Abstract

Plastic pollution in rivers has become a critical environmental issue, harming ecosystems, wildlife, and human health. Much of the waste produced daily is improperly discarded, with plastic debris posing significant risks as it pollutes waterways and leaches harmful chemicals.

Research highlights that three rivers in India are responsible for over 90% of global plastic waste entering the oceans—the Indus, Ganga, and Brahmaputra. These rivers are major contributors to plastic waste. The Indus ranks second in terms of mismanaged plastic waste, while the Ganga and Brahmaputra together rank sixth. The source of pollution originates from both urban and rural areas, with common pollutants including PET bottles, plastic bags, and discarded plastic items.
To tackle this challenge, this project aims to improve waste management systems along riverbanks by developing a device that automatically sorts waste into plastic and non-plastic components using a flapper mechanism. This innovation will enhance efficiency and reduce reliance on manual sorting.Studies indicate that 57 major rivers carry between 40 lakh tonnes of plastic waste into oceans annually, with just ten rivers responsible for 90% of this pollution. A combination of high population density along riverbanks and inadequate waste management contributes to this crisis.

The approach aligns with Sustainable Development Goal 14 (Life Below Water), emphasizing the protection of marine environments. This project aims to enhance river waste management and contribute to environmental preservation by addressing riverine plastic pollution at the source. Furthermore, this research seek to collobrate partnerships with government agencies and NGOs to combat plastic pollution, ensuring a cleaner and healthier environment for future generations.

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Chapter 1

Introduction

1.1 Introduction

Plastics play a vital role in numerous industries and are made up of long chains of molecular monomers that create large macromolecules. Despite their extensive use, there are rising concerns about their non-biodegradable nature and the harmful emissions released when they are burned. The adaptability of plastics enables their application in fields such as packaging, agriculture, automotive, and healthcare. While there are ongoing efforts to create sustainable polymer products from renewable sources, environmental issues related to marine/river pollution continue to worsen due to poor waste disposal practices. This problem is heightened by the health risks linked to seafood that is contaminated with plastic particles and toxic substances, like phthalates and heavy metals.

In India, three significant rivers the Indus, Ganga, and Brahmaputra—are among the leading sources of plastic pollution in the oceans. The Indus ranks second in the quantity of plastic waste it carries, while the Ganga and Brahmaputra combined hold the sixth position. The repercussions of plastic pollution can be felt in both economic and ecological aspects, with over 300 million metric tons of plastic produced globally each year, nearly half of which is discarded shortly after its initial use. It is essential to implement effective waste management strategies for plastics and to enhance the development of biocompatible polymer implants for medical uses. The build-up of plastic waste in bodies of water presents a serious environmental danger, threatening aquatic ecosystems, marine life, and human health. If left unresolved, large plastic waste can break down into smaller microplastics, which are more difficult to manage and pose long-term ecological and health risks. A clear example of these challenges can be found at Dadar Beach in Mumbai, where ongoing cleanup initiatives have revealed the urgent need for better and more sustainable waste management solutions. This initiative seeks to align with the United Nations Sustainable Development Goals (SDGs) 14 (Life Below Water) to enhance plastic waste management

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practices, minimize ecological damage, and protect marine ecosystems by building a device in boundary of river

1.2 Motivation

The motivation of this project is to address the urgent issue of plastic pollution in rivers, which are vital ecosystems for millions. The rampant use of plastic, combined with poor waste management, leads to significant environmental and health challenges. The conversion of larger plastics into microplastics poses long-lasting ecological threats, as these particles persist in the environment for centuries. The socio-economic impacts such as reduced fish stocks and increased cleanup costs further highlight the need for immediate action. To combat this, the project aims to develop an autonomous device for waste segregation primarily into plastic, organic, and non-plastic along with the integration of hotspots. This idea seeks to combat the plastic waste produced by major rivers and thereby support recycling of the waste for industries and government organizations.

1.3 Objectives

1. To develop a device that can efficiently collect waste from the boundary of the rivers.
2. To differentiate the waste collected by the device i.e plastic waste and other debris
3. To notify the authorized users using Cloud technology
4. To Collaborate with local communities, NGOs, and policymakers to promote sustainable practices, raise awareness, and support regulatory compliance for effective coastal waste management.

1.4 Scope

1 The device is intended for use specifically in river areas.
2 It classifies waste into two categories: plastic and non-plastic. This method of separation restricts the sorting of different kinds of waste.
3 As build in smaller scale, the device can take maximum 2 pieces of waste / second

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Chapter 2

Literature Review

The paper [1] presents an IoT-based water surface waste-collecting robot designed to automate waste removal from rivers using a conveyor belt mechanism and real-time monitoring. It integrates ultrasonic sensors for obstacle detection and solar power for sustainability, reducing human intervention and operational costs. The proposed system enhances efficiency through remote control and automation, but limitations exist in waste classification, scalability, and navigation. The study concludes that while the robot effectively collects floating debris, improvements in AI-based waste differentiation, GPS navigation, and battery optimization* are needed for large-scale applications. Addressing these gaps will improve the system's adaptability and long-term efficiency in cleaning polluted water bodies.

The paper [2] presents the design and development of a solar-powered, remote-controlled trash collector boat to remove floating waste from water bodies. The system features a conveyor belt mechanism for efficient waste collection and uses lightweight materials for better maneuverability. A microcontroller-based control system enables remote operation, while solar panels ensure sustainable energy use. The study concludes that the prototype effectively collects waste but has limited autonomy and storage capacity, making large-scale deployment challenging. The main research gaps include the need for autonomous navigation using AI and GPS, automated waste classification, and increased storage capacity for long-term operations. Additionally, real-world testing in dynamic water environments is necessary to assess its durability and scalability. Future improvements should focus on AI-based sorting, enhanced automation, and larger-scale deployment to improve efficiency in real-world applications.

The authors in [3] investigates the efficiency of manual versus automated sorting systems for plastic waste. The study utilizes NIR/VIS optical sorting technology, it evaluates sorting

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parameters such as purity and capacity at different conveyor speeds. Results show that automated systems achieve over 95% sorting purity at higher capacities, proving more economical and effective than manual sorting. The study advocates for automated sorting technologies as a sustainable solution for municipal plastic waste management, emphasizing their economic viability and environmental benefits in a circular economy.

The paper introduces the MARBLE (Mobile Autonomous RoBot for Litter Emptying) project, focusing on optimizing waste management using autonomous robots. The authors in this study [4] employs machine learning to predict litter bin (LB) filling levels, it enhances route planning and operational efficiency. Techniques like the Knapsack algorithm and Simulated Rebalancing reduced energy consumption by 31% and operational time by 26%, outperforming traditional methods. The XGBoost model achieved 81% accuracy in filling level predictions. This approach minimizes unnecessary trips, reduces resource consumption, and supports sustainable urban waste management, aligning with the UN's Sustainable Development Goals.

The study [5] offers a thorough examination of artificial intelligence applications within waste management, particularly in the context of smart cities. It emphasizes the difficulties created by rising waste production linked to urban development and economic expansion. The research investigates a range of AI-based innovations such as waste-to-energy technologies, smart bins, automated sorting systems, and waste monitoring solutions. It highlights how AI contributes to optimizing logistics, cutting costs, enhancing recycling effectiveness, and lessening environmental harm. Furthermore, the review addresses the combination of chemical analysis with AI to improve waste-to-energy conversion processes and better estimate carbon emissions. Overall, the paper illustrates AI's significant potential to transform waste management systems into more sustainable and efficient operations worldwide.

The research paper [6] investigates the issue of plastic waste accumulation in Indonesia using a comprehensive approach that integrates remote sensing, statistical methods, and socio-demographic data. It constructs a multi-scenario model to estimate the volume of unmanaged plastic waste in river estuaries, factoring in elements such as land use, population density, and economic indicators including nighttime light intensity. The study

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identifies significant regions contributing to plastic pollution and outlines three scenarios—low, medium, and high—regarding the mismanagement of plastic disposal. The findings highlight the critical need for effective spatial planning and policymaking to tackle plastic waste at its source, enhance management approaches, and meet sustainable development goals. This research provides an important framework for prioritizing intervention areas and implementing targeted strategies.

The paper [7] explores existing autonomous waste collection and classification systems, highlighting advancements and limitations in robotic trash sorting. Prior studies have implemented AI-driven waste classification, but many solutions are either costly, inefficient, or lack adaptability for diverse environments. Research on deep learning models like YOLOv5 has shown promise in object detection, yet few applications integrate it into a mobile manipulator framework for waste management. Traditional waste sorting techniques rely on sensor-based detection, but these often struggle with complex waste differentiation. Additionally, robotic grasping mechanisms in waste collection have been explored, but optimizing grasp poses for efficient pickup remains a challenge. This paper aims to bridge these gaps by developing a low-cost, autonomous waste-sorting robot that combines YOLOv5 for classification, ultrasonic sensors for object detection, and a 6-degree-of-freedom robotic arm for grasping and sorting.

The authors of the paper [8] introduce VERO, a quadruped robot equipped with a vacuum system for efficient litter removal, addressing key gaps in existing robotic waste management solutions. Unlike traditional wheeled waste-collecting robots, VERO is designed to navigate uneven terrains effectively. The study integrates AI-driven computer vision to accurately detect and classify litter in real-world environments, overcoming limitations in prior models that struggle with variable trash appearances. The vacuum system enhances waste collection efficiency, reducing the need for mechanical gripping mechanisms that may be less effective in certain conditions. This research provides a novel combination of mobility, AI-based waste detection, and vacuum-powered collection, making it a more adaptable and efficient solution compared to previous waste collection robots.

