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"AUTOMATED WASTE SEGREGATOR"

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ABSTRACT :

Waste management and segregation are crucial procedures in metropolitan cities and urban areas to reduce the transmission of diseases. India is projected to generate 42.0 million tons of municipal solid waste annually. Debris dispersed in the area and discarded on open land is a considerable problem for many dangerous bacteria and viruses. Consequently, the segregation, transportation, processing, and disposal of trash must be rigorously regulated to reduce risks to public health and the environment. The breakdown of mixed dry and wet waste in lowland regions produces detrimental greenhouse gases. Segregation enhances the effective management and recycling of waste. This waste segregation system effectively classifies refuse. When refuse is disposed of in the pipe, the infrared sensor will identify the waste. Waste is categorized into three types: Wet, Dry, and Metallic. A distinct sensor will identify the type of garbage. Based on the employed algorithm, if the trash is metallic, the mechanism will align the metal collection bin beneath the pipe, enabling the waste to fall into the bin by a servo motor. The process will similarly repeat following the identification of wet waste. Should the sensor fail to engage the specified category, the waste will be categorized as dry waste. Domestic segregation system for direct processing transmission. The objective is to classify refuse into metallic waste, organic garbage, and dry waste. The AWS features a parallel resonant impedance sensing technique to identify metallic particles and incorporates capacitive sensors to distinguish between wet and dry garbage. Experimental results demonstrate that the categorization of waste into metallic, moist, and dry classifications has been successfully implemented using the AWS.

CHAPTER 1 INTRODUCTION

Definition of Waste Segregation

Waste segregation entails the classification and organization of waste to improve recycling efficacy, hence yielding savings in both time and financial resources.

Waste Segregation in developed countries

1.Numerous industrialized countries, like Germany, the Netherlands, and the USA, are utilizing sophisticated management strategies (Enhanced Resolution, Mobile Sorting) that significantly reduce waste and improve opportunities for recycling and reuse.
2.The execution of these methods in Germany resulted in a recycling rate of 62% by 2010, whereas landfilling was almost eradicated by that time.
3.While adequate law is essential for a waste-free nation, Germany has enacted a prohibition on landfilling municipal solid waste by mandating specifications for organic material composition.

Chapter 3 Scope of project

In-Scope Activities

Waste Detection and Classification

- Detect and identify types of waste (e.g., organic, plastic, metal, glass).
- Use sensors (IR, moisture, capacitive, inductive, or cameras with AI) to analyze waste materials.

Segregation Mechanism
Develop a mechanical/electromechanical system (like conveyor belts, rotating bins, or robotic arms) to direct waste to the correct bin.

Automation and Control

- Implement microcontroller-based control (e.g., Arduino, Raspberry Pi).

- Use basic AI/ML (optional, for advanced models) for waste recognition using image processing.

Data Logging and Monitoring

- Log segregated waste categories and volumes.
- Optional: Wireless transmission of data (IoT-based monitoring).

Prototyping and Testing

- Build a functional prototype.
- Test with different waste types under controlled conditions.

Out-of-Scope Activities

- Large-scale industrial deployment. Handling of hazardous or radioactive waste.
- Waste treatment or recycling after segregation.
- Legal or municipal integration (e.g., city waste management policies).

Application Areas

- Smart cities and municipal waste systems.
- Hospitals and industrial sites for better waste handling.
- Schools and institutions for educational and eco-friendly initiatives. Residential societies to promote waste awareness.

Technologies Involved

- Sensors: IR, moisture, metal, proximity. Microcontrollers: Arduino, Raspberry Pi. Actuators: Servo motors, DC motors.
- Optional: Computer vision, ML for image classification. IoT: For data transmission and real-time monitoring

Chapter 4 methodology

4.1 PROPOSED SYSTEM

The Smart bin consists of three compartments. Each compartment fulfills a specific role: the first compartment houses an infrared sensor and a metal detector; the second compartment contains an additional infrared sensor and a moisture sensor for distinguishing between dry and wet waste; the final compartment is partitioned into three bins for the collection of segregated waste. The complete system is regulated by a microprocessor. All components are linked to the microcontroller board. The necessary code for controlling the sensors and motors is executed in embedded-C language, facilitating the clear description of input and output ports. This project employed an IDE compiler to construct the code and transfer it to the board using an A-B cable. We employed a Liquid Crystal Display device to display the decisions rendered by the Arduino CPU.

