MAHATMA GANDHI INSTITUTE OF TECHNOLOGY(A)
DEPARTMENT OF INFORMATION TECHNOLOGY

AN INDUSTRY ORIENTED MINI PROJECT(IT653PC)
ON

IoT-Driven Smart Waste Segregation

BY

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ABSTRACT

- Efficient waste management requires proper segregation for effective recycling and disposal. This automated waste segregation system classifies waste into dry, wet, and metal using sensors and an Arduino-based setup.Key components include an IR sensor, rain drop sensor, and proximity switch for waste detection. A servo motor and stepper motor control bin movement, while a buzzer provides alerts.
- The system, powered by 18650 Li-ion batteries, ensures portability and energy efficiency.Waste is detected by the proximity switch, with the IR sensor distinguishing solids from liquids and the rain drop sensor identifying moisture content. The stepper motor then directs the waste to the appropriate bin.
- This system enhances waste management, recycling, and environmental sustainability in homes, offices, and industries.

INTRODUCTION

- Waste mismanagement is a significant environmental issue, leading to pollution, inefficient recycling, and increased health hazards. Traditional waste segregation methods require human effort, which can be time-consuming and inaccurate. To address this, the IoT-Driven Smart Waste Segregation System automates the sorting process, ensuring efficient and eco-friendly waste disposal.
- The system works by analyzing the waste placed in the input box. The IR sensor differentiates between solid and liquid waste, the rain drop sensor detects moisture levels to classify it as wet or dry, and the proximity switch identifies metallic objects. Once the data is collected, the Arduino UNO processes the information and determines the appropriate waste category.
- After classification, the system activates stepper and servo motors, which guide the waste into the correct bin. The entire system is powered by 18650 Li-ion batteries, making it energy-efficient and sustainable. By minimizing human intervention and improving segregation accuracy, this project promotes better waste management and environmental sustainability.

EXISTING SYSTEM

- Existing waste segregation processes are largely manual or semi-automatic, hence labor-intensive, imprecise, and hazardous. A few rely on IoT technology to track the level of bins but have no capability to sort waste into types such as dry, wet, and metal.
- Current solutions are also not portable and do not have a continuous supply of power. Smart bins and deep learning techniques are the subject of some studies, but most only deal with monitoring waste and not segregation. Hence, there is an evident requirement for a completely automated and energy-efficient solution capable of real-time detection, classification, and sorting of waste.

PROPOSED SYSTEM

- The system employs an Arduino-based design with sensors to sort waste automatically into metal, wet, and dry types. A raindrop sensor identifies moisture, an IR sensor separates liquids from solids, and a proximity sensor identifies waste.
- The Arduino UNO processes information and powers servo and stepper motors to channel waste into the right bin. Alerts are provided by a buzzer, and 18650 Li-ion batteries supply power to the system for mobility and efficiency. The system ensures precise, environment-friendly, and contactless waste segregation.

APPLICATIONS

- **Households** – For efficient and hygienic daily waste segregation.
- **Offices** – Reduces manual effort and promotes green practices.
- **Hospitals** – Minimizes human contact with waste, improving safety.
- **Industries** – Handles bulk waste sorting to support recycling.
- **Smart Cities** – Integrates with IoT infrastructure for automated waste management.
- **Educational Institutions** – Promotes environmental awareness and sustainable habits.

REQUIREMENTS

SOFTWARE:

- Arduino IDE
- Arduino Libraries:

  1.Servo.h

  2.CheapStepper

- Language: C++

HARDWARE:

- Stepper motor Driver
- IR sensor
- Arduino UNO
- Stepper motor
- Jumper Wires
- Proximity sensor
- Servo motor
- Rain drop sensor
- 18650 Li-ion batteries