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Environmental activists are increasingly concerned about waste accumulation, particularly in river areas where debris eventually flows into the ocean. To address this issue, the paper [9] introduces the RT-Bot (River Trash Bot), a remote-controlled robot designed to collect floating waste from water bodies. The research involves designing a 3D model, integrating mechanical and electronic components, and conducting testing and deployment. The robot operates on a rechargeable battery powered by solar panels, ensuring sustainable energy use. Experimental trials compared three different propeller types, with net propellers proving the most effective for garbage collection, outperforming metal fishbone and plastic propellers. The study found that the propeller net significantly enhanced collection accuracy, and the robot could function for approximately 1.4 hours per charge. Additionally, solar panel data revealed a maximum voltage of 19.50V at 12:00 noon under clear, sunny conditions. Overall, the findings confirm the robot's efficiency in removing floating waste from river environments.

The authors of paper [10] introduced the "Aquatic Iguana," a cost-effective and advanced floating robot designed to remove floating waste such as plastic, packets, and leaves from water surfaces. In addition to its waste collection capabilities, the robot is equipped with pH, turbidity, and temperature sensors for real-time water quality monitoring. It also features live streaming, enhancing its functionality and data collection. The development of this robot aims to clean water bodies efficiently while simultaneously generating a comprehensive dataset for future water quality predictions.

The study [11] introduces an innovative robot, powered by a Raspberry Pi 4B and Arduino Uno, designed to detect and collect plastic waste with minimal human intervention. Equipped with a camera module and ultrasonic sensor, the robot autonomously identifies waste, optimizes its position for collection, and utilizes a rotating collector mechanism for efficient retrieval. By integrating image processing using OpenCV and sensor-based adjustments, the system enhances accuracy in waste detection and collection. The Segra-Bot is envisioned as an advanced waste collection system that independently detects, categorizes, aligns, adjusts distances, and retrieves plastic waste. With key components such as gear motors and intelligent control units, this scalable robotic solution offers a significant step towards reducing pollution and promoting environmental sustainability.

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The system introduces an automated robotic solution for waste sorting and recycling by identifying and categorizing different types of waste. Traditional waste sorting is time-consuming and susceptible to human errors, but the authors of the paper [12] integrates IoT and machine learning to enhance efficiency. The process begins with sensors and cameras in the waste collection area, where sensors capture weight, size, and color, while cameras provide visual data. A Raspberry Pi processes this information and transmits it to the cloud for further analysis. The Support Vector Machine (SVM) algorithm, trained on a dataset of waste categories, classifies materials as recyclable or non-recyclable. Based on this classification, robotic arms or conveyor belts segregate waste into designated containers, ensuring precise and efficient sorting. Real-time video management enhances accuracy and enables simultaneous data collection from multiple waste collection points. The cloud-based system allows for real-time data processing and analysis, improving waste classification accuracy through machine learning. By integrating IoT, machine learning, and cloud computing, this innovative approach enhances waste management, minimizes manual labour, and promotes sustainable recycling practices.

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Chapter 3

Problem Statement

3.1 Drawback of Current Approaches

Through various research studies, we have identified several limitations in the devices implemented to date. Some devices use a net system to collect waste, which can unintentionally capture marine life, thereby decreasing their populations. Other devices are designed with a conveyor belt that collects all types of junk, but the devices do not distinguish between different waste categories. Additionally, a few devices segregate waste into solid, wet, and dry categories; however, none have successfully separated plastic from other types of litter. Therefore, the solution to the existing problems will be explained in Section 3.2

3.2 Solution to Above Problem

The device would be implemented near the boundary of the river. The device features a conveyor belt that collects junk. This belt moves continuously, driven by electric motors powered by batteries. In the front of the belt, there will be V-shaped rods equipped with blades that will direct waste to the belt. This device is integrated with an IR sensor to detect incoming waste, capacitive sensors that detect the waste collected, and an Ultrasonic sensor to track the bin level. Once the capacitive sensor identifies the plastic and non-plastic waste, an automated sorting mechanism equipped with a flapper directs the waste into the two bins. Plastic Waste Bin: A container specifically designed to hold collected plastic waste and a Non-Plastic Waste Bin: A separate container for other types of waste such as organic matter, solid litter, or debris. Once either of the bin statuses becomes full, a notification will be sent to the authorized user, indicating the user to empty the bins. Also, this study focuses on the impacts of plastic on marine life.

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Chapter 4

Project Description

4.1 Overview of Project

This project aims to segregate waste into three categories: plastic, organic, and non-plastic. The segregation happens directly on the device, which employs a flapper mechanism and conveyor belts to process the waste. The device will be installed along the banks of a river, where V-shaped pipes equipped with blades will direct waste onto the conveyor belt. Once the waste is on the conveyor belt, it will be sorted by the flapper, which rotates at a 60-degree angle via a servo motor. The waste will be categorized based on density and color and collected into three separate bins. The primary goal of this project is to effectively manage waste and reduce its harmful impact on humans and the environment.

The segregation process is supported by data collected from sensors and sent to the NodeMCU 32. When any of the bins are maximum, the conveyor belt will stop, and a notification will be sent to the designated person responsible for waste collection. After the waste is collected, an analysis will be conducted to identify areas with higher concentrations of plastic waste, ultimately helping to protect marine life and human health.

4.2 Module Description

4.2.1 Conveyor Belt and Motorized System

Conveyor belts are specifically engineered to gather floating debris on river surfaces. A motor consistently advances the waste toward a designated separation area. The sturdy design of the conveyor allows it to handle substantial amounts of debris and to perform well under different environmental conditions.

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4.2.2 Segregation Module

The system utilizes infrared and ultrasonic sensors to accurately detect the type and quantity of waste. Non-plastic materials are redirected to a separate non-plastic waste stream, while identified plastic items are sent to the designated plastic waste. This process effectively ensures that waste is sorted correctly for either disposal or recycling.

4.2.3 Smart Bin

Ultrasonic sensors will be utilized to monitor the capacity of the bins. When the bins reach full capacity, an alert will be dispatched via a GSM module, which will also include the GPS coordinates of the bin's location. Additionally, data will be uploaded to the cloud using LoRa technology for efficient remote monitoring.

4.2.4 Cloud Integration

The data from sensors, which includes information on bin status, GPS locations, and waste levels, is sent to the cloud for storage and analysis. This processed data is then visualized, providing users with real-time statistics on the bins and their waste collection activities.

4.2.5 User Interface and Alerts

The web interface provides status details that encompass the system's overall health, the fill levels of the bins, and the rates for each category. When a bin reaches full capacity, users are notified via SMS, and Google Maps can be used to pinpoint the bin's location.

