal, and IR Sensors

Er. Praveen Agrawal[1], Mansvi Yadav[2], Hemant Singh Rathore[3], Rahul Kumar Meena[4], Dilraj Meena[5]
Dept. of Electrical Engineering, Arya College of Engineering & Information Technology, Jaipur, India

Abstract: ***Waste management is an optimal problem in most cities because of the rapidly growing population and inadequate waste disposal techniques.***
Poor waste segregation causes a large percentage of wastes7 to go to landfills, along with pollution and even more significant problems regarding recycling. This research develops an automatic waste segregator with Arduino Uno microcontroller using wet, metal, and infrared (IR) sensors to differentiate wastes as wet, dry, and metal. The system can detect the properties of various types of waste materials, and segregates them into appropriate bins, which increases the efficiency of waste sorting and minimizes environmental problems.
This proposed design intends to reduce manual effort, improve the recycling percentage, and aid in smart waste management. It is designed to be low cost, of a reasonable size, and can be used in residential, commercial, and industrial places. It is green in nature because it uses embedded systems and sensors for automated waste classification, which can further incorporate IoT and artificial intelligence for a greener approach. In this manner, the waste disposal process can become fully automated, minimizing health risks and promoting sustainable urbanization.

I. INTRODUCTION

An automatic waste segregation system improves the effectiveness of any waste management plan. Poor waste management results in pollution hazards, health issues, and difficulties in recycling. Manual waste segregation is inefficient, dangerous, and poses health issues for employees. An automated waste segregation system eliminates these issues while ensuring accurate classification.

Waste can be divided into the following three categories:

1) Wet Waste: Consists of organic matters like food residue, vegetable scraps, and other biodegradable matter.
2) Dry Waste: Comprises non-organic substances such as plastic, paper, and glass.
3) Metal Waste: Composed of canned items, tin foil, and aluminum pieces.

Municipal solid waste can be effectively separated through various methodologies, including:

a) Trommel separators and drum screens;
b) Eddy current separators
c) Inductor sorting
d) Near-infrared sensors
e) X-ray technology
f) Manual sorting.

The automatic waste segregator (AWS) is the core component of an automated waste segregation system.

II. LITERATURE REVIEW

Many researches have focused on creating automated waste segregation systems and the majority of them already illustrate the accuracy and correctness of sorting using sensors.

A. Sensor-Based Waste Segregation

Sharma et al. (2023) reported an automated waste segregation system that uses several sensors for the waste classification. The results claimed that the application of wet sensors, IR sensors, and metal sensors in combination achieved a high rate of accuracy in the waste segregation process.

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B. IoT and Smart Waste Management

Patel (2022) made a review about IoT enabled waste management systems and pointed out the remote monitoring, data storage and analysis capabilities as helpful to improving collection and recycling of waste. Their study speculated that the integration of IoT technology to waste segregators would help improve firmly established practices of waste management in metropolitan areas.

C. AI and Machine Learning in Waste Sorting

Gupta (2021) described the implementation of machine learning algorithms as part of the methodology to enhance the process of waste categorization. Their research exemplified what was possible by teaching a model to recognize images and use sensors to get sorting accuracy greater than that obtainable by the use of sensors alone.

D. Embedded Systems in Waste Management

According to Roy (2020), waste embedded systems microcontrollers such as Arduino and Raspberry Pi can be used to automatically segregate waste. His work pinpointed energy-efficient designs that help solve the problem of waste management in an affordable manner.

E. Environmental Impact of Automated Waste Sorting

Lee (2019) made a thorough account of the environmental aspects of automated systems dealing with waste sorting processes and their conclusions noticed that automation of waste segregation processes decreases the amount of waste sent to the landfill and enhances the efficiency of recycling activities.

III. NOVELTY OF THE WORK

The developed system provides the following new contributions:

1) Waste classification in real-time through the use of multiple sensors (wet, metal, IR) integrated into one system.
2) Low-cost automation for the segregation of urban waste on a micro-level using Arduino Uno.
3) An improved mechanism for sorting that maximizes recycling and minimizes waste in landfills.
4) Adaptable for residential use as well as industrial use due to its compact and scalable design
5) Capability to monitor and collect data for the purpose of bettering waste management in real time.
6) Minimized power consumption, maximized energy efficiency, and eco-sustainability are the hallmarks of the design

IV. SYSTEM COMPONENTS

A. Arduino Uno

Functions as a main controller that gathers information from the sensors and manages the actuators.

B. Wet Sensor

Measures the moisture level of a waste to determine if it is classified as wet waste. Conductivity measurement enables recognition of wet and dry substances.