LITERATURE SURVEY

S.NO	AUTHOR NAMES, YEAR OF PUBLICATION	JOURNAL OR CONFERENCE NAME AND PUBLISHER NAME	METHODOLOGY / ALGORITHM / TECHNIQUES USED	MERITS	DEMERITS	RESEARCH GAPS
1	M. P. Arthur et al., 2024	*Artificial Intelligence Review*, Springer	Survey of IoT-based smart dustbins with deep learning	Combines IoT and deep learning for accurate real-time waste monitoring	Limited coverage on large-scale deployment issues	Need for cost-effective, scalable models
2	N. H. Mohamed et al., 2024	*Discover Sustainability*, Springer Nature	Waste 4.0 with AI-based medical waste segregation and digital tracking	Addresses healthcare waste challenges using AI and automation	High implementation cost and regulatory concerns	Integration of secure systems with privacy safeguards

3	*B. Fang et al., 2023*	*Environmental Chemistry Letters*, Springer	Review of AI in waste management using ML, computer vision, and optimization techniques	Offers comprehensive AI-based strategies for smart city waste solutions	Lacks practical implementatio n details	Need for real-world case studies to validate AI models
4	S. K. Singh et al., 2023	*Neural Computing and Applications*, Springer	IoT-based smart bin with fill-level sensors and classification	Improves collection efficiency and reduces overflow	Sensor failures may cause incorrect readings	Need for adaptive systems with error-handling
5	M. S. Sivakumar et al., 2022	*Environmental Science and Pollution Research*, Springer	Computer vision-based waste classification with IoT integration	High accuracy in automated waste segregation	Requires high-quality images and infrastructure	More robust models needed for diverse waste types

PROBLEM STATEMENT

- Traditional waste segregation is mostly manual, time-consuming, unhygienic, and often inaccurate in sorting dry, wet, and metal waste.
- The improved system is intelligent, automated, and energy-efficient, capable of accurately detecting and separating waste types with minimal human effort, promoting better recycling and environmental sustainability.

OBJECTIVES

- To automate waste segregation using sensor-based detection.
- To classify waste into dry, wet, and metal categories accurately.

MODULES DESCRIPTION

The IoT-Driven Smart Waste Segregation System is structured into several functional modules that work in coordination to achieve efficient and automated waste classification. Each module is designed to perform specific tasks to ensure accurate segregation with minimal human intervention.

1. Waste Detection Module

This module is responsible for sensing the presence of waste and identifying its physical characteristics. It comprises:

An IR sensor/Rain drop sensor to differentiate between solid and liquid waste.
A proximity sensor to detect the presence of metallic objects.

Upon detection, this module activates the classification process and passes the input data to the processing unit.

2. Waste Segregation Module

This mechanical module performs the physical segregation of waste into appropriate bins. It includes:

A stepper motor to rotate and align the disposal opening with the correct bin.

A servo motor to operate the flap mechanism for releasing the waste.

The stepper motor positions the system based on waste type (dry, wet, or metal), while the servo motor facilitates smooth and controlled release.

3. Notification and Feedback Module

This module provides audible and visual feedback to users, using:

- A buzzer to indicate successful detection and sorting operations.
- The Serial Monitor (during testing phase) to display sensor readings and system status for debugging and monitoring.

This enhances user interaction and supports real-time feedback.

Methodology

The smart waste segregation system operates through an automated detection and classification mechanism, leveraging sensors and motorized actuation to sort waste into predefined categories. The following methodology outlines the working process in stages.

A. Initialization

Upon system startup, all sensors and actuators are initialized. This includes:

- Proximity Sensor for detecting metallic components.
- IR Sensor for the presence of solid or liquid waste.
- Raindrop Sensor to evaluate moisture levels.
- Servo Motor for bin flap control.
- Stepper Motor for directional bin alignment.
- Buzzer for audio alerts.

B. Waste Detection and Classification

1. Metallic Waste Detection
   If the proximity sensor returns a LOW signal, the system identifies the object as metallic waste. The buzzer is triggered to indicate detection. The stepper motor rotates to the metal bin position, and the servo motor opens the bin flap to dispose of the item. Subsequently, all components return to their default states, ensuring readiness for the next cycle.