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4.3 UML Diagrams

4.3.1 Block Diagram

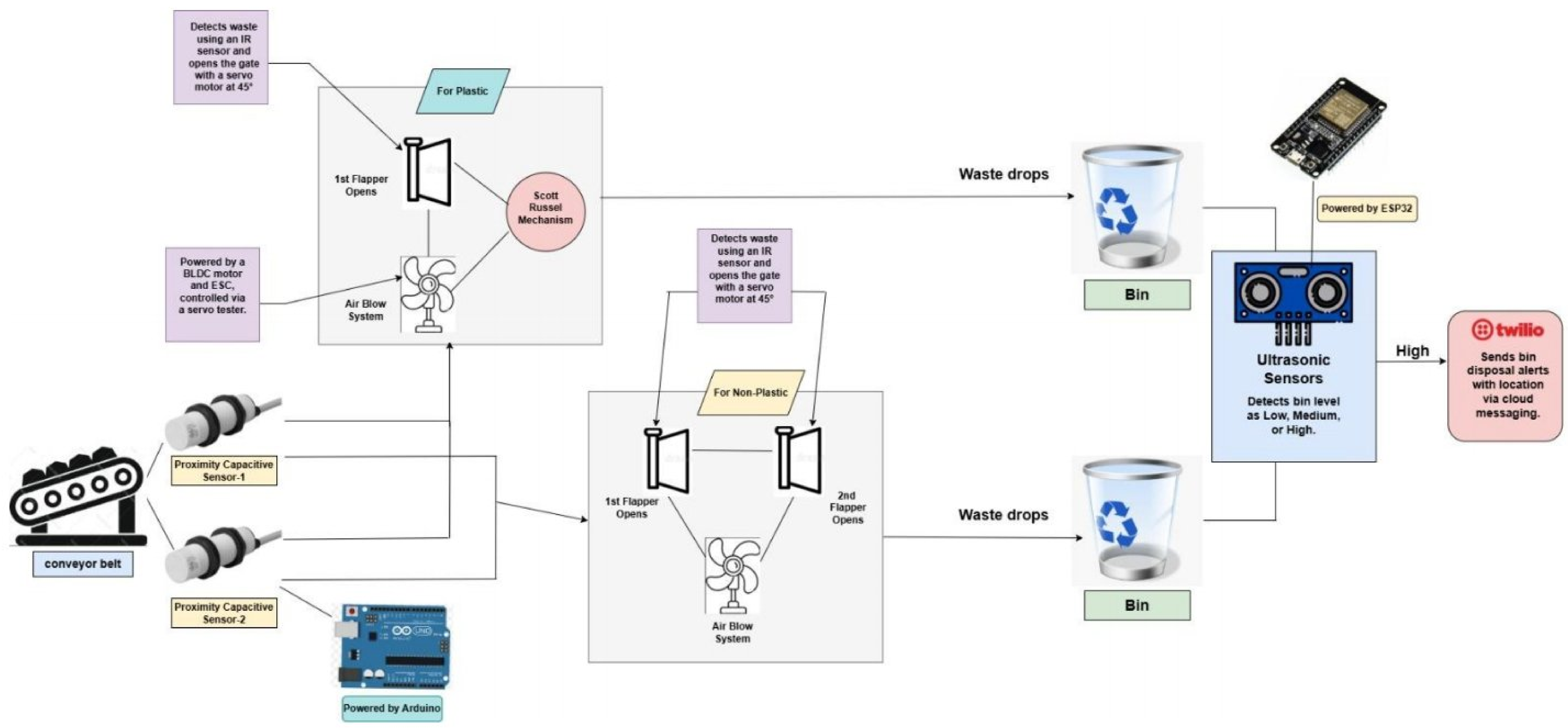

Fig 4.3.1 Block Diagram of the system

Fig 4.3.2 Flowchart of the system

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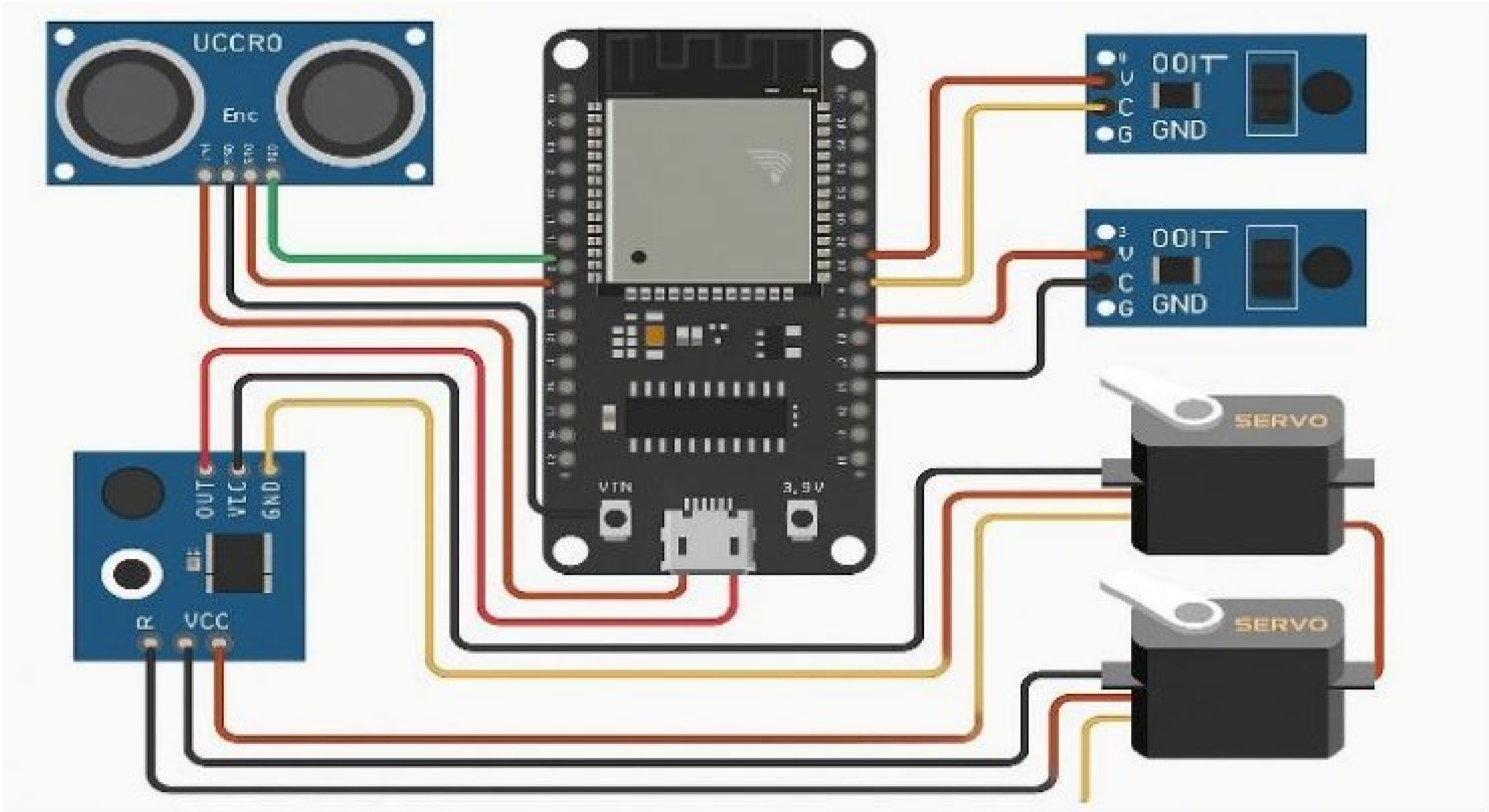
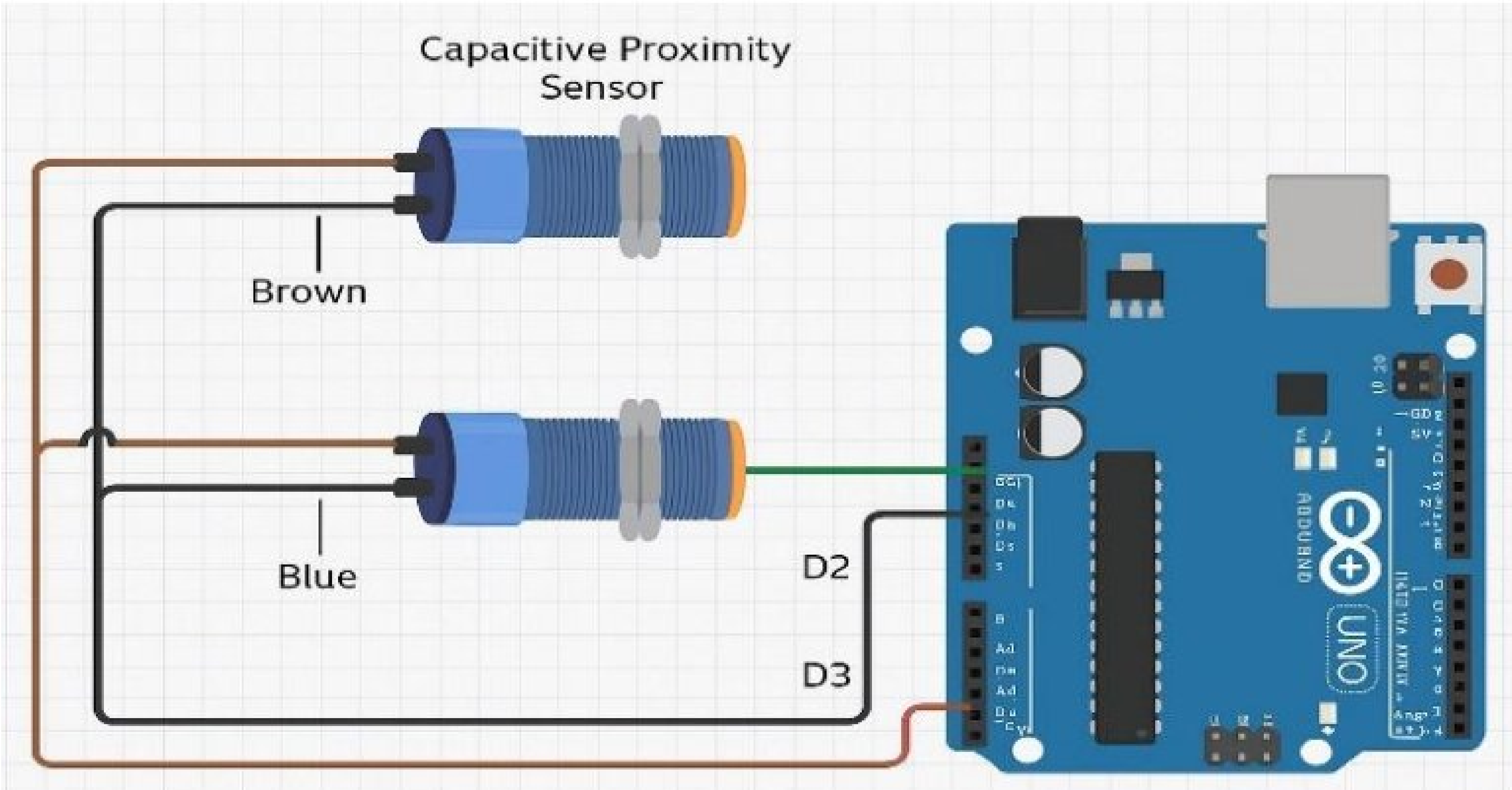
4.4 Circuit Diagrams

