A MINI PROJECT REPORT

on

AI BASED DISPOSAL SORTING

Submitted for partial fulfillment of the requirements for the award of the degree

of

BACHELOR OF TECHNOLOGY

In

CSE (Artificial Intelligence & Machine Learning)

Submitted by

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CERTIFICATE

This is to certify that project work entitled "**AI Based Disposal Sorting**" submitted by

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The results embodied in this Project report have not been submitted to any other University or institute for the award of any degree.

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DECLARATION

We hereby declare that the work reported in the present project entitled "**AI Based Disposal Sorting**" is a record of Bonafide work duly completed by us in the Department of CSE (AI&ML) from Vignan's Institute of Management and Technology for Women, affiliated to JNTU, Hyderabad. The reports are based on the summer internship work done entirely by us and not copied from any other source. All such materials that have been obtained from other sources have been duly acknowledged.

The results embodied in this Project report have not been submitted to any other University or Institute for the award of any degree to the best of our knowledge and belief.

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ABSTRACT

Waste management is of increasing importance to our society with increased urbanization and a growing population globally. Human labor has historically controlled waste separation, leading to inefficiencies, inconsistencies, and classification mistakes. This project is attempting an AI-based smart disposal and sorting system using Internet of Things (IoT) sensor technology to minimize human involvement in the separation of waste into three categories: wet, dry and metal (hazardous). The system uses sensors to sort waste in real time, automatically detecting and classifying waste without human intervention. Once waste type is determined, the system automatically directs the waste into one of three bins — green for wet waste, blue for dry waste, and red for metal waste — using a mechanism controlled by the sensors. The IoT system also allows for monitoring the fill levels of each bin and alerts personnel when a bin is full, enabling timely and efficient waste management. Ultimately, the system proposes a feasible solution that removes humans from the sorting process, improves sorting efficiency, and optimizes checkout for recycling purposes. It greatly assists in reducing the volume of waste being directed to landfills and addresses and maximizes operational cost savings.

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Chapter – 1

1.INTRODUCTION

1.1 Introduction:

In today's urban environments, waste management is a growing challenge that municipalities face, with traditional manual segregation methods proving to be inefficient, error-prone, and time-consuming. The improper disposal of waste not only harms the environment but also poses a significant threat to public health. Addressing this pressing issue requires innovative solutions that leverage advanced technologies like Artificial Intelligence (AI) and the Internet of Things (IoT).

This project focuses on the development of AI and IoT-enabled smart bins designed to revolutionize the way waste is managed in municipalities. These smart bins use sensors to automatically detect and segregate waste into three categories: metal, wet, and dry. The bins are color-coded—Red for metal waste, Green for wet waste, and Blue for dry waste—making it easier for users to dispose of waste correctly.

In addition to waste segregation, the smart bins are equipped with IoT-based fill-level monitoring, which allows for real-time alerts when bins are nearing capacity. This helps optimize waste collection schedules, reduce overflow, and improve overall operational efficiency for municipalities. By automating the waste segregation process, the system not only reduces the reliance on human effort but also improves recycling efficiency, contributing to cleaner and more sustainable cities.

Through the integration of AI and IoT technologies, this project aims to support municipalities in creating more efficient, cost-effective, and environmentally-friendly waste management systems.

1.2 Problem Statement:

Waste management in urban areas is increasingly challenging due to the growing population and waste generation. Traditional waste management systems, which rely on manual segregation and collection, are inefficient, prone to errors, and lead to environmental harm. Improper waste disposal contributes to pollution and missed opportunities for recycling valuable materials. Moreover, waste bins often overflow before they are emptied, leading to unsanitary conditions and inefficiencies in the waste collection process.

To address these issues, we propose an AI and IoT-enabled smart bin system designed to automate waste segregation and improve the efficiency of waste management. The system uses color-coded bins (Red for metal waste, Green for wet waste, and Blue for dry waste) to categorize waste. Each bin is equipped with specialized sensors: an inductive proximity sensor for the red bin to detect metal objects, a moisture sensor for the green bin to detect wet or organic waste, and an infrared sensor for the blue bin to identify dry waste such as paper and plastic.

In addition to waste segregation, the system includes IoT-enabled fill-level monitoring that provides real-time alerts to municipalities when bins near capacity, ensuring timely collection and preventing overflow.

This approach will automate the waste sorting process and increase the efficiency of recycling and waste management systems, promoting cleaner urban spaces and reducing the environmental impact of waste.

Chapter–2

2.1 Survey Table:

S. No	Title	Author(s)	Methodology	Limitations
1	Interdisciplinary Implementation of Supervised Real-Time Waste Management.	Praveen Kumar et al(2021) Link	Combines ML and IoT for real-time waste detection and monitoring.	Limited to basic categories, struggles with mixed waste and lighting conditions
2	Smart Dustbin Monitoring System using Arduino	Dr. Sudha L et al Link	Smart dustbin with sensors for automatic dry and wet waste segregation and real-time waste level monitoring.	Limited to basic segregation, affected by environmental conditions, requires regular maintenance.
3	An AI-Based Approach to Automatic Waste Sorting	Springer et al Link	Uses computer vision and ML for automatic recognition of waste materials from unsorted waste.	Requires further validation for real-time performance and scalability.
4	AI for Waste Management in Smart Cities	Bingbing Fang et al Link	Explores AI in smart bins and waste prediction	Lacks specific implementation details and case studies.