2. Solid/Liquid Waste Detection
   If the IR sensor returns LOW, indicating non-metal waste, the buzzer is activated. The system then reads an analog value from the raindrop sensor to determine moisture content. Based on the threshold (20%), waste is classified as:

   - Wet Waste (Moisture > 600):
     The stepper motor rotates towards the wet bin, and the servo motor opens the bin flap to drop the waste.

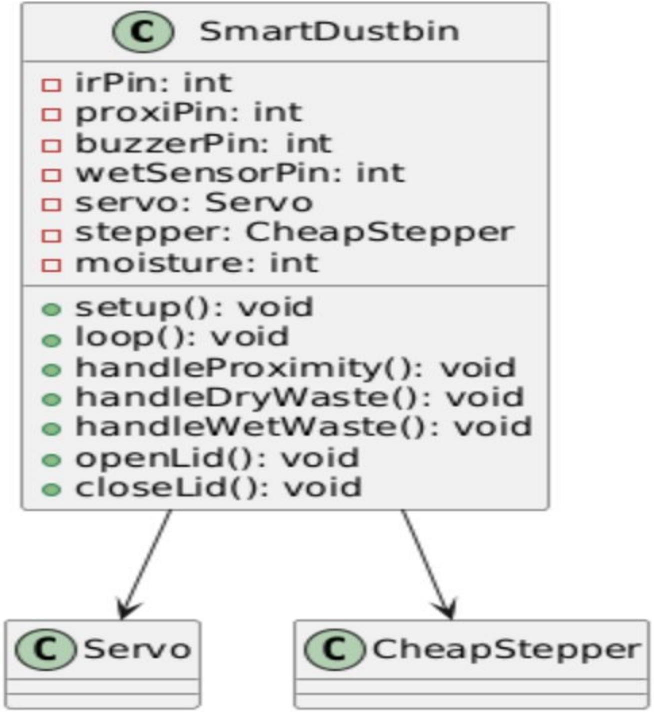
   - Dry Waste (Moisture ≤ 600):
     The waste is considered dry and is dropped into the default dry waste bin without rotating the stepper motor.

C. Continuous Operation

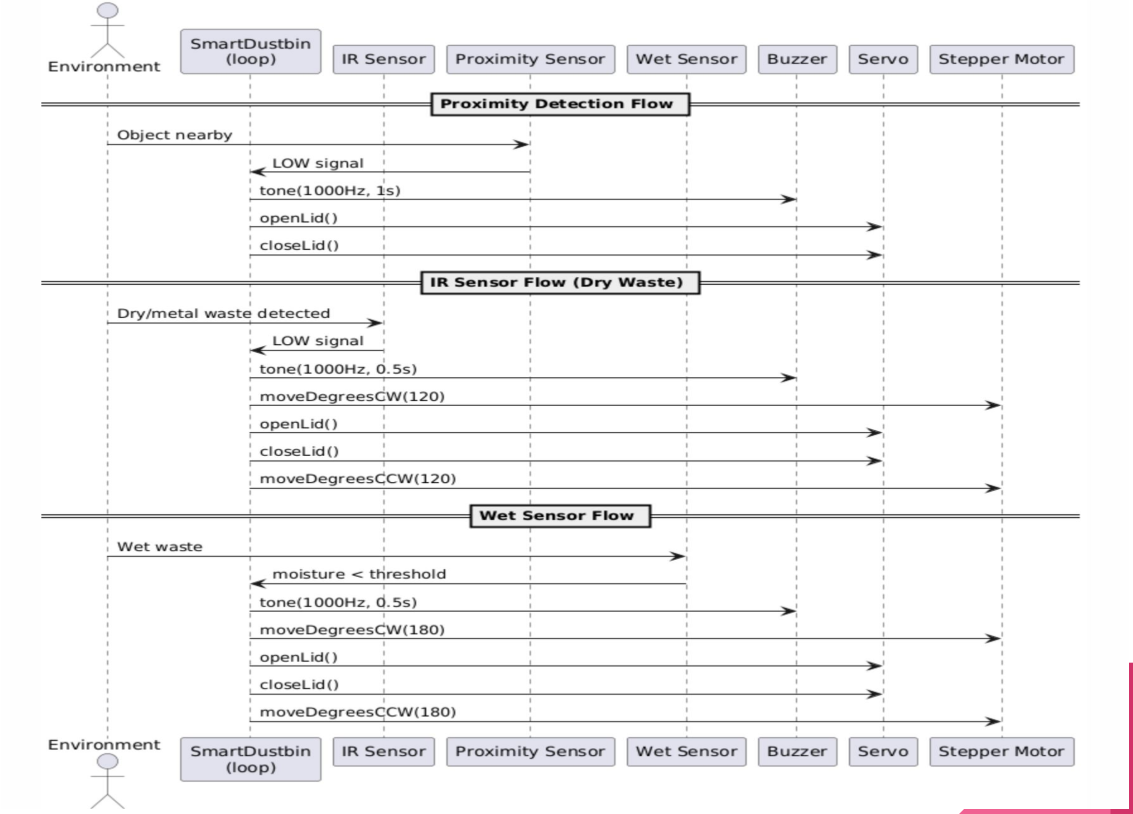
The system loops back to monitor for new waste inputs, allowing for uninterrupted, autonomous waste classification. This loop-based automation minimizes human intervention and enhances real-time responsiveness.