Theoretical Approach

The study began with a theoretical examination of waste materials and their properties. Waste goods were categorized based on their physical characteristics, which directly influence their detectability and sorting efficiency.

The chosen categories for this scheme were:
Biodegradable waste: Substances like food scraps or paper distinguished by high moisture content.
Recyclable waste include materials such as plastic, glass, and aluminum, which are typically dry and exhibit specific physical properties, including metallic conductivity and optical reflection.
Non-recyclable waste: Waste that cannot be classified as biodegradable or recyclable, encompassing things such as Styrofoam or contaminated packaging.
Thus, sensor selection became essential. Moisture sensors were employed for biodegradable waste because of their capacity to detect increased moisture levels associated with food or organic materials. Inductive proximity sensors were selected for metal detection in recyclable materials, whereas infrared sensors were utilized for plastic identification. Theoretical analysis was utilized to determine the sensitivity ranges and operational thresholds for these sensors, ensuring the system's ability to effectively distinguish between waste types.

Computational Approach

Following the establishment of the theoretical framework, a computational approach was utilized to assess the sensor data and make categorization conclusions. The core element of the system's decision-making process depended on the Arduino microcontroller. The microcontroller was programmed to recognize waste by executing a series of if-else conditions depending on sensor inputs, including moisture levels, metal detection, and infrared reflectivity

Predefined criteria were set for each sensor to categorize the sort of waste in the code.
Moisture sensor: The threshold value was determined at a specific voltage indicating the presence of moisture, associated with biodegradable waste. A value over this threshold compels the system to categorize the waste as biodegradable.
.
Inductive sensor (for metals):): The system was engineered to detect metallic waste based on the sensor's output value, thereby commencing the appropriate sorting process.

IR sensor: The IR sensor's threshold was set to distinguish plastics from other materials based on reflectance. Materials with high reflectivity were categorized as plastic.

Experimental Approach

The experimental methodology involved creating a functional prototype of the waste segregation system. . The prototype included:
a sensor array comprising a moisture sensor, an infrared sensor, and an inductive sensor for material detection
A mechanical sorting system utilizing servo motors to operate flaps that direct waste into designated bins based on its classification.

The Arduino Uno functions as the principal control unit for processing sensor data and regulating motor activities.
Waste samples were tested in real-time to evaluate the system's classification effectiveness. A variety of products, including biodegradable paper, a recyclable plastic bottle, and an aluminum can, were processed through the detection platform. Sensor data for each sample was documented, and the system's decision-making process was analyzed to ensure precise waste classification. The sensor thresholds were adjusted during initial testing to improve the system's accuracy.

Data from these exams were documented for analysis as confusion matrices and accuracy assessments. Parameters like sensor sensitivity, response time, and sorting efficiency were evaluated. Error handling was instituted to manage edge cases where sensors may produce ambiguous data (e.g., lack of garbage detection or values surpassing the allowable range).

Parameter Tuning and Testing

Following the initial prototype setup and testing, **parameter tuning** was performed to refine sensor performance. This included:
Moisture sensor calibration: Different moisture levels were tested with various biodegradable materials (e.g., banana peel, food waste) to set an optimal threshold for classification.
Inductive sensor calibration: Various metallic items (e.g., aluminum foil, steel can) were tested to ensure that only metals triggered the sorting mechanism.
IR sensor calibration: Plastic waste and other materials were tested to ensure that the reflectivity threshold was tuned for accurate plastic detection.
In addition to these parameter adjustments, further **experimental validation** was done by running the system with random waste combinations. The system was evaluated on the following parameters:

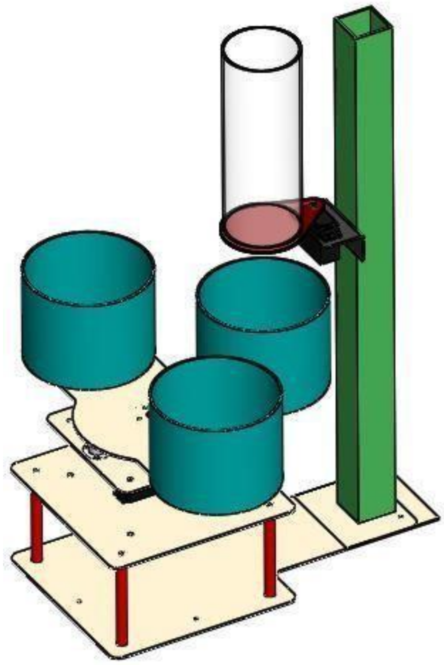
Sorting accuracy: Percentage of correctly classified items.