2.2 Motivation:

In recent years, the rapid growth of urban populations and industrialization has led to a dramatic increase in waste generation. A large portion of this waste remains improperly segregated, resulting in serious challenges for recycling plants, municipal corporations, and environmental sustainability. Improper waste segregation causes recyclable materials to end up in landfills, increases pollution, and poses health hazards to waste workers and communities.

Traditional waste segregation relies heavily on manual labor, which is not only inefficient and error-prone but also exposes workers to health risks. Moreover, existing smart bins have limited capabilities, often detecting only basic waste types like wet and dry. They struggle with identifying metals or hazardous waste, and their dependency on consistent internet and power supply makes them less viable in rural or resource-constrained areas.

With the advancement of AI and IoT, there is a growing potential to transform the way we handle and manage waste. The motivation behind this literature survey is to understand what has already been developed, identify what works and what doesn't, and highlight how an improved, AI-integrated solution can help automate the process of waste sorting in a more accurate, efficient, and scalable way. This also supports larger goals like smart cities, zero waste initiatives, and environmental conservation.

2.3 Objective:

The objective of this literature survey is to conduct a comprehensive review of existing Artificial Intelligence (AI) and Internet of Things (IoT)-based waste sorting technologies. This involves critically analysing current systems to understand how they function, evaluating their performance in real-world applications, and identifying both their technical strengths and limitations. Special attention is given to how effectively these systems classify waste into distinct categories—particularly wet, dry, and metal—and the degree of accuracy achieved through different AI models.

Furthermore, the survey aims to explore challenges faced by existing solutions, such as limited ability to handle complex or mixed-material waste, high dependency on environmental conditions (e.g., lighting, moisture, contamination), and operational issues like power or internet outages that affect IoT functionality. By identifying these research gaps, the survey provides valuable insights that can inform the design and development of a more robust and intelligent waste segregation system.

Ultimately, this analysis lays the groundwork for creating an improved AI-based smart bin solution—one that utilizes advanced object detection algorithms, real-time sensor feedback, and IoT connectivity to automate and enhance waste sorting. The goal is to increase classification accuracy, reduce the burden on human labor, optimize recycling workflows, and support sustainable waste management practices in both urban and rural settings.

Chapter–3

SYSTEM ANALYSIS

3.1 Existing System:

Currently, most waste management systems in urban areas rely on basic segregation techniques that separate waste into only two main categories: wet and dry. These systems often use basic sensors or depend heavily on user compliance for initial sorting. While some smart bins have been introduced that can distinguish between organic (wet) and inorganic (dry) waste using moisture or infrared sensors, they do not have the capability to detect or segregate metal waste separately. This limitation leads to metal waste being mixed with other types, which not only reduces the quality of recyclable materials but also makes further manual sorting necessary. Additionally, most of these systems lack IoT integration for real-time monitoring, resulting in bins that frequently overflow before they are emptied, causing hygiene issues and operational inefficiencies. The absence of full automation and real-time data collection contributes to higher labor costs, delayed collection, and poor recycling rates. These drawbacks highlight the need for a more comprehensive and intelligent solution that can segregate metal, wet, and dry waste automatically and support municipalities with real-time fill-level data to optimize their collection schedules.

3.2 Drawbacks of Existing System:

- **Segregation Limitations**: Most existing smart bin systems are limited to differentiating between wet and dry waste. This overlooks metal waste, which is recyclable and should be handled separately.
- **Lack of Smart Monitoring:** Many bins do not feature IoT-based real-time fill-level monitoring, which results in inefficiencies such as overflowing bins or underutilized collection routes.
- **Dependence on Manual Labor:** Even with partial automation, manual intervention is still needed to verify or re-segregate waste, introducing human error.
- **Reduced Recycling Efficiency:** The failure to isolate metal waste leads to contamination of recyclable streams, decreasing the effectiveness of recycling processes.

3.3 Proposed System:

To address the shortcomings of existing waste management systems, this project proposes an innovative AI and IoT-enabled smart bin system designed to automate the segregation of waste into three distinct categories: metal, wet, and dry, utilizing cutting-edge sensor technology. The system features Red bins that are equipped with inductive proximity sensors, which allow the detection and segregation of metal waste, ensuring that metals are accurately identified and separated for recycling. Green bins are equipped with moisture sensors that can detect the presence of water, identifying wet or organic waste such as food scraps or biodegradable materials, allowing for the efficient processing of compostable materials. Blue bins, fitted with advanced infrared sensors, are capable of recognizing dry waste like paper, plastic, and other non-organic materials, ensuring that these items are effectively sorted for recycling or disposal. In addition to the automatic waste segregation capabilities, each bin in the system is integrated with IoT modules that continuously monitor and transmit real-time fill-level data to a central monitoring system, providing waste management operators with up-to-date information about bin capacity. This feature allows for timely waste collection, preventing bin overflow and minimizing the risk of unsightly waste accumulation in public spaces. Furthermore, the integration of IoT technology enables a more efficient and responsive waste management process for municipalities, improving operational effectiveness, reducing costs, and contributing to a cleaner, more sustainable environment by ensuring that waste is sorted, collected, and processed in a more organized manner.