C. Metal Sensor

Performs identification of metallic waste through the use of electromagnetic induction. A metal placed close to the sensor causes an electric current that activates the sorting device.

D. IR Sensor

Separates dry waste from the general rubbish based on how reflective the material compared to other substance is. It uses the mechanism of sending an infrared signal and capturing the reflected wave.

E. Servo Motor

Enables movement of the waste containers for automatic sorting. Automatic sorting is achieved by the motor directing waste into a container determined by the sensors.

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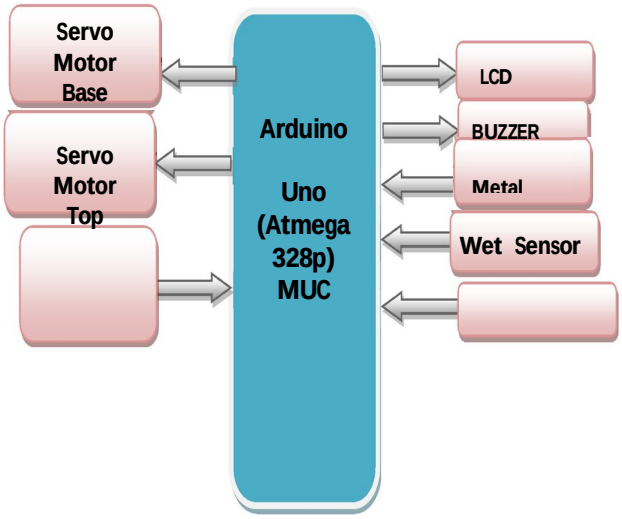
F. Conveyor Belt (Optional Enhancement)

To enhance the design, incorporation of a conveyor belt mechanism could be used to automatically transport waste materials towards the sensors, allowing non-stop sorting.

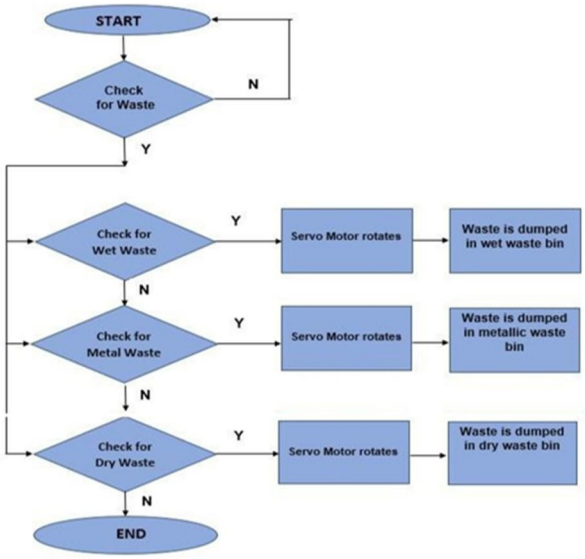
V. METHODOLOGY

1) Waste Detection: The waste is placed on a platform that is equipped with a sensor.
2) Metal Segregation: The metal sensor examines the waste, and if it contains any metal, the waste is sorted into the metal bin.
3) Wet Waste Identification: If there is no detected metal, a wet sensor checks for moisture content in the waste to determine whether it is wet.
4) Dry Waste Classification: Waste is categorized as dry if no metal or wet waste is detected.
5) Bin Partitioning Mechanism: Based on the readings taken by the sensors, the servo motor sorts the waste into the right bin.
6) Data Logging (Optional): Readings from the sensors may be stored for further investigation to enhance the efficiency of waste management systems.

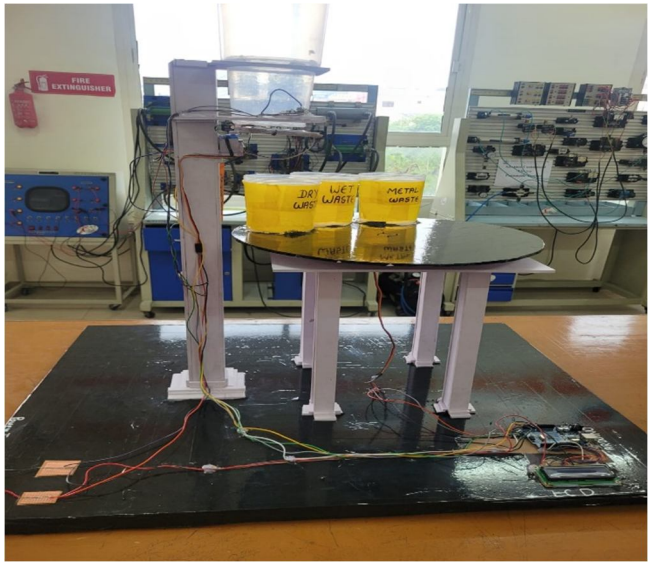
Block Diagram of Automatic Waste Segregator