Throughput rate: Time taken for the system to classify and segregate waste.

Reliability: Consistency of sensor outputs and system behavior over repeated tests.

WORKING

1. Drop the waste into the pipe.
2. IR sensor will sense the waste and it will rest on the bottom plate
3. Now the sensor on the plate will sense the waste as in 3 categories Metallic or wet.
4. Now the algorithm is so made that if the waste is metallic then the mechanism will bring the metal collecting bin below the pipe and the servo will let the waste fall into the bin.
5. Similarly, the process will be repeated for wet test.
6. If the sensor does not activate then the waste will be detected as dry waste.



BLOCK DIAGRAM

Fig.4.4.1 Block diagram

WORKING PROTOTYPE

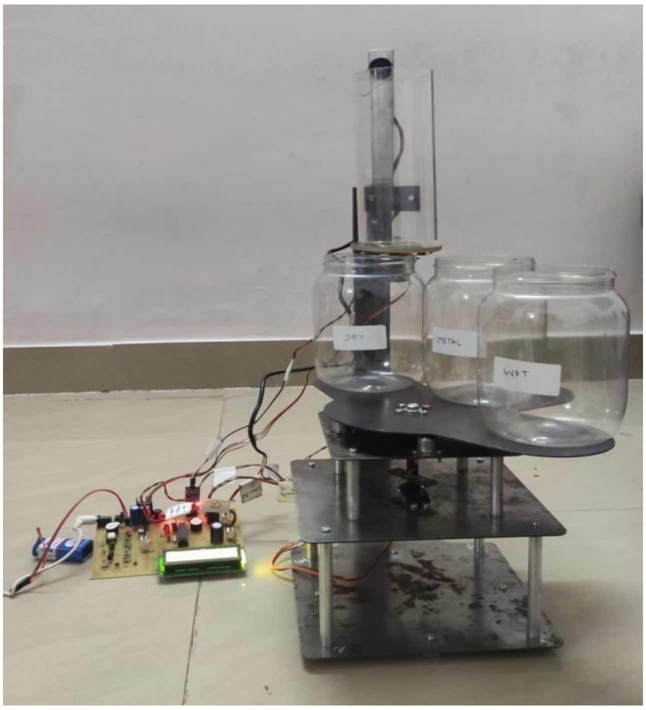


Fig 4.4.2 Working prototype

DESIGN CONSIDERATIONS

- Strength
- Rigidity
- Reliability
- Safety
- Cost
- Weight
- Ergonomics
- Aesthetics
- Manufacturing considerations
- Assembly considerations
- Conformance to standards
- Friction and wear
- Life
- Vibrations
- Thermal considerations
- Lubrication
- Maintenance
- Flexibility
- Size and shape
- Stiffness
- Corrosion
- Noise
- Environmental considerations

DESIGN PROCEDURE

- Definition of problem
- Synthesis
- Analysis of forces
- Selection of material
- Determination of mode of failure
- Selection of factor of safety
- Determination of dimensions
- Modification of dimensions
- Preparation of drawings

CHAPTER 5

RESULTS AND DISCUSSION

The term "segregator and monitoring system" refers to a device that separates trash into three distinct categories: metal, plastic, and wet (organic) waste. Organic waste, such as vegetable peels, leftover food, and other similar items, are examples of wet waste. It is imperative that we separate our waste because the volume of rubbish that is being produced in the modern world presents a significant concern. After conducting tests on the wastes that are produced in every home in the modern world, we have arrived at the following conclusion with regard to the household wastes. After being subjected to our waste monitoring and segregation system that operates automatically. Both the management of the whole collection process and the monitoring of the process of collecting solid waste would be possible with the system that is being presented right now.

It would ensure that solid garbage is collected in a timely manner. The technologies that are utilized in the system that is being offered are of sufficient quality to guarantee being both practical and ideal for the monitoring and administration of the process of collecting solid waste in order to maintain a green environment.

Table 1: Result of Metallic Waste Separation.

Sl. No.	Type of Metal Waste	Discarded or Not
1	Safety pin	Yes
2	Paper clip	Yes
3	Battery	Yes
4	Nail	Yes

Table 2: Result of Organic Waste Separation.