3.4 Hardware and Software Requirements:

3.4.1 Hardware Requirements:

- Arduino Board
- Battery holder
- lithium battery
- Raindrop sensor
- IR sensor
- proximity sensor
- servo motor
- stepper motor driver
- Dc stepper motor
- jumper wires
- dc power connector 12 volts

3.4.2 Software Requirements:

- C language
- Arduino IDE

Chapter–4

SYSTEM DESIGN

4.1 Architecture:

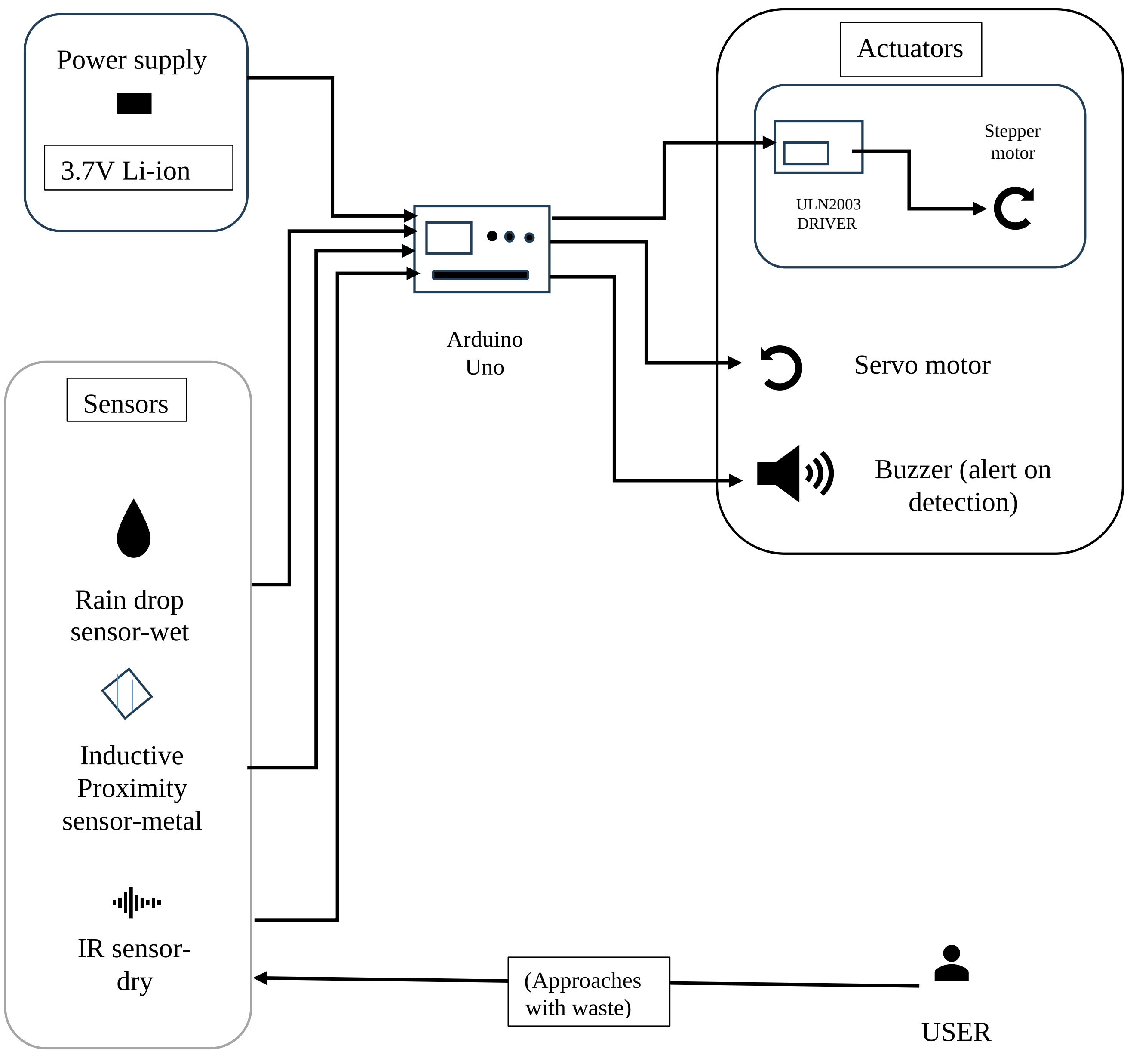

fig.no:4.1.1: System Architecture

4.2 UML Diagram:

4.2.1 Activity Diagram:

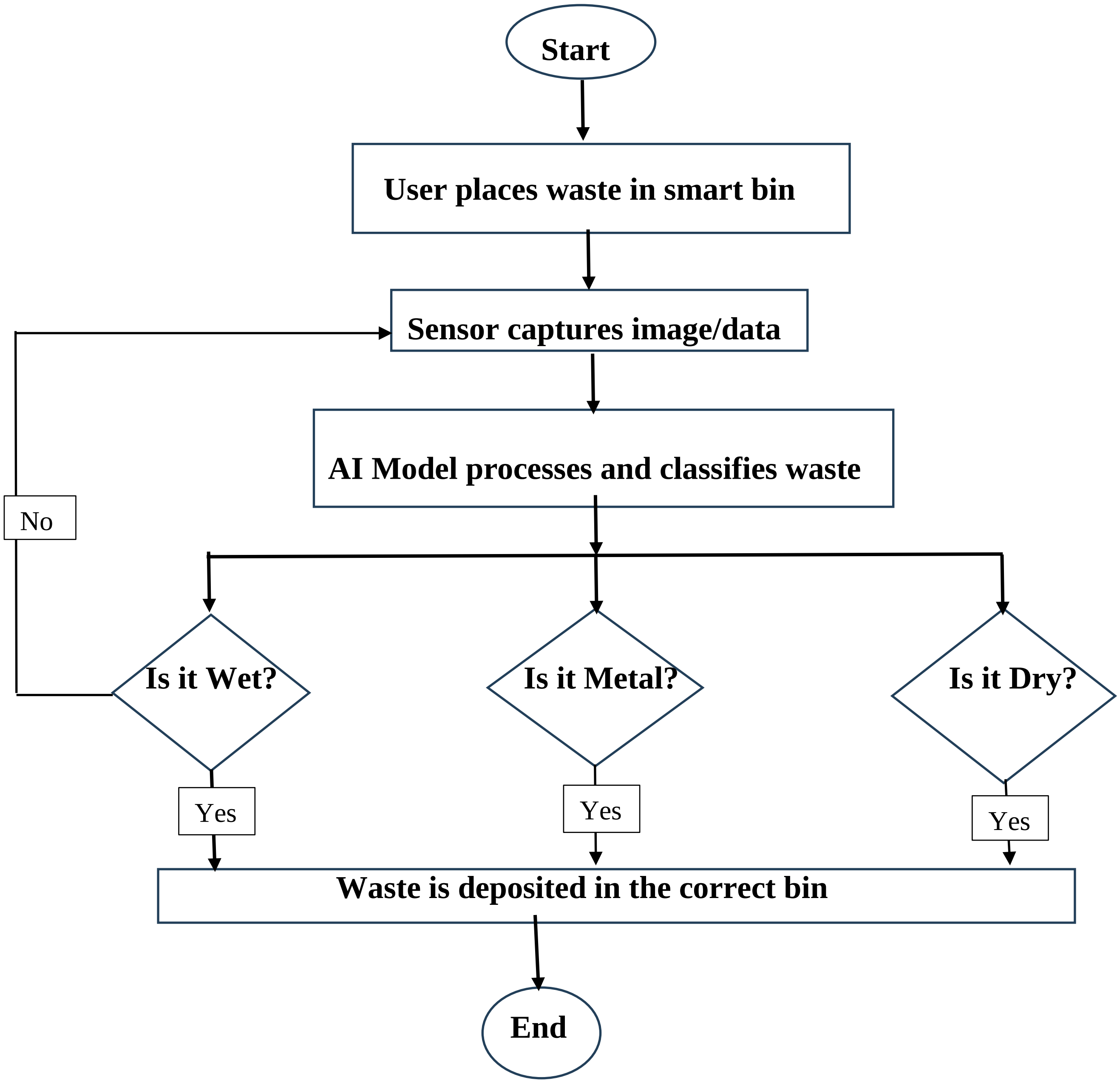

fig.no:4.2.1: Activity Diagram

4.2.2 Sequence Diagram:

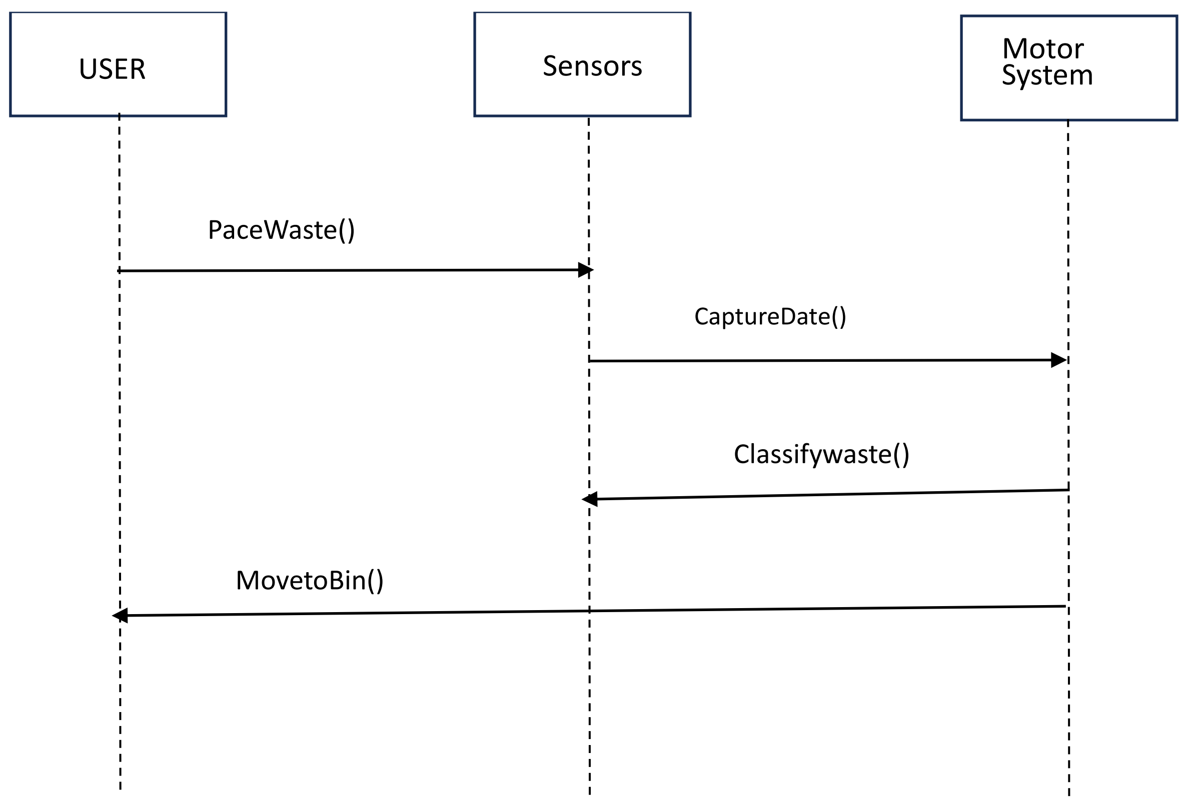

fig.no: 4.2.2: Sequence Diagram

4.2.3 Use Case Diagram:

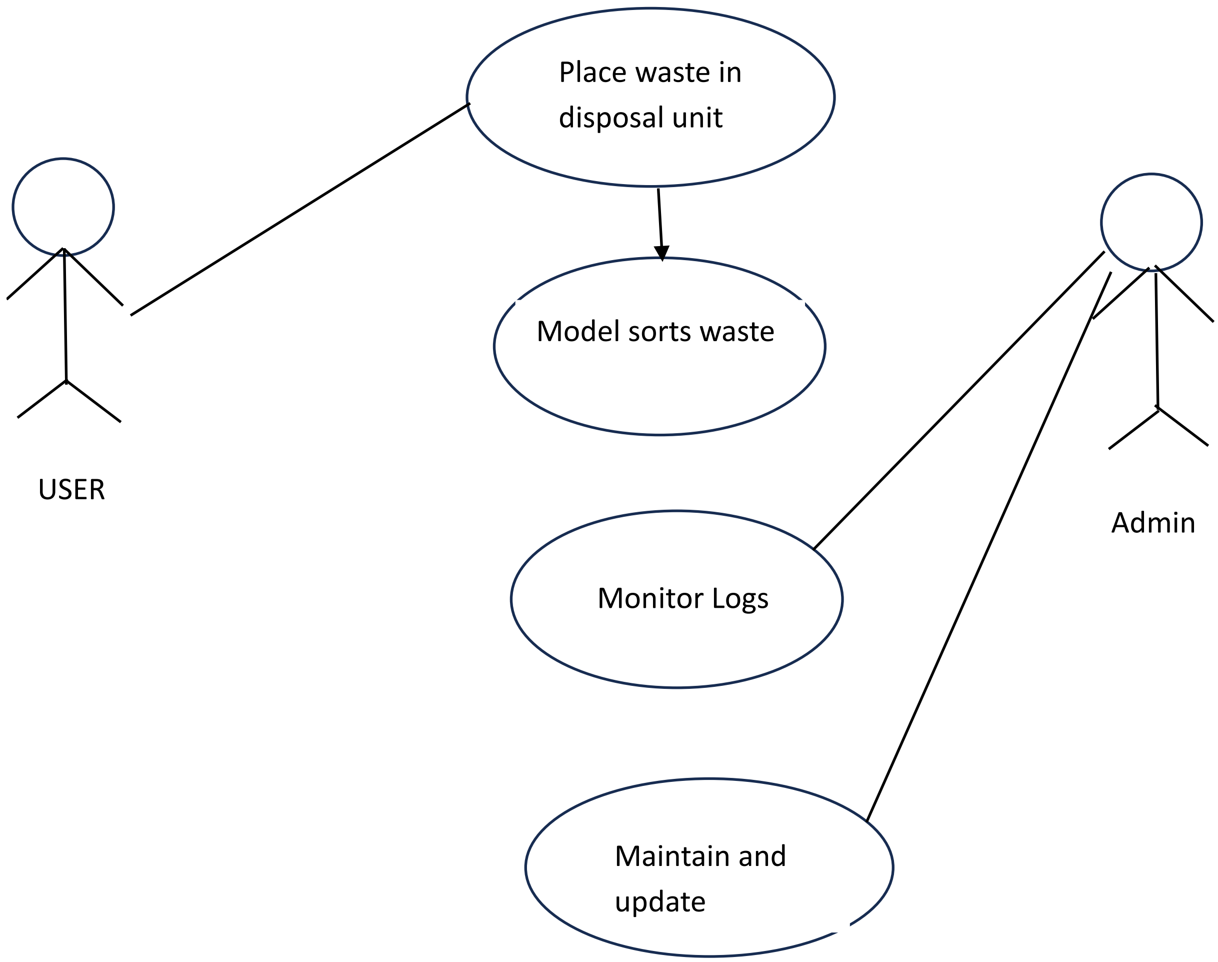

fig.no:4.2.3: Use Case Diagram

Chapter–5

IMPLEMENTATION

5.1 Module Split-up:

1. Waste Input Module

This module allows users to input various types of household or municipal waste into the system, preparing it for sorting and processing.

2. Sensor Detection Module

Moisture Sensor: Detects wet waste (organic waste like food scraps, etc.).

Inductive Proximity Sensor: Detects metal waste (such as aluminum cans, steel items, etc.).

Default Logic: Any waste that doesn't fall under wet or metal is considered dry waste (such as paper, plastic, etc.).

3. Processing & Controller Module