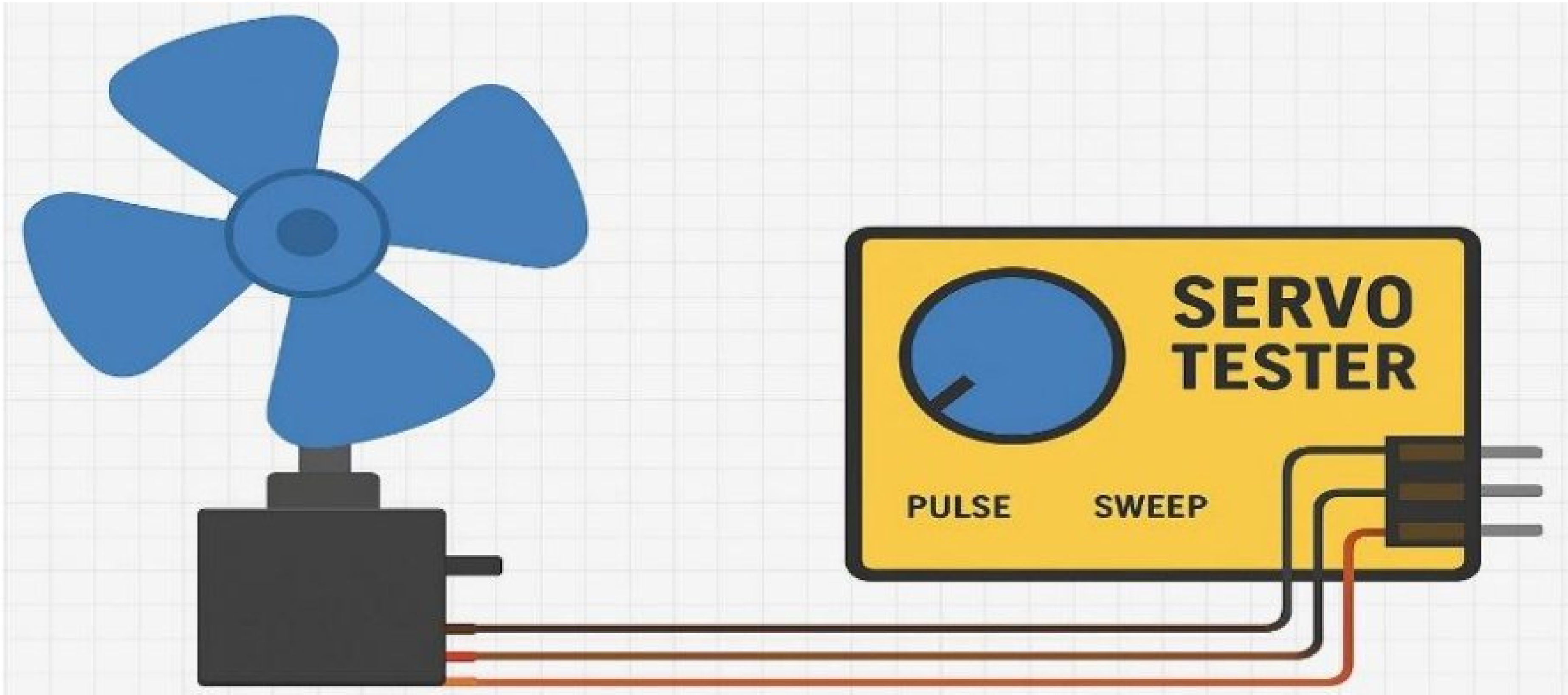
4.4.1 Integration of IR & Ultrasonic Sensors, Servo Motors with ESP 32



4.4.2 Integration of Proximity Capacitive Sensors with Arduino Uno



4.4.3 Air Blow System



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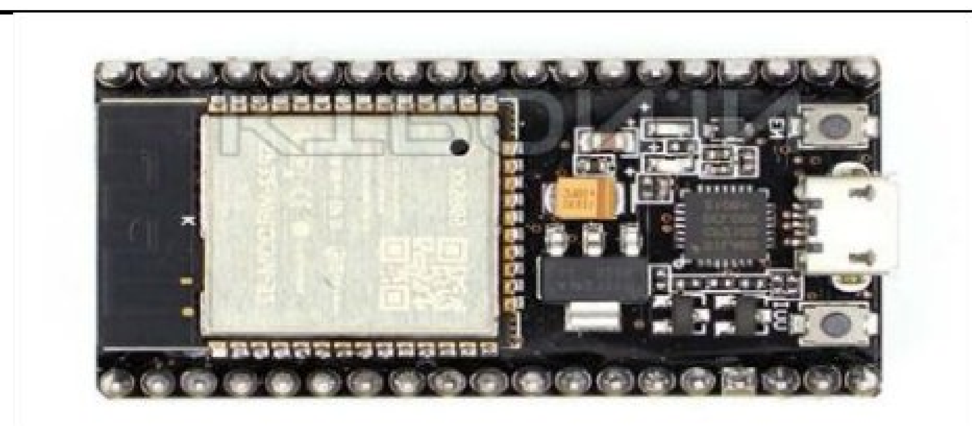
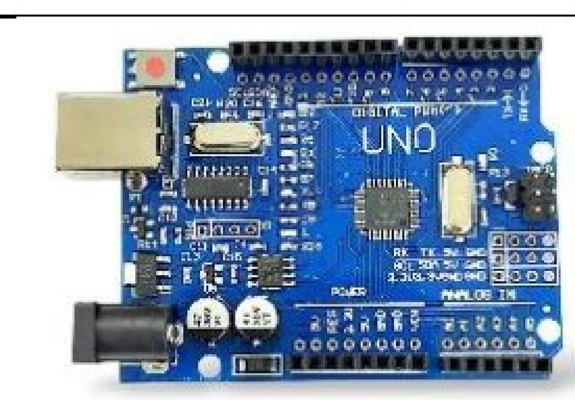
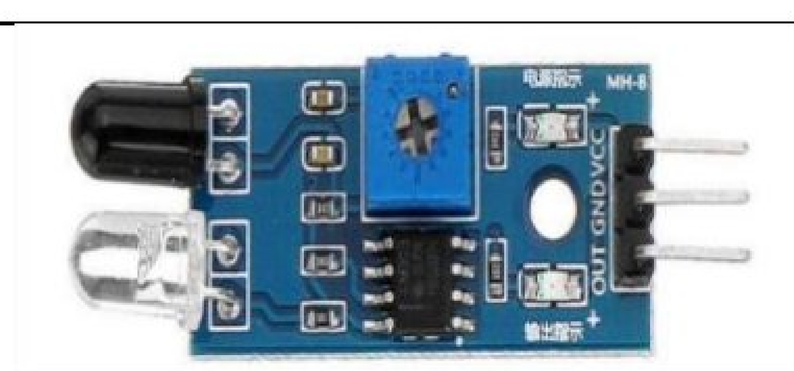
Chapter 5

System Design and Requirements

5.1 Hardware Requirements for the System

Components Name	**Purpose**
 Node MCU 32	Microcontroller to control the sensors and real-time monitoring
 Arduino Uno	Microcontroller to control the proximity capacitive sensors
 HC-SR04 Ultrasonic	To measure the fill levels of the bins.
 REES52 IR Sensor	To detect the incoming waste
 CM30-3020NC Proximity Capacitive Sensor	To detect the different types of waste

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 GPS Module	To get the locations of the bin
 Aluminium Sheet	The material used to create stands for the conveyor belt
 60 X 4 RPM Torque Motors	To provide the rotation for the conveyor belt
 7V Battery	To provide power to the motors
 60 cm X 15 cm Conveyor Belt	To collect the waste from the river boundary

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 4 X Wheels	Attached to the motors for continuous movement of the belt
 8 X L-Shaped Claps	To provide a support system for the stands
 3 x Propellers	To give a thrust force for incoming waste near the river boundary
 2 X Rods	Vertical V-Axis rods to support the motors and propellers

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5.2 Software Requirements for the System

Platform Names	Purpose
Arduino IDE	For programming and testing the hardware components
Firebase	Cloud service for data storage of bin level
Google Maps	To know the location of the bins once they are full i.e latitude and longitude
Twilio	To send the SMS to the authorized users once the bins are full