UML DIAGRAMS

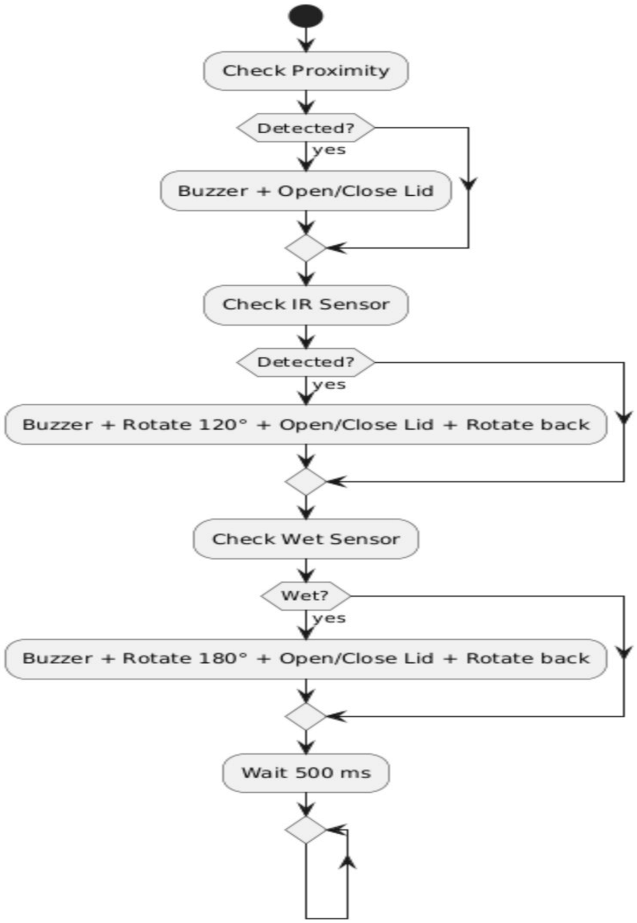
Class diagram



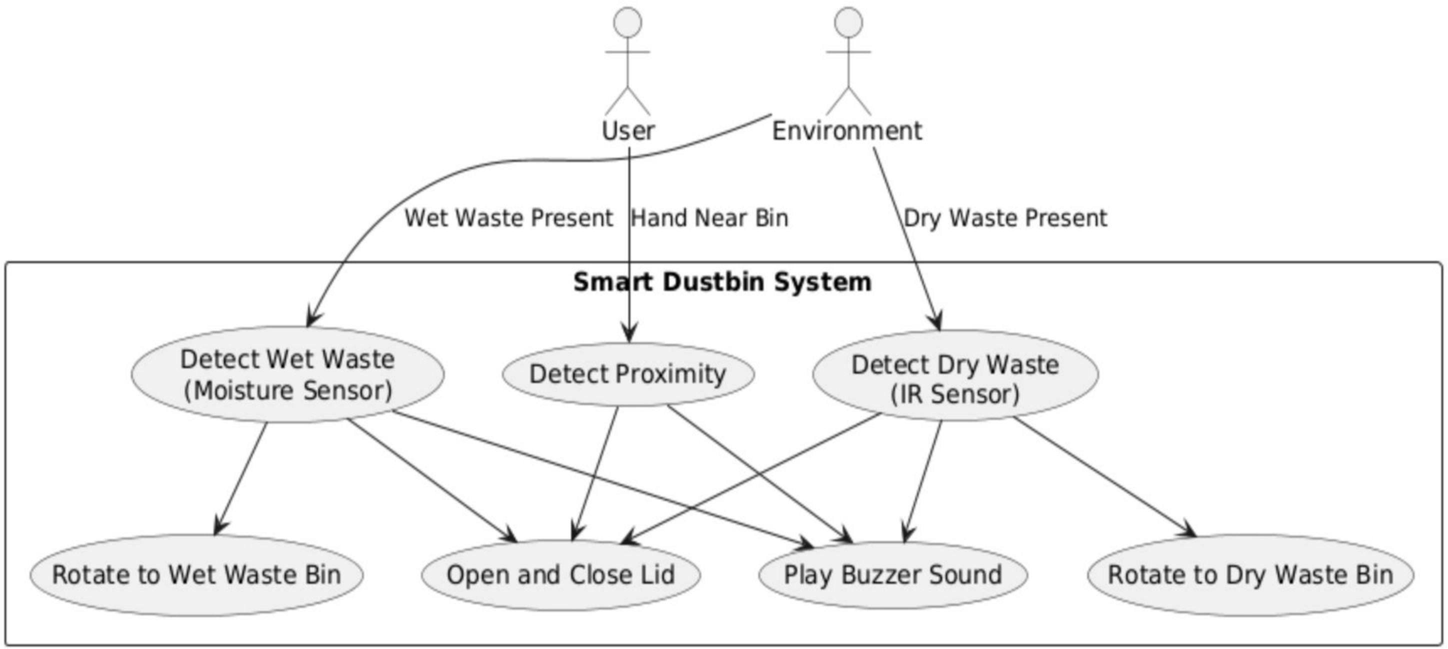
Sequence diagram



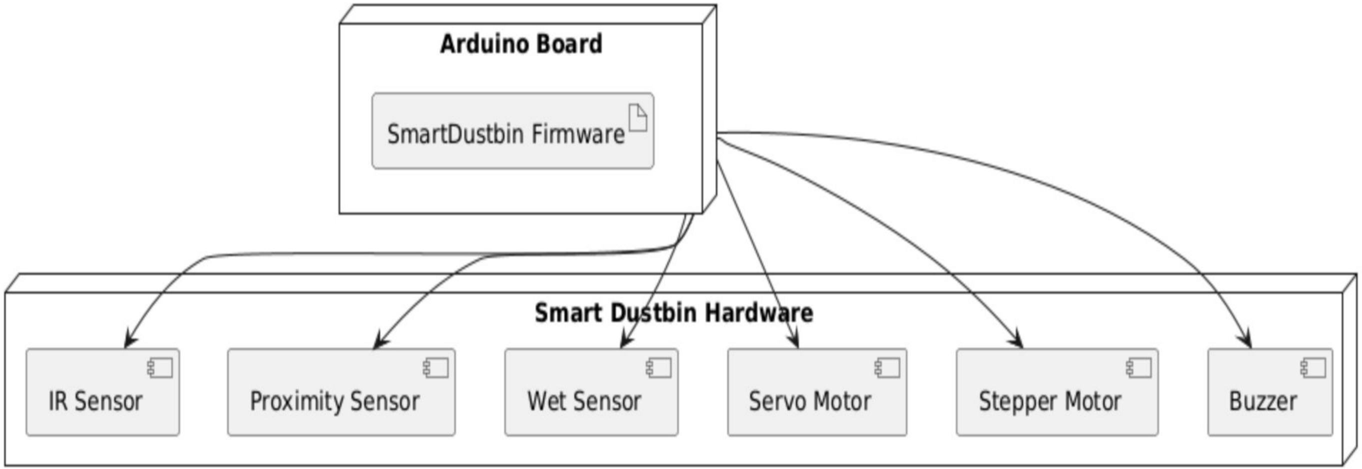
Activity diagram



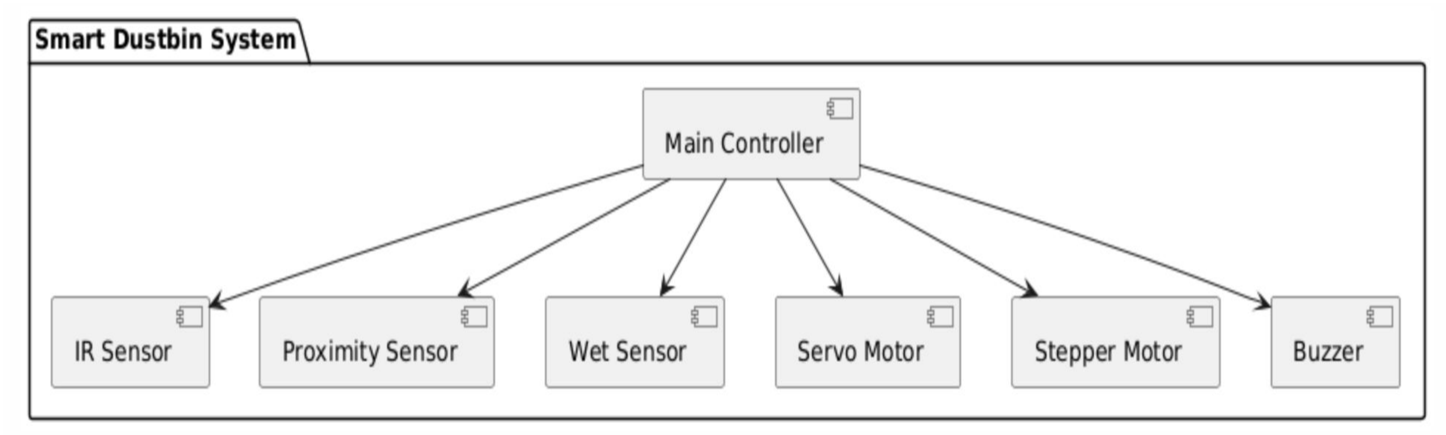
Use Case diagram



Deployment diagram



Component diagram