An Arduino Uno processes input from the sensors and uses simple conditional AI logic to classify the waste type (metal, wet, or dry) based on sensor data.

4. Sorting & Movement Module

Once the waste type is identified, a servo motor activates to rotate or shift a flap/gate, directing the waste into the correct bin (metal, wet, or dry).

5. IoT Monitoring Module

- **Fill Level Monitoring**: The system uses **IR sensors** or **proximity sensors** to measure the fill levels of each bin. These sensors detect the amount of waste inside the bins by assessing the distance or presence of waste near the top of the bin.

- **Data Transmission**: The fill-level data is sent to an IoT platform allowing for remote monitoring of bin status.

- **Alerts**: The system generates alerts when a bin reaches its capacity, triggering an **LED light indicator** to show that the bin is full. This helps optimize waste collection schedules by notifying the relevant authorities when bins need to be emptied.

5.2 Implementation:

The implementation phase involves integrating hardware and software components to bring the smart waste segregation system into action. The goal is to deploy a working prototype that automatically detects and classifies waste into three categories (wet, dry, and metal) and directs each type to the correct bin. Below is the detailed breakdown of the implementation:

Hardware Setup

Sensors:

- **IR Raindrop Sensor:** Used to detect wet waste by measuring moisture levels.
- **Proximity Sensor:** Detects metal waste by identifying the presence of metallic objects.
- **IR / Optical Sensors:** Used to detect dry waste (e.g., paper, plastic).

Microcontroller (Arduino):

- Acts as the central processing unit (CPU) that receives input from sensors.
- Processes sensor data and executes logic to determine the waste type.
- Controls the servo motors to sort waste into the correct bin.

Servo Motors:

- Used to rotate or open the appropriate bin flaps, directing waste into the correct bin (metal, wet, or dry).

Buzzer and Display:

- Provides user feedback and alert messages during system operation.
- Software and IoT Integration

Microcontroller Programming:

- Programmed using Embedded C or the Arduino IDE.

Logic:

- **Metal Waste:** If metal is detected, direct the waste to the Red Bin.

- **Wet Waste:** If wet waste is detected (via IR raindrop sensor), direct to the Green Bin.
- **Dry Waste:** If neither metal nor wet waste is detected, direct to the Blue Bin.

IoT Integration:

- **Fill Level Monitoring**: Instead of ultrasonic sensors, the system uses **IR sensors** or **proximity sensors** to measure the bin fill levels.
- **Fill Level Indicator**: When a bin reaches its capacity, an LED light is activated to indicate that the bin is full.

Working Flow:

- **Waste Insertion:** User inserts waste into the smart bin.
- **Waste Detection:** Sensors (IR raindrop, proximity, and IR) detect the type of waste (wet, dry, or metal).
- **Data Processing:** Microcontroller processes sensor data to classify the waste.
- **Action:** The servo motor activates to sort the waste into the appropriate bin.
- **Waste Sorting:** The waste is dropped into the correct bin (Red, Green, or Blue).
- **Bin Monitoring:** The system monitors bin fill levels using IR sensors or proximity sensors. When the bin is full, an LED light is triggered to indicate the bin is full.

5.3 Technologies Used:

This project utilizes a combination of Artificial Intelligence (AI), the Internet of Things (IoT), and sensor technology. AI algorithms enable automatic classification of waste into metal, wet, and dry categories, while IoT modules with ultrasonic or infrared sensors monitor bin fill levels in real-time. Microcontrollers, such as Arduino or Raspberry Pi, serve as the system's processing units, enabling communication between sensors and cloud-based dashboards for efficient data tracking and alert generation. Together, these technologies create an intelligent, automated waste management solution.

5.4 ALGORITHM:

Step1: Power on the system to begin operations.