Sl. No.	Types of Organic Waste	Discarded or Not
1	Kitchen waste	Yes
2	Leftover food	Yes
3	Vegetable peel/Fruit peel	Yes
4	Rotten fruits and Vegetables	Yes

Table 3: Result of Dry Waste Separation.

Sl. No.	Type of Dry Waste	Discarded or Not
1	Paper	Yes
2	Small bottles	Yes
3	Heavy cartons	No
4	Milk cover	Yes
5	Dry leaves	Yes
6	Clothes	Yes
7	Tetra pack	No

CHAPTER 6

CONCLUSION AND SCOPE OF FUTURE WORK

- Inlet selection can be incorporated with a crusher mechanism to reduce size of incoming waste.
- Provisions can be made for on spot decomposition of wet waste
- Solar panel can be used for power supply.
- This type of product can be used in housing societies, offices, etc. Since it is cost effective, it can be implemented on a large scale as well with some modifications.
- Using a robotic arm along with a conveyor belt will make the process of segregation easier.
- Also, more sensors can be used to segregate bio-degradable and non-bio-degradable waste, plastics, recyclable waste, e-waste, and medical waste.
- Conclusion
- As the name suggests, it segregates the waste into three major classes: Dry waste, Wet waste, Metallic waste.
- The proposed system would be able to monitor the solid waste collection process and management of the overall collection process.

Our project provides one of the most efficient ways to keep our environment clean and green.

COMPONENTS

Mechanical

1. Supporting Frame
2. Collecting Bins
3. Flaps
4. Joints and Screws

Electronic

1. IR Sensor
2. Metal Sensor
3. Liquid Crystal Display

4. Servo Motor
5. Circuit board

CHAPTER 7 APPENDICES

Inductive Proximity (Moisture) Sensor
power supply

- ***Supporting Frame***

Fig.7.1.1 supporting frame

A frame is often a structural system that supports other components of a physical construction and/or steel frame that limits the construction's extent. Here the Frame allows us to mount all other components on it.

Collecting Bins

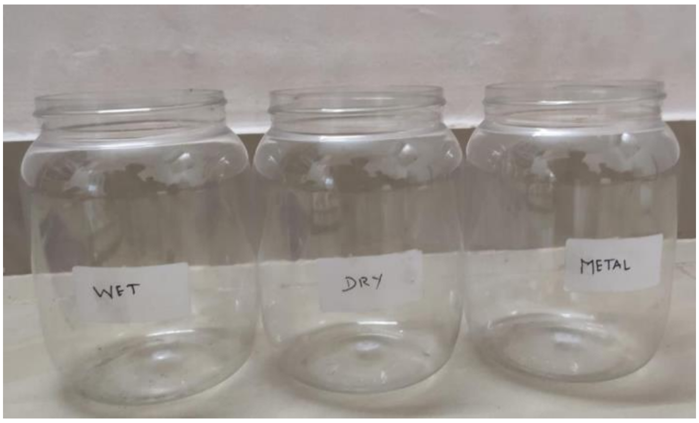


Fig.7.1.2 Collecting bins

The collecting bins are used to collect the segregated waste in the respective bins.

Moving disc

Fig.7.1.3 Moving disc

Moving Disc is the component whose primary task is to collect trash in the respective bin with the help of the servo motor. All the trash collecting bins will be placed on it.

IR Sensor

Fig.7.1.6 IR sensor

IR sensor is one of the most commonly used sensors in the field of electronics; it has a large number of applications at the domestic as well as at the industrial level. IR module is a sensor module that consists of both IR transmitter and a receiver. Operating voltage of this module is 5 volts and the obstacle detection range is 5 cm that can be increased by 15 cms. An IR sensor can detect the heat of an object as well any motion in the surrounding. Here this is used to detect the trash in the inlet. The functioning of an IR module is pretty straightforward. As the module contains both transmitter and receiver. When powered, IR transmitter starts to transmit continuous IR waves, if an obstacle is placed in the path of the waves, they get reflected back from the obstacle and are received by the receiver.

Metal Sensor

An Inductive Proximity Sensor is a non-contact electronic proximity sensor used for the detection of metals. Sensing range of this sensor completely depends upon the metal being detected. Their working principle is based on a coil and an oscillator that generates an electromagnetic field in the surrounding of the sensing range. Presence of any metallic substance in the sensing range causes dampening of oscillation amplitude.