code

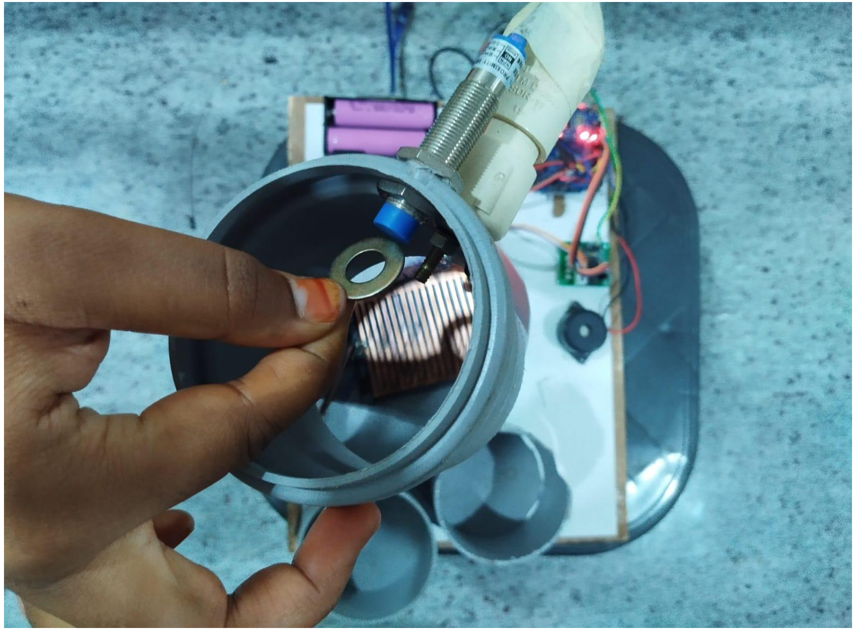
```
#include <CheapStepper.h>

#include <Servo.h>

#define ir 5

#define proxi 6

#define buzzer 12

#define wetSensorPin A0

Servo servo1;

CheapStepper stepper(8, 9, 10, 11);

void setup() {

  Serial.begin(9600);

  pinMode(proxi, INPUT_PULLUP);