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Chapter 6

Implementation Details

6.1 Methodology

6.1.1 CAD Design

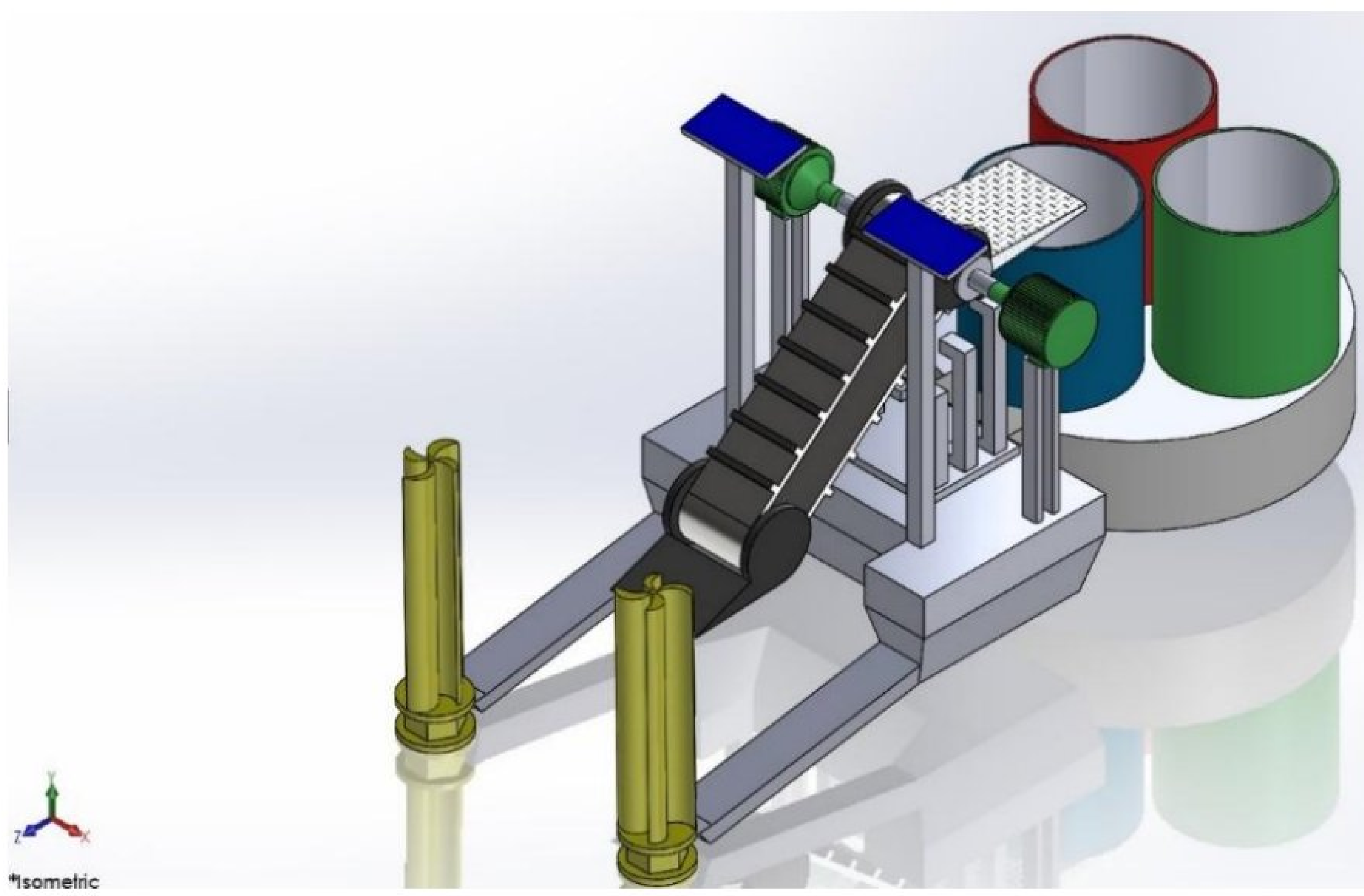

Fig 6.1.1 Overall Design

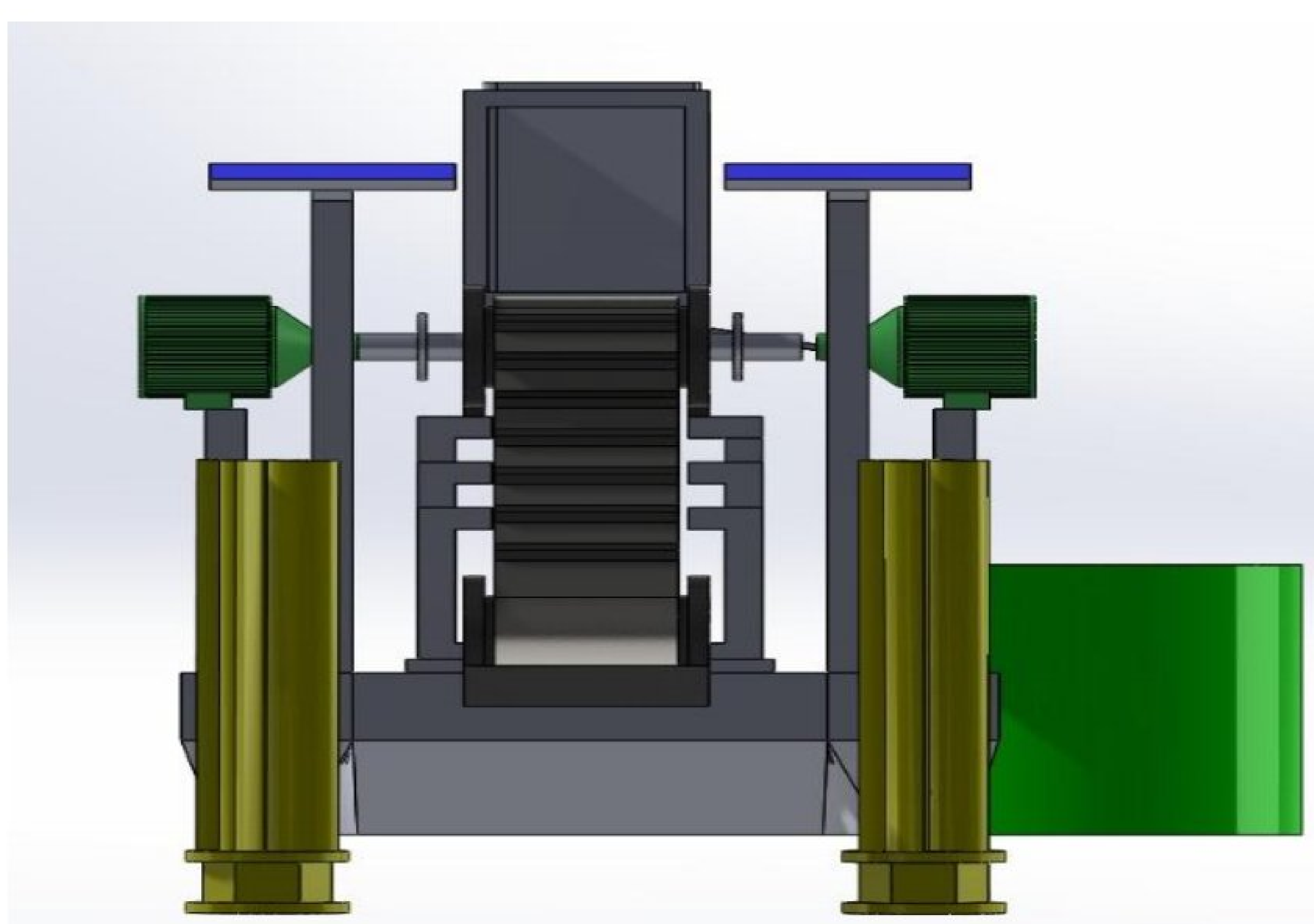

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Fig 6.1.2 Front View od CAD Model