Step2: Set up all required components, including:

IR sensor

Rain drop sensor

Proximity sensor

Servo motor

Stepper motor

Step3: Wait for an object to be placed in the detection area for processing.

Step4: Retrieve sensor data from the following components:

IR sensor value (IR_Value)

Rain drop sensor value (Rain_Value)

Proximity sensor value (Proximity_Value)

Step5: Analyze the sensor data to categorize the waste:

- **If metal is detected by the proximity sensor:**

  Identify the object as metal waste.

  Rotate the stepper motor to direct the object towards the metal bin.

  Trigger the servo motor to drop the metal waste.

- **If moisture is detected by the rain drop sensor:**

  Identify the object as wet waste.

  Move the stepper motor to position the wet bin correctly.

  Activate the servo motor to release the wet waste into the bin.

- **If the IR sensor detects an object (not metal or wet):**

  Classify the object as dry waste.

  Turn the stepper motor to align the dry bin in place.

  Activate the servo motor to release the dry waste into the bin.

- **If no object is detected:**

  Display a message indicating "No object detected."

Step6: Reset the motors (servo and stepper) to their initial positions for the next operation.

Step7: Repeat the process by waiting for the next object to be placed in the detection area, starting from Step 3.

Step8: Stop the system once the waste sorting task is complete.

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RESULT

6.1 Screenshots:

- **Wet Detection:**

fig.no:6.1.1: Wet Detection

- **Dry Detection:**

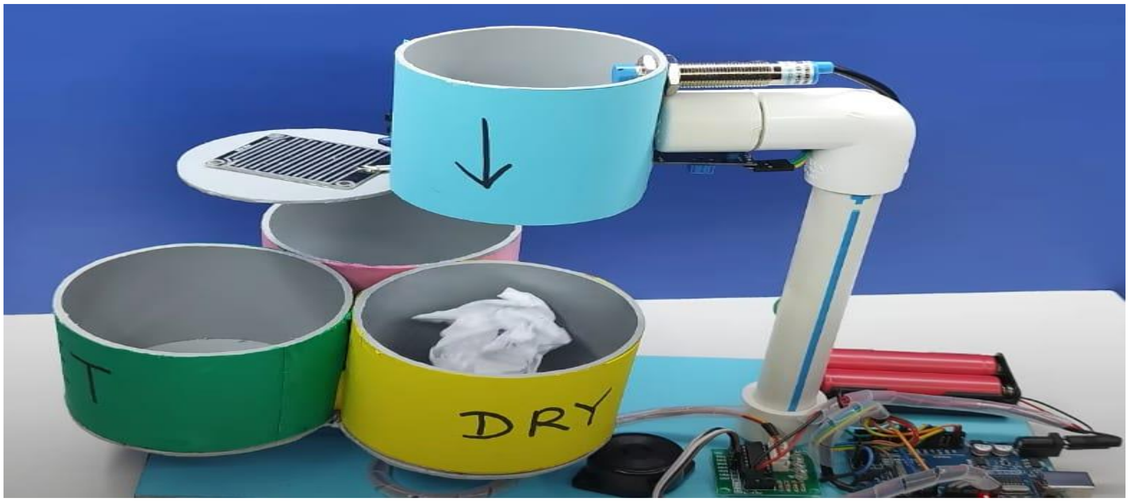

fig.no:6.1.2:Dry Detection

- **Metal Detection:**

fig.no:6.1.3: Metal Detection

Chapter–7

TESTING

7.1 Unit Testing:

Unit testing was conducted on each individual component of the smart waste segregation system to verify its basic functionality before integration. The IR raindrop sensor was tested to ensure it accurately detects moisture levels to identify wet waste, while the proximity sensor was evaluated for its ability to sense metal objects effectively. The IR sensor was also tested to confirm its reliability in detecting dry waste when neither wet nor metal characteristics were present. Additionally, servo motors were checked to confirm that they could rotate smoothly and precisely in response to sorting commands. The LED indicators and the Wi-Fi communication module were also individually tested to ensure correct signaling and stable connectivity for data transmission.

7.2 Integration Testing:

After confirming the functionality of individual components, integration testing was carried out to examine how these components worked together in a complete system. This phase involved connecting the sensors to the microcontroller and testing whether correct inputs led to the expected servo motor responses. For example, when wet waste was detected, the system had to trigger the servo motor to direct waste to the green bin. The integration testing also ensured that if metal was detected, the red bin was selected, and if neither wet nor metal waste was identified, the system defaulted to sorting the waste into the blue bin for dry materials. Additionally, the system was tested to confirm that the LED indicators were activated only when a bin became full based on readings from the proximity or IR sensors positioned near the top of each bin. This phase ensured that the logical flow from sensor input to physical movement and visual output worked cohesively and consistently, mimicking real-world operation.