  pinMode(ir, INPUT);

  pinMode(buzzer, OUTPUT);
```

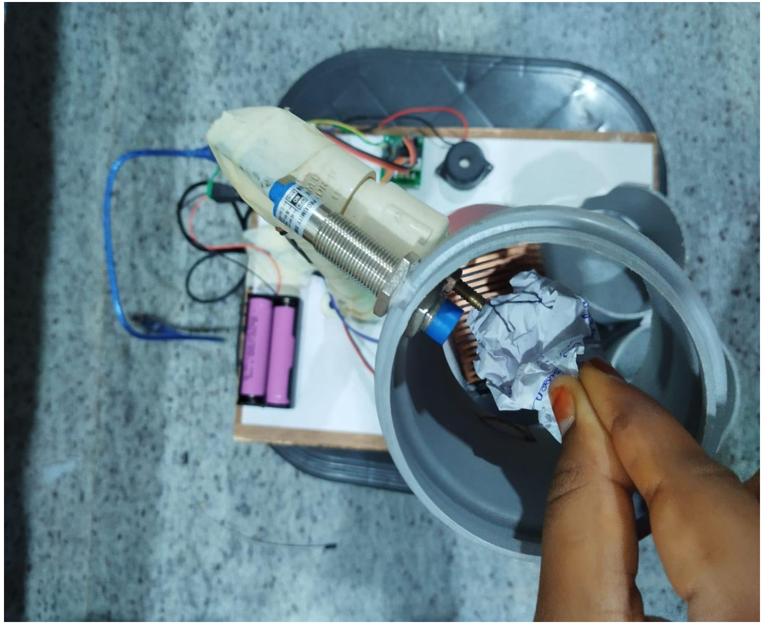
```
  servo1.attach(7);

  stepper.setRpm(17);

// Initialize lid to closed

  servo1.write(180);

  delay(1000);

  servo1.write(70);

  delay(1000);

}void loop() {

  // Proximity Sensor Logic (just open/close lid)

  if (digitalRead(proxi) == LOW) {

    Serial.println("Proximity Detected!");  // Print when proximity sensor detects

    tone(buzzer, 1000, 1000);

    servo1.write(180); delay(1000);  // Open

    servo1.write(70);  delay(1000);  // Close

  }
```