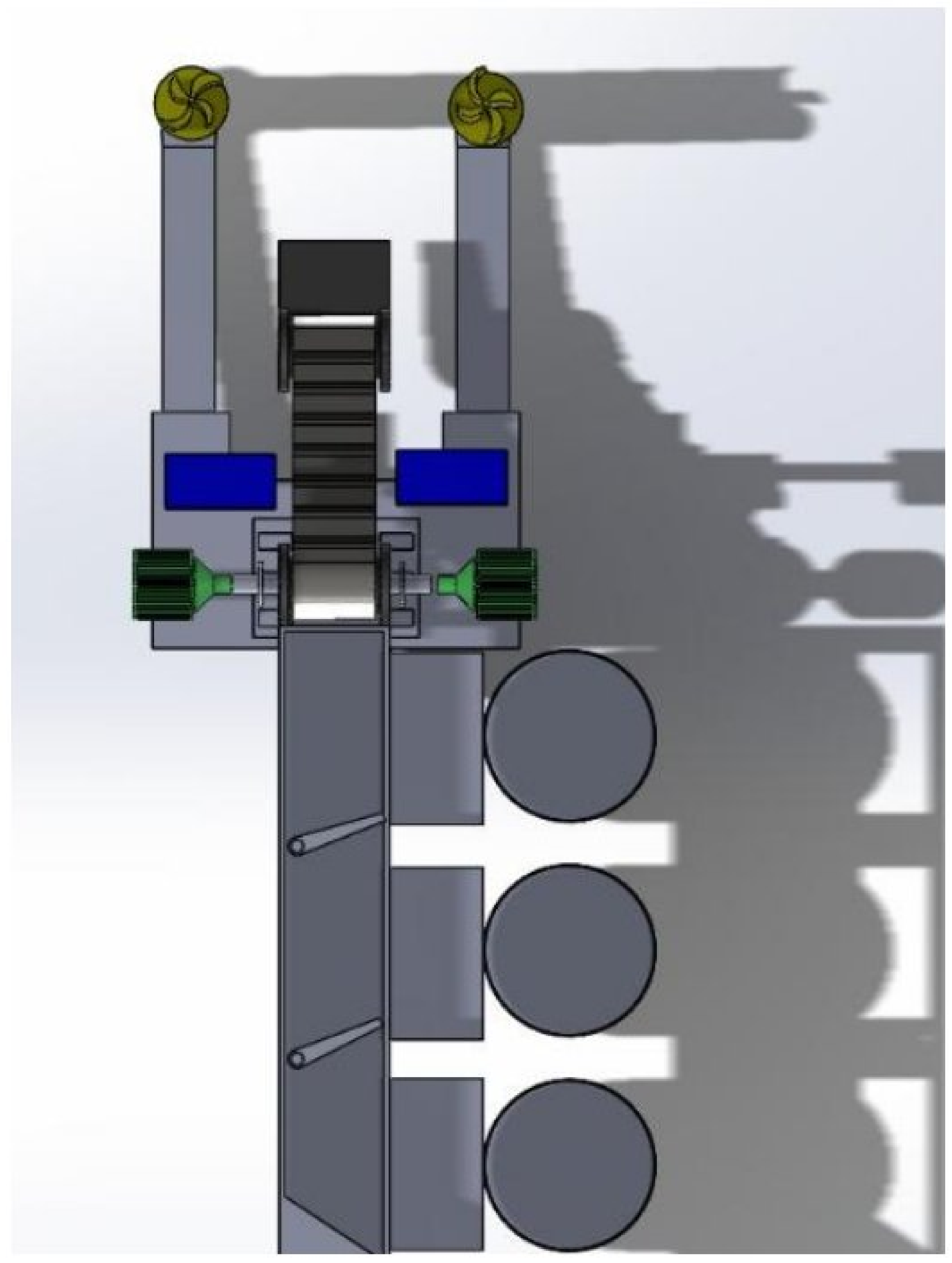

Fig 6.1.3 Top View of CAD Model

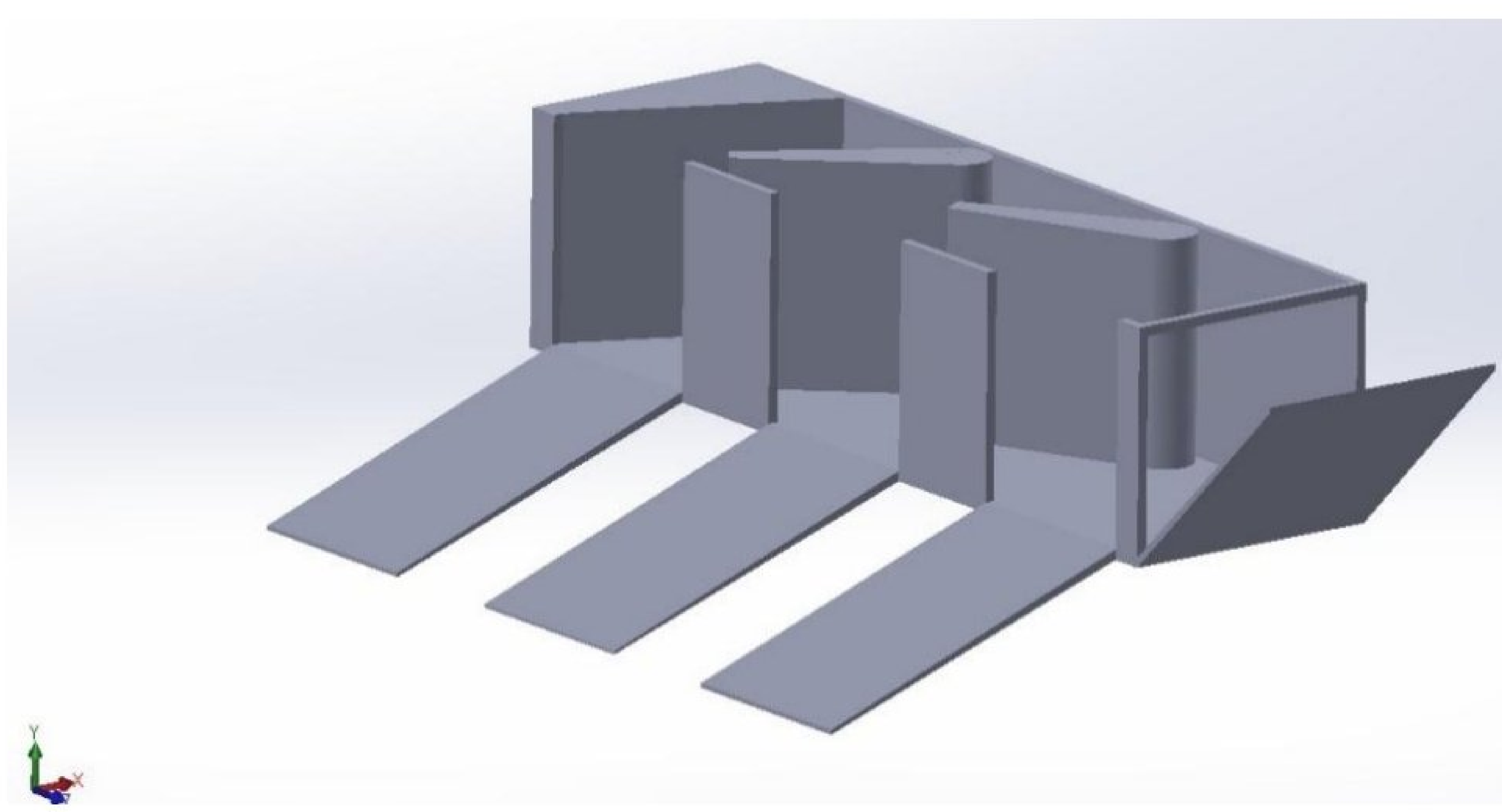

Fig 6.1.4 Flapper Mechanism

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6.2 Hardware setup

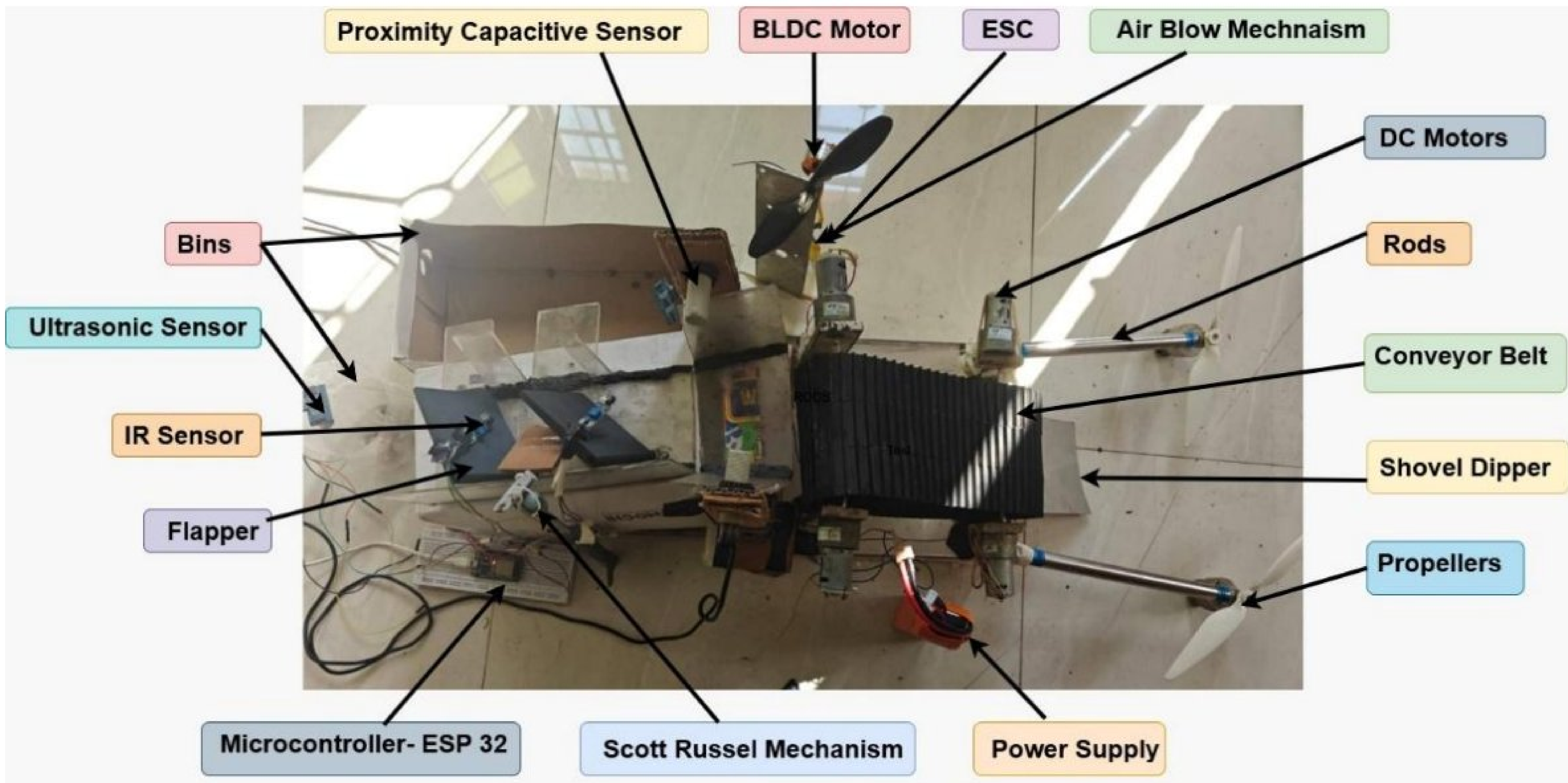

Fig. 6.2.1 Model Overview

Fig.6.2.2 Side View of Model

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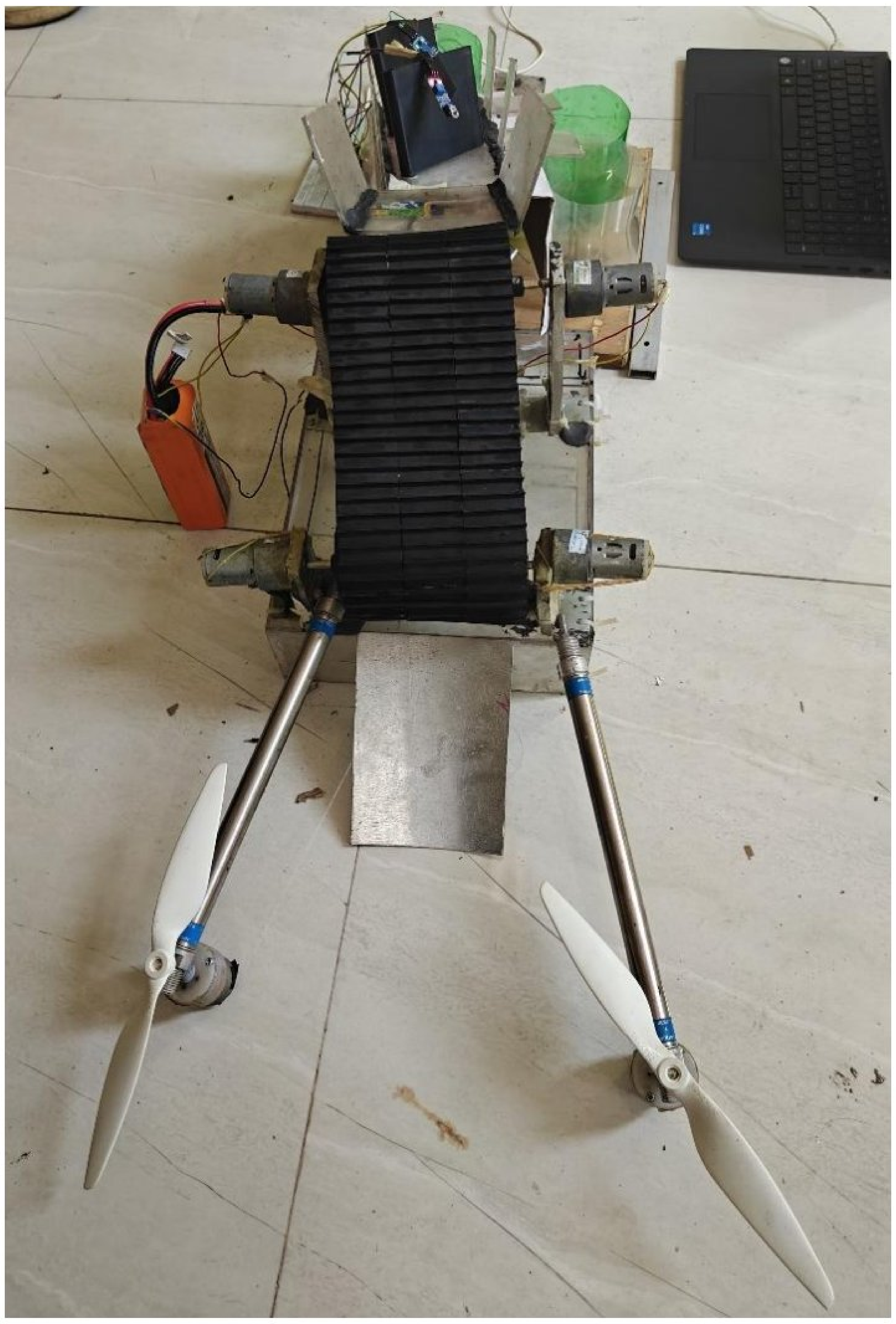