Rise and fall of amplitudes is detected by a threshold circuit that causes a corresponding change in the output of the sensor. If a metal contains some percentage of ferrous, the sensing range is longer, while non-ferrous metals like copper reduce the sensing range by 60 percent. There are two possible outputs of this sensor, hence it is also called inductive proximity switch. Common applications of inductive sensors include metal detectors, traffic lights, etc and a plethora of industrial automated processes.

Moisture Sensor

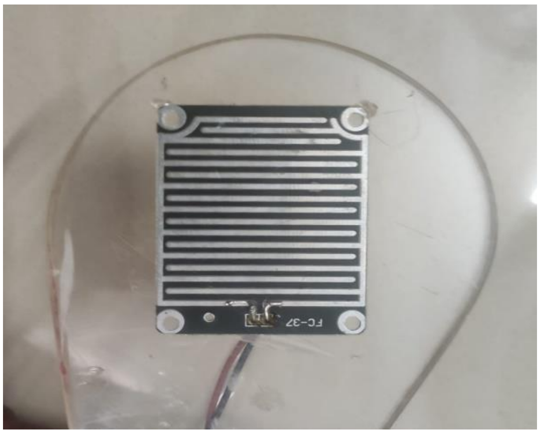


Fig.7.1.8 Moisture sensor

As the name indicates, this sensor is used to measure the moisture content in a given material. These sensors use the volumetric water content indirectly by making use of some other properties like electrical resistance, dielectric constant. In general cases, the sensor generates a voltage proportional to the dielectric permittivity and therefore measures the moisture content of a material.

Servo Motor

Fig.7.1.10 Servo motor

A servomotor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration.[1] It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors.

Servomotors are not a specific class of motor, although the term *servomotor* is often used to refer to a motor suitable for use in a closed-loop control system.

Servomotors are used in applications such as robotics, CNC machinery or automated manufacturing. Here servomotor rotates the moving disk to make the trash fall in its bin.The degree of rotation for servo motor is pre defined in the code which is embedded in the circuit board.

Power supply

Fig 7.1.12 12Volt adapter **Fig 7.1.13 HLW battery**

The power adapter of 12V – 2A and HLW High Power Battery of 9 V are used to power this Project

CODE EMBEDDED IN MICROCONTROLLER

```
#include <LiquidCrystal.h> #include
<Servo.h>
Servo myservo1.
Servo myservo2.
const unsigned int led=4; const unsigned int
buzzer=A3;
const unsigned int rain_drop = A5; const unsigned int
metal_detector = 3; const unsigned int proximity = A4;
bool sensor_1 = 0;
bool sensor_2 = 0; unsigned int sensor_3
= 0;
LiquidCrystallcd(5, 6, 8, 7, 9, 10); void setup() {
myservo1.attach(12); myservo2.attach(13);
lcd.begin(16, 2);
lcd.print("            AUTOMATED               ");
lcd.setCursor(0,1);
lcd.print("  SEGREGATOR  "); delay(2000);
pinMode(led,OUTPUT);
pinMode(buzzer,OUTPUT);
digitalWrite(LED_BUILTIN, LOW); pinMode(rain_drop,INPUT);
pinMode(metal_detector,INPUT); pinMode(proximity, INPUT);
  }
void loop()
```

```
{
lcd.clear(); lcd.print("Monitoring ..");
delay(2000);
    while (1)
    {
      sensor_1 = digitalRead(proximity); if (sensor_1 ==
      0)
      {
lcd.clear();
lcd.print("Object Detected"); delay(1000);
        sensor_2 = digitalRead(metal_detector); sensor_3 =
        analogRead(rain_drop);
        if (sensor_2 == 1)
        {
lcd.clear();
lcd.print("METAL DETECTED");
delay(2000);

          myservo2.write(180);
delay(4000);
          myservo1.write(180);
delay(4000);
          myservo1.write(0);

lcd.clear(); lcd.print("Monitoring ..");

          myservo2.write(0);
delay(3000);
         }
         else if(sensor_3 < 700 )
         {
lcd.clear();
lcd.print("WET DETECTED"); delay(2000);
```

```
            myservo2.write(60); delay(4000);
            myservo1.write(180);
delay(4000);
            myservo1.write(0);


lcd.clear(); lcd.print("Monitoring ..");
            myservo2.write(0);

    delay(3000);


            }
           else
           {


lcd.clear();
lcd.print("DRY DETECTED"); delay(2000);
            myservo1.write(180);
delay(3000);
            myservo1.write(0); lcd.clear();
lcd.print("Monitoring .."); delay(3000);
            }
       }
     }
}
```

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