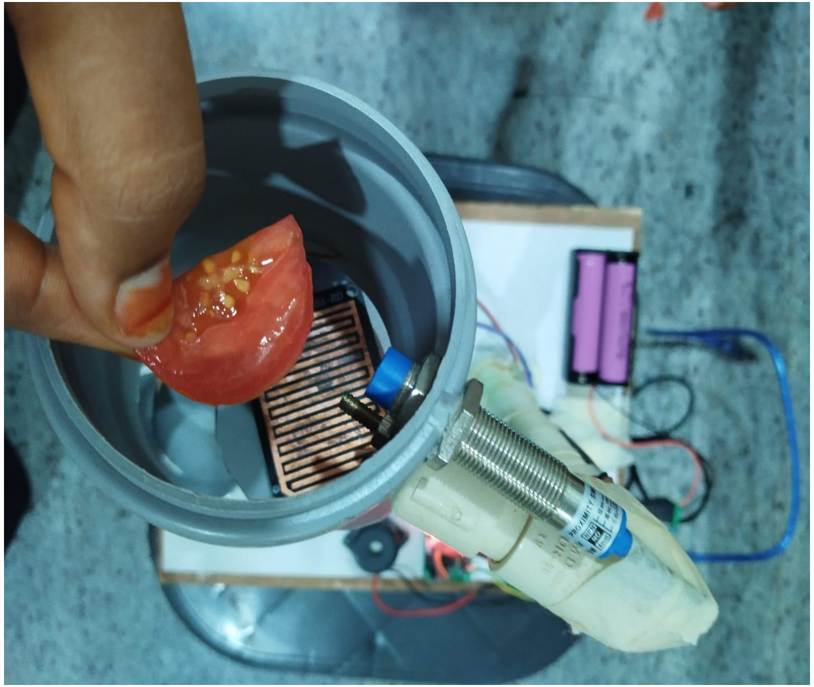
```
  // IR Sensor (Dry Waste or Metal Waste)
  if (digitalRead(ir) == LOW) {
    Serial.println("Dry Waste Detected!");  // Print when IR sensor detects dry waste or metal
    tone(buzzer, 1000, 500);
    delay(1000);
    stepper.moveDegreesCW(120); delay(1000);
    servo1.write(180); delay(1000);
    servo1.write(70);  delay(1000);
    stepper.moveDegreesCCW(120); delay(1000);
  }
// Wet Sensor (Soil Moisture)
  int moisture = analogRead(wetSensorPin);
  Serial.print("Moisture: ");
  Serial.println(moisture);
```

```
  if (moisture < 600) { // Wet detected

    Serial.println("Wet Waste Detected!");  // Print when wet waste is detected

    tone(buzzer, 1000, 500);

    delay(1000);


    stepper.moveDegreesCW(180); delay(1000);

    servo1.write(180); delay(1000);

    servo1.write(70);  delay(1000);

    stepper.move Degrees CCW(180); delay(1000);

  }


  delay(500); // Small pause between checks

}
```

RESULTS







Test Cases:

Test Case ID	Input Condition	Expected Output	Actual Output	Result
TC01	Proximity sensor detects object	Lid opens and closes automatically	Lid opens/closes	Pass
TC02	IR = LOW, Moisture < 600	Stepper moves 120°, waste to dry bin	Correct dry bin selection	Pass
TC03	IR = LOW, Moisture >= 600	Stepper moves 180°, waste to wet bin	Correct wet bin selection	Pass

TC04	Proximity = LOW (metal detected)	Stepper moves to metal bin, servo opens	Metal sorted correctly	Pass
TC05	No sensor triggered	System remains idle	No motion or alert	Pass

CONCLUSION

- Successfully automated waste segregation into dry, wet, and metal categories.
- Reduces manual labor and improves hygiene in waste handling.
- Uses sensor-based detection and motor-driven sorting, enabling real-time waste classification.
- Powered by 18650 Li-ion batteries, ensuring portability and energy efficiency.
- Provides a cost-effective, scalable, and eco-friendly solution for domestic and industrial use.

FUTURE SCOPE

- Sorting of mix of waste materials

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THANK YOU