Flow Chart



VI. WORKING PROTOTYPE



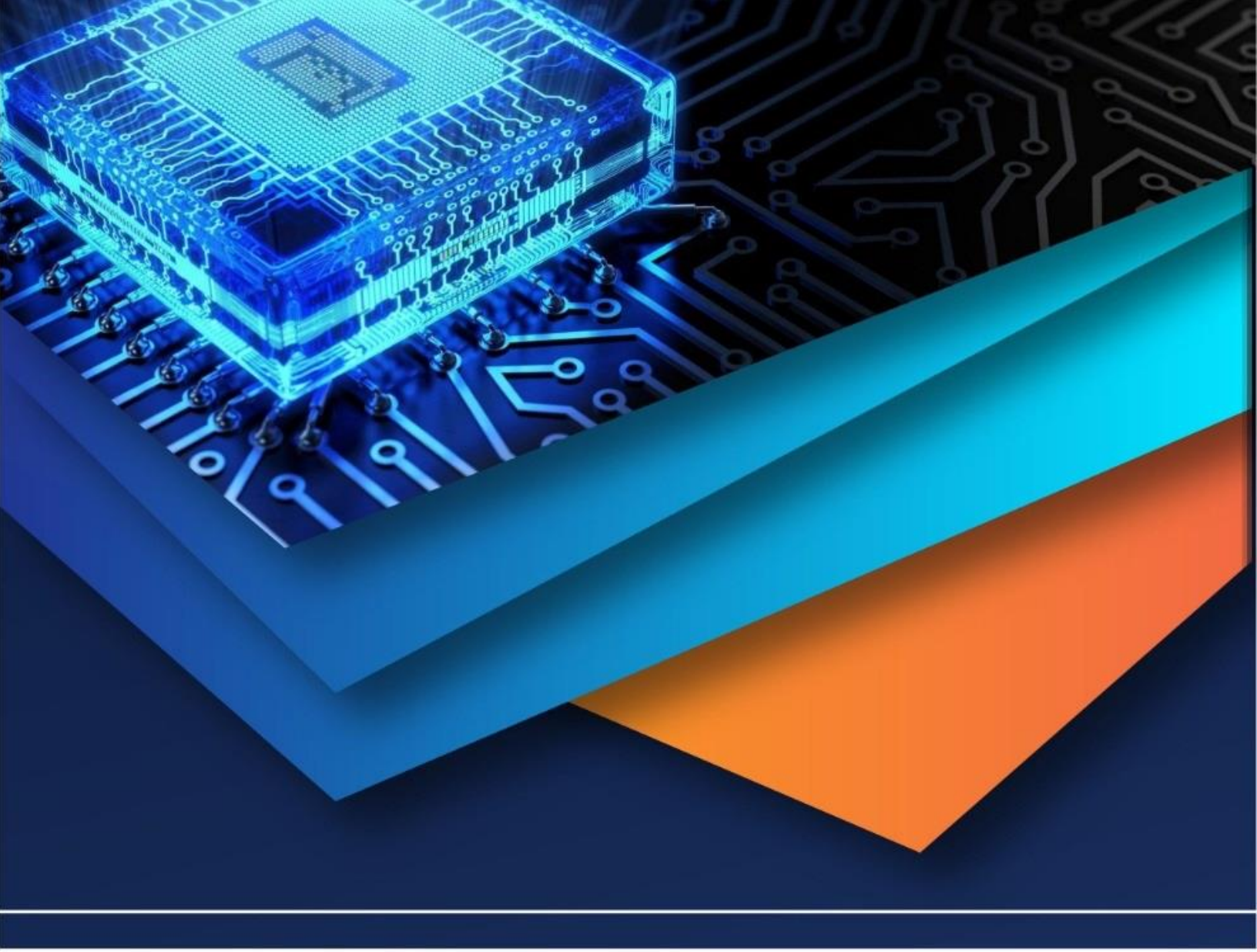
VII. CONCLUSION

An elaborate examination has been successfully conducted on a novel affordable, effective and mechanized waste separation system employing Arduino Uno and multi-sensors. This system effectively diminishes the manual sorting effort, thus increasing the rate of recycling activities and protecting the environment consequently. Future upgrades consist of more accurate deep learning machine algorithms and the possibility of remote monitoring of waste collection via wireless communication. This suggested solution moves a bit forward to smart waste management by minimizing landfill obstruction and enhancing cleanliness in cities.

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