Fig.6.2.3 Front View of Model

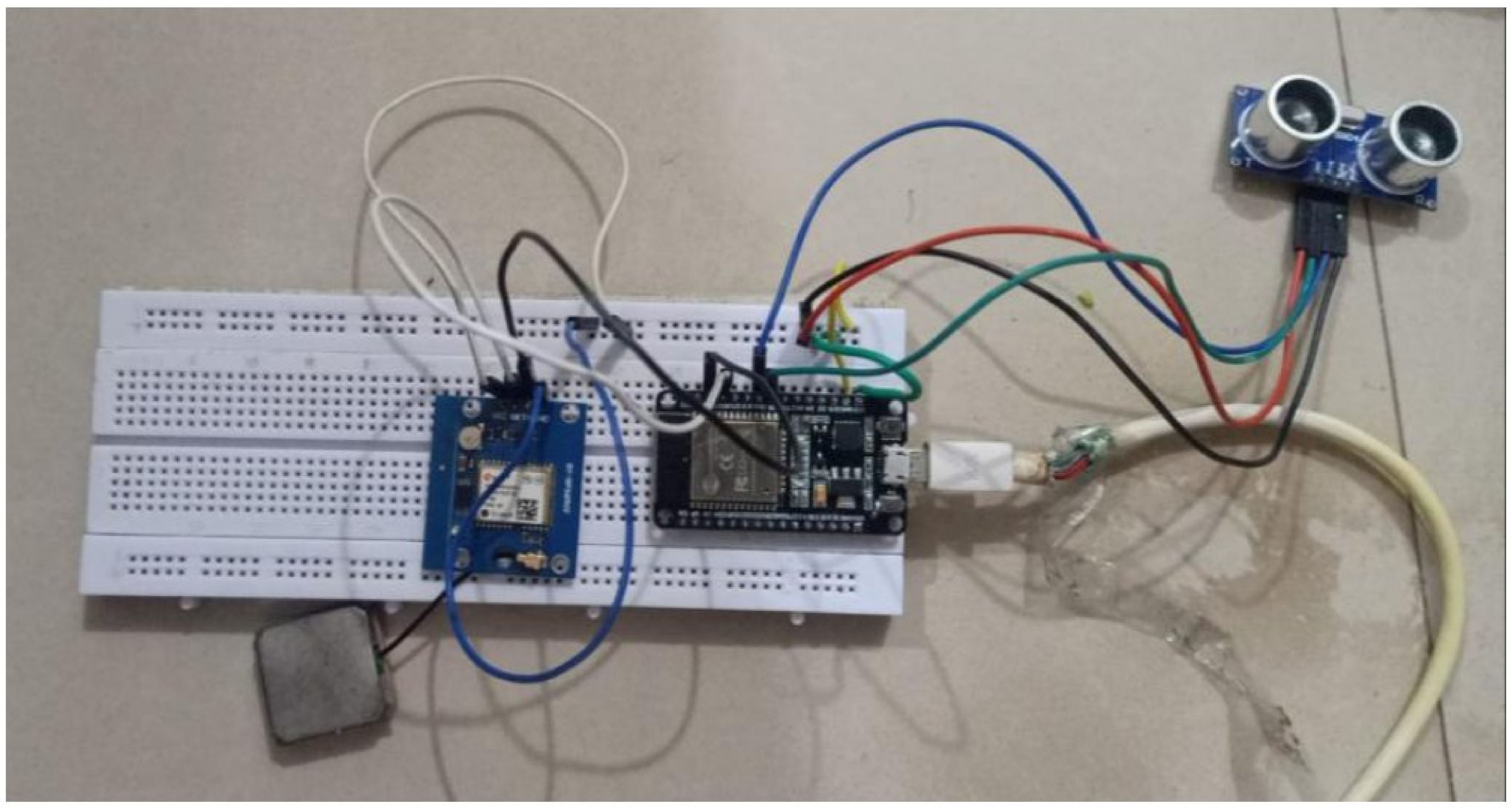

Fig.6.2. Bin status and SMS setup

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6.3 Software Development

```
isonic.ino
#include <WiFi.h>
#include <HTTPClient.h>
#include <LiquidCrystal_I2C.h>
#include <ArduinoJson.h>

// Replace with your network credentials
const char* ssid = "Don";
const char* password = "11052002";

// Firebase project details
#define FIREBASE_HOST "wastemanagement-1aa76-default-rtdb.firebaseio.com"  // Firebase Database URL
#define FIREBASE_AUTH "PKIB89JSgz5Oy3I4FCVkkYsRGnuK3u7fU5DK6D4W"           // Firebase Database Secret

// Google API key
const char* apiKey = "AIzaSyDCGfgoNdcA_uoTJZ80uty1yzs-WVdTzbM";

// Twilio credentials
const String twilio_sid = "AC98c95bb7aface3f4508a9df237e3c8f3";          // Twilio SID
const String twilio_auth_token = "b388ab4a3773a622e9cc12ece1fa71d0";   // Twilio Auth Token
const String twilio_number = "+17655883818";   // Twilio Phone Number
const String recipient_number = "+918928041230";  // Recipient Phone Number

// LCD setup (I2C address 0x27, 16 columns, 2 rows)
LiquidCrystal_I2C lcd(0x27, 16, 2);

// Pin definitions
#define TRIG_PIN 5    // Ultrasonic Trig pin connected to GPIO 5
#define ECHO_PIN 18   // Ultrasonic Echo pin connected to GPIO 18

void setup() {
  Serial.begin(115200);             // Serial monitor
  pinMode(TRIG_PIN, OUTPUT);
  pinMode(ECHO_PIN, INPUT);
```

Code Snippet for initial setup

```
  // Initialize LCD
  lcd.init();             // Initialize the LCD
  lcd.backlight();        // Turn on the backlight
  lcd.setCursor(0, 0);
  lcd.print(F("Smart Bin Init"));  // Store string in flash memory

  // Connect to Wi-Fi
  WiFi.begin(ssid, password);
  while (WiFi.status() != WL_CONNECTED) {
    delay(1000);
    Serial.println(F("Connecting to WiFi..."));
    lcd.setCursor(0, 1);
    lcd.print(F("."));
  }
  Serial.println(F("Connected to WiFi"));
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print(F("WiFi Connected"));
  delay(2000);
}

void loop() {
  // Ultrasonic Sensor Logic to measure distance
  digitalWrite(TRIG_PIN, LOW);
  delayMicroseconds(2);
  digitalWrite(TRIG_PIN, HIGH);
  delayMicroseconds(10);
  digitalWrite(TRIG_PIN, LOW);

  long duration = pulseIn(ECHO_PIN, HIGH);
  float distance = duration * 0.034 / 2;  // Distance in cm

  String binStatus;
```

Code Snippet for measuring distance from the bin using ultrasonic sensor

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asonic.ino

```
void loop() {
  // Ultrasonic Sensor Logic to measure distance
  digitalWrite(TRIG_PIN, LOW);
  delayMicroseconds(2);
  digitalWrite(TRIG_PIN, HIGH);
  delayMicroseconds(10);
  digitalWrite(TRIG_PIN, LOW);

  long duration = pulseIn(ECHO_PIN, HIGH);
  float distance = duration * 0.034 / 2;  // Distance in cm

  String binStatus;

  // Determine bin level based on distance
  if (distance > 15) {
    binStatus = "LOW";     // Waste level is low when distance is more than 15 cm
  } else if (distance > 5 && distance <= 15) {
    binStatus = "MEDIUM";  // Waste level is medium when distance is between 5 cm and 15 cm
  } else if (distance <= 5) {
    binStatus = "FULL";    // Waste level is full when distance is 5 cm or less
  }

  // Display bin status on LCD
  lcd.clear();                    // Clear the display
  lcd.setCursor(0, 0);
  lcd.print(F("Bin Status: "));
  lcd.print(binStatus);

  Serial.print(F("Bin Status: "));
  Serial.println(binStatus);

  // Upload bin status to Firebase
  if (WiFi.status() == WL_CONNECTED) {
```

Input Serial Monitor

Code Snippet for Ultrasonic Sensor - Bin Level Detection

```
  // Upload bin status to Firebase
  if (WiFi.status() == WL_CONNECTED) {
    HTTPClient http;

    // Send bin status
    String binStatusPath = "https://" FIREBASE_HOST "/smartBin/binStatus.json?auth=" FIREBASE_AUTH;
    String payload = "{\"binStatus\": \"" + binStatus + "\"}";
    http.begin(binStatusPath);
    http.addHeader("Content-Type", "application/json");
    int httpResponseCode = http.POST(payload);
    http.end();
  }

  // If the bin is full, send an alert via Twilio
  if (binStatus == "FULL") {
    sendTwilioAlert(binStatus, distance);
  }

  delay(2000);  // Delay between readings
}
```

Code Snippet for sending bin status data to Firebase

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```
}

void sendTwilioAlert(String binStatus, float distance) {
  if (WiFi.status() == WL_CONNECTED) {
    HTTPClient http;

    String url = "https://api.twilio.com/2010-04-01/Accounts/" + twilio_sid + "/Messages.json";