7.3 Acceptance Testing:

Acceptance testing involved running the complete prototype in real-world conditions to evaluate its effectiveness and adherence to the intended use-case. The smart bin system was loaded with various common types of waste to observe how accurately and reliably it could detect, classify, and sort them. Wet waste like vegetable peels and damp paper were identified correctly by the moisture sensor and directed to the green bin. Metal items such as aluminum foil or keys were accurately classified and directed to the red bin, while other dry waste such as plastic wrappers or cardboard were sorted into the blue bin. During extended use, the system’s response time, sorting accuracy, and indicator reliability were evaluated. The LED indicators functioned as expected when bins were nearly full, helping to signal the need for manual waste collection. This testing confirmed the system’s readiness for deployment in public or residential waste management environments.

7.4 Testcases:

To ensure thorough validation, a wide range of test cases were designed and executed. These test cases covered both normal operation and edge scenarios to assess how the system would behave under different conditions. Tests were created to verify the sensor responses to various materials, including slightly moist or partially metallic items, to evaluate detection accuracy. The microcontroller's logic was tested under different sequences of waste inputs to confirm that decision-making remained consistent. Sorting accuracy was measured by tracking servo motor direction and final waste placement. Fill-level detection was tested by gradually filling each bin and ensuring the LED light turned on precisely at the set threshold. Long-duration tests were also carried out to evaluate the durability and consistency of the system under repeated use. These test cases provided a complete understanding of the system’s performance, reliability, and areas for potential improvement.

Chapter–8

CONCLUSION

In this project, we developed a smart bin system that automates the segregation of waste into three categories: wet, dry, and metal. Using advanced sensors like IR, raindrop moisture, and proximity sensors, the system accurately detects and classifies waste types, ensuring proper disposal without manual intervention. Additionally, the system is equipped with a feature that alerts users with a visual light indicator when a bin is full, allowing for timely waste collection and preventing overflow. This smart waste management solution is specifically designed for municipalities, helping to streamline waste collection processes, reduce human error, and enhance overall waste management efficiency. By automating sorting and monitoring, the system contributes to cleaner and more sustainable urban environments.

Chapter–9

FUTURE ENHANCEMENT

While the current smart waste segregation system meets the primary objectives of automating waste sorting and providing real-time alerts for bin fill levels, there are several future enhancements that could further improve its functionality and impact:

- **AI-Based Waste Classification:**

  Implementing machine learning algorithms could allow the system to refine its waste classification capabilities, improving its accuracy in identifying a wider range of waste materials, such as glass, textiles, and electronic waste.

- **Mobile Integration and Notifications:**

  Integrating mobile apps could allow waste management teams or even citizens to receive real-time notifications when bins are full, ensuring that waste collection schedules are optimized and efficient.

- **Solar-Powered Bins:**

  Incorporating solar panels into the bins would make the system more energy-efficient, especially in remote or off-grid areas, by providing sustainable power for the sensors and communication modules.

- **Data Analytics and Reporting:**

  Enhancing the system with data analytics tools could help municipalities track waste patterns, bin usage, and waste generation trends. This data could assist in optimizing waste collection routes and strategies.

- **Integration with Smart City Infrastructure:**

  Connecting the waste segregation system with other smart city systems, such as traffic management or environmental monitoring, could improve overall operational efficiency and create a more cohesive smart city ecosystem.

- **Automated Waste Collection Vehicles:**

  Future upgrades may include automated waste collection vehicles that communicate with the smart bins. These vehicles would collect waste only when bins are full, improving fuel efficiency and reducing unnecessary collection trips.

- **Public Awareness and Engagement:**

  Adding features that engage the public in waste management, such as educational displays or gamification features on the bins, could promote better recycling habits and raise awareness about sustainability.

Chapter–10

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SAMPLE CODE

```
#include <CheapStepper.h>

#include <Servo.h>

Servo servo1;

#define ir 5

#define proxi 6

#define buzzer 12

int potPin = A0; //input pin

int soil=0;

int fsoil;

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);

  servo1.write(180);

delay(1000);

servo1.write(70);

delay(1000);

}
```

```
void loop()
{
  fsoil=0;
  int L =digitalRead(proxi);
Serial.print(L);
if(L==0)
{
  tone(buzzer, 1000, 1000);
 stepper.moveDegreesCW (240);
delay(1000);
servo1.write(180);
delay(1000);
servo1.write(70);
delay(1000);
stepper.moveDegreesCCW (240);
delay(1000);
}
if(digitalRead(ir)==0)
{
   tone(buzzer, 1000, 500);
 delay(1000);
  int soil=0;
  for(int i =0;i<3;i++)
```

```
{

 soil = analogRead(potPin) ;
      soil = constrain(soil, 485, 1023);
        fsoil = (map(soil, 485, 1023, 100, 0))+fsoil;
          delay(75);
      }
    fsoil=fsoil/3;
    Serial.print(fsoil);
    Serial.print("%");Serial.print("\n");
    if(fsoil>20)
           {
            stepper.moveDegreesCW (120);
            delay(1000);
              servo1.write(180);
              delay(1000);
              servo1.write(70);
                delay(1000);
              stepper.moveDegreesCCW (120);
                delay(1000);
              }
else {
         tone(buzzer, 1000, 500);
```

```
  delay(1000);

            servo1.write(180);


 delay(1000);

              servo1.write(70);

                delay (1000);

}

}

}
```