    // Compose the alert message
    String message = "Alert: Bin is " + binStatus + ". Distance to waste: " + String(distance) + " cm.";

    // Prepare the HTTP POST request
    String payload = "From=" + twilio_number + "&To=" + recipient_number + "&Body=" + message;

    http.begin(url);
    http.setAuthorization(twilio_sid.c_str(), twilio_auth_token.c_str());
    http.addHeader("Content-Type", "application/x-www-form-urlencoded");

    // Send the request
    int httpResponseCode = http.POST(payload);

    if (httpResponseCode > 0) {
      Serial.println("Twilio Alert Sent Successfully!");
    } else {
      Serial.println("Error sending Twilio alert: " + String(httpResponseCode));
    }

    http.end();
  } else {
    Serial.println(F("WiFi Disconnected, cannot send Twilio alert"));
  }
```

Code Snippet to send SMS via Twilio

```
#Servo Motor to rotate the Flapper
def rotateFlapper (p, wasteType):
    if(wasteType == "Non-Plastic"):
        p. ChangeDutyCycle(2.5)
    eliF(wasteType == "Plastic"):
        p. CangeDutyCycle(7.5)
    else:
        p.ChangeDutyCycle(12.5)

#Setup
GPIO.setmode (GPIO.BOARD)

#Setup-Servo
servoPIN = 11
GPIO.setup(servoPIN, GPIO.OUT)
p = GPIO.PWM(servoPIN, 50)
p.start(7.5)

#Call servo
rotateFlapper (p, wasteType)
```

Code Snippet for Servo Motor

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```
#Flapper  Code

def flapper(pos, neg):
    GPIO.output(neg, True)
    GPIO.output(pos, False)
    print("Flapper Open")

    #Wait to open
    time.sleep(1.5)

  #Close
  GPIO.output(neg, False)
  GPIO.output(pos, True)
  print("Flapper Closed")

  #Wait to close
  time.sleep(1.5)

  #Switch off servo motor
  GPIO.output(neg, False)
  GPIO.output(pos, False)
# Setup
GPIO.setmode (GPIO. BOARD)

#Setup Flapper
doorPosPIN 40
doorNegPIN 37
GPIO.setup(doorPosPIN, GPIO.OUT)
GPIO.setup(doorNegPIN, GPIO.OUT)

#Call Flapper
door (doorPosPIN, doorNegPIN)
```

Code Snippet for Flapper Mechanism

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```
# Check sensors Detect Weste Type
def detectWasteType (cap1PIN, cap2PIN):
    t_end = time.time() + (60 * 2) secs  # 2 secs
    flag cap1
    = False
    flag cap2 = False

    print("Detecting waste")

    while(time.time() < t_end):
        #Check sensor output
         input_state_cap1 = GPIO.input(cap1PIN)
         input_state_cap2 = GP1O.input(cap2PIN)

        if input_state_capl == True:
            print("Non-Plastic Capactive- True")
            flag_cap1= True

         if input_state_cap2 == True:
            print("Plastic Capactive- True")
            flag_cap2= True

         time.sleep(0.2)

    #Check type of waste
    if(flag_capl == True and flag_cap2==True):
       TRIG = Trig1 # Choose Bin
       ECHO = Echo1
       return(" Non-Plastic")  # Return Waste Type

    else(flag_cap2 == True):
       TRIG = Trig2 # Choose Bin
       ECHO = Echo2
       return(" Plastic")  # Return Waste Type

# Setup
GPIO.setmode (GPIO.BOARD)

# Setup- Non-Plasic Capacitive Sensor
cap1PIN = 22
GPIO.setup(cap1PIN, GPIO.IN)

#Setup- Plastic Capacitive Sensor
cap2PIN = 36
GPIO.setup(cap2PIN, GPIO.IN)

# Call sensors- detect type of waste
wasteType = detectWasteType(cap1PIN, cap2PIN)
print(wasteType)
```

Code Snippet of Sensors for Type of Waste Detection

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Chapter 7

Conclusion and Future Enhancements

7.1 Result Analysis

Fig 7.1.1 Status of bin

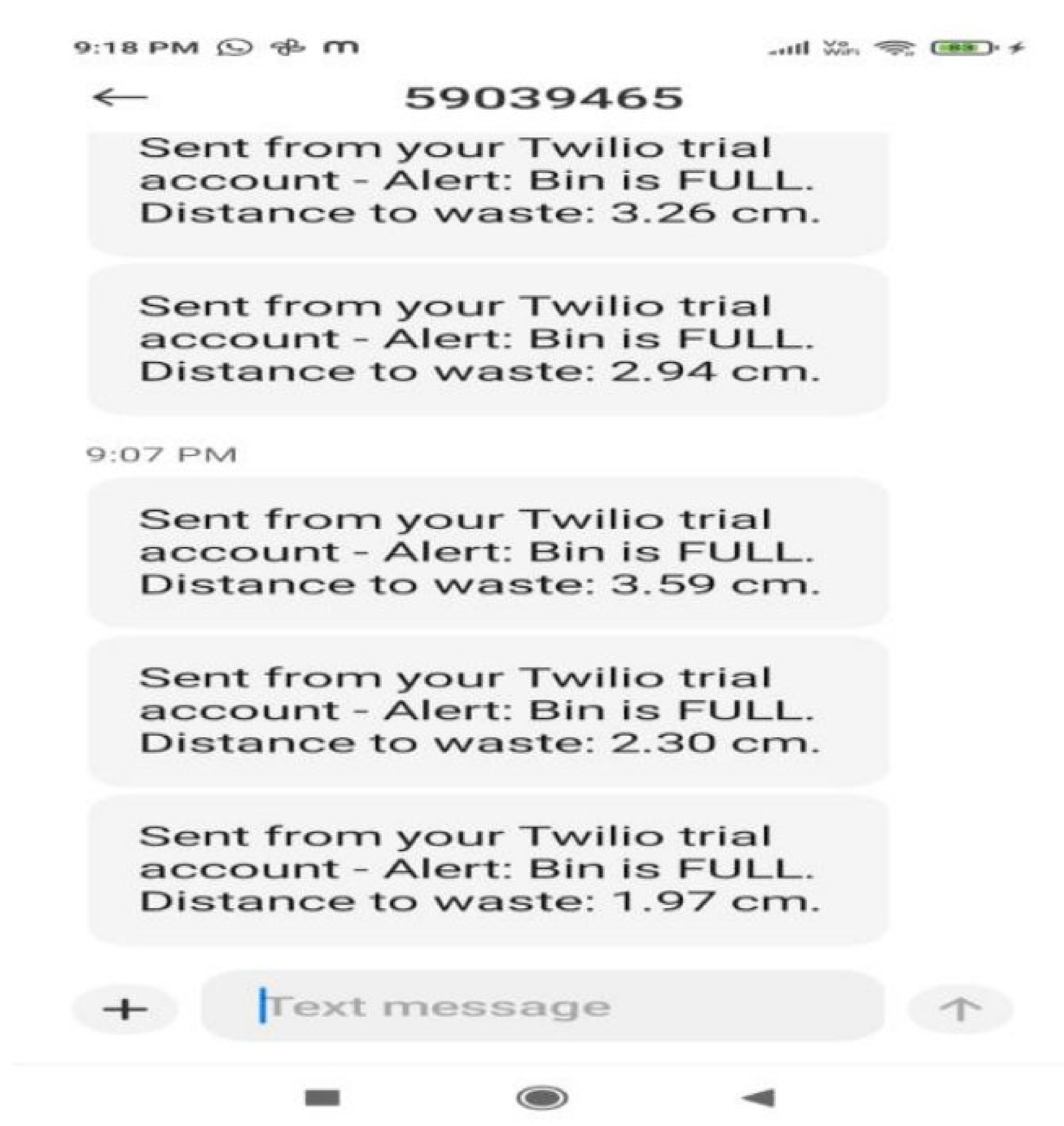

Fig 7.1.2 Message send through Twilio

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Item	Actual type	Cap 1	Cap 2	Detected	Result
Tissue Paper	Non -Plastic	False	False	Non- Plastic	Correct
Cardboard	Non -Plastic	False	False	Non- Plastic	Correct
Plastic scrap	Plastic	True	False	Plastic	Correct
Wrapper	Plastic	True	False	Plastic	Correct
Bottle Cap	Plastic	True	False	Plastic	Correct
Glass	Non -Plastic	-	-	None	Incorrect
Wood Piece	Non-Plastic	-	-	None	Incorrect

Table 7.1. Result Analysis

Total items tested	7
Total Items correctly segregated	5
Total Items incorrectly segregated	2

Table 7.2. Final Results

7.2 Conclusion

The proposed river waste collection device offers an efficient and sustainable solution to reduce plastic pollution at river boundaries. The device collects the waste from the river boundary and is equipped with sensors to detect the status of the bins. It also sends alert notifications to the users in real-time for regular cleanup activities. This device not only prevents plastics from entering marine ecosystems but also addresses the broader environmental impacts of waste on marine life, contributing to cleaner rivers and healthier aquatic habitats. However, the drawback of this system is limited to the density of the waste, higher density waste could not be included in the segregation module.

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7.3Future Enhancements

1. The device is designed to be stationary, which means it can only collect waste that is directly within its reach. However, we can modify this device to operate near boundaries while also being able to move to collect litter throughout the river.

2. The device's size limits its operation to rivers with a steady flow of water, which helps minimize the risk of damage or sinking. By focusing on this aspect, we can optimize the design for large-scale deployment across various water bodies.

3. Additionally, the device can be equipped with vertical-axis wind turbines and solar panels to generate power, eliminating the need for motors or batteries.

4. Currently, the bins collect waste based on their capacity. To increase the amount of waste collected, a compressor can be integrated, allowing for more efficient storage

5. For improved accuracy in segregation, ballistic separators can be integrated alongside the flapper mechanism

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