SUMMER TRAINING REPORT

On

SMART WASTE MANAGEMENT SYSTEM

Submitted in partial fulfilment of the requirements for the completion of one month’s summer internship/training [ART 355]

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AICTE IDEA Lab

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Summer Internship 2024

ज्योतिर्वृणीत तमसो विजानन्

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Certificate of Completion

This is to certify that Mr. Karan Bhatia Student of USAR, GGSIPU has successfully completed a Six week Summer Internship Programme 2024 held at AICTE IDEA Lab~GGSIPU during 24 June To 02 August 2024.

The Title of Project work : Smart Waste Management System

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DECLARATION

I hereby declare that the Summer Training Report entitled **"SMART WASTE MANAGEMENT SYSTEM"** is an authentic record of work completed completed requirements of Summer Training (ART 355) during the period from 24/06/2024 to 02/08/2024 in **AICTE Idea Lab Guru Gobind Singh Indraprastha University New Delhi - 110078** under the supervision of **Mr. Sourabh Anand**

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About Company

AICTE-IDEA (Idea Development, Evaluation & Application) Labs are being established across the country for encouraging students for application of science, technology engineering and mathematics (STEM) fundamentals towards enhanced hands-on experience, learning by doing and even product visualisation. As a common facility embedded in the institution, the IDEA Lab will make engineering graduates more imaginative and creative, besides getting basic training in the 21st century skills like- critical thinking, problem solving, design thinking, collaboration, communication, lifelong learning etc. IDEA Lab can empower the students and faculty to "engage, explore, experience, express and excel", addressing the need of new age learning. IDEA Lab would serve as an infrastructure for faculty to take up and promote multidisciplinary education and research. Accordingly, faculty would be encouraged to get trained in these Labs and strive for creating problems/ projects/ internships in their own subjects/ disciplines and mentor the students.

IDEA Lab will provide all facilities under one roof, for conversion of an idea into a prototype. The idea need not always be new (which will always be encouraged) but the emphasis would be on graduating engineers working with their hands using equipment, tools and consumables (listed in the Scheme Document). With these facilities available 24x7 in the campus, more students and faculty will be encouraged to take up creative work and in the process, get training on creative thinking, problem solving, collaboration etc. which conventional labs are not focussing on. The focus will be on training students so that they become imaginative and creative and stay so at the workplaces they join. The ultimate objective is to transform engineering education with such a Lab in all colleges and for this they must proactively expose all students to the IDEA Lab, organise training sessions for interested students as well as support projects and by providing online learning materials.

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Abstract

Waste management is a pressing global issue, with traditional methods often proving inefficient, environmentally harmful, and wasteful of resources. Overflowing bins, irregular collection schedules, and inefficient route planning contribute to environmental pollution, public health concerns, and increased operational costs. The integration of technology, particularly the Internet of Things (IoT), offers a promising avenue to revolutionise waste management practices. This project introduces an IoT-based waste management system designed to address the shortcomings of conventional approaches. By incorporating ultrasonic sensors, a central monitoring station, and a mobile application, the system enables real-time monitoring of bin fill levels, automated notifications for collection, and optimised route planning. This not only enhances operational efficiency but also minimises the environmental impact associated with overflowing bins and unnecessary collections. The system's core components include ESP32 microcontrollers, HC-SR04 ultrasonic sensors, GSM modules, and solar panels. These elements work in synergy to create a self-powered, sustainable, and intelligent waste management solution. The ultrasonic sensors accurately measure waste levels within bins, transmitting data to the central monitoring station. Upon reaching a predetermined threshold, the system triggers notifications to both garbage collectors and designated dump yards via the GSM module. The central monitoring station aggregates data from all bins, facilitating proactive planning of collection routes and schedules based on real-time insights. Additionally, a user-friendly mobile application empowers waste management authorities to monitor bin statuses, receive notifications, and optimise collection operations.

Introduction

This project introduces an IoT-based waste management system designed to address the shortcomings of conventional approaches. By incorporating ultrasonic sensors, a central monitoring station, and a mobile application, the system enables real-time monitoring of bin fill levels, automated notifications for collection, and optimised route planning. This not only enhances operational efficiency but also minimises the environmental impact associated with overflowing bins and unnecessary collections. The system's core components include ESP8266 microcontrollers, HC-SR04 ultrasonic sensors, GSM modules, and solar panels. These elements work in synergy to create a self-powered, sustainable, and intelligent waste management solution. The ultrasonic sensors accurately measure waste levels within bins, transmitting data to the central monitoring station. Upon reaching a predetermined threshold, the system triggers notifications to both garbage collectors and designated dump yards via the GSM module. The central monitoring station aggregates data from all bins, facilitating proactive planning of collection routes and schedules based on real-time insights. Additionally, a user-friendly mobile application empowers waste management authorities to monitor bin statuses, receive notifications, and optimise collection operations.

Problem Statement

The challenge is to design and develop a sophisticated waste management system that significantly enhances the efficiency and effectiveness of waste collection processes. This system will leverage the power of microcontrollers and the Internet of Things (IoT) to intelligently monitor and manage waste disposal.

Key Components

- **Sensor-Equipped Waste Bins:** These bins will be outfitted with an array of sensors designed to measure critical data points such as:
  - Fill level or capacity
  - Waste type (e.g., recyclable, organic, general)
  - Location (using GPS or other positioning technology)
  - Potentially other environmental factors like temperature or odour
- **Central Monitoring Station:** A centralised hub will act as the "brain" of the system. It will:
  - Receive and process real-time data from all the sensor-equipped waste bins in the field
  - Analyse this data to generate valuable insights about waste collection needs
  - Make intelligent decisions about optimal collection routes and schedules
  - Alert relevant personnel in case of any issues (e.g., overflowing bins, sensor malfunctions)
- **Mobile/Web Application:** A user-friendly mobile application and/or web interface will provide a comprehensive view of the entire system, allowing authorised users to:
  - Monitor the status of all waste bins in real-time
  - Track collection progress and routes
  - Access historical data and analytics to identify trends and make informed decisions
  - Receive notifications and alerts

Overall Goal

The overarching goal of this project is to create a smart waste management system that:

- Reduces unnecessary collection trips, thereby saving time, fuel, and resources
- Prevents overflowing bins, improving public hygiene and aesthetics
- Enables data-driven decision-making to optimise waste management strategies
- Improves the overall efficiency and sustainability of waste collection operations

By combining the power of embedded systems, wireless communication, and cloud-based data management, this smart waste management system has the potential to revolutionise the way waste is collected and managed, leading to cleaner, greener, and more efficient cities.

<u>Description of various Training Module</u>

This summer internship project on smart waste management involved hands-on training in several key areas, enabling the design and implementation of a prototype system. The following modules were crucial in developing the necessary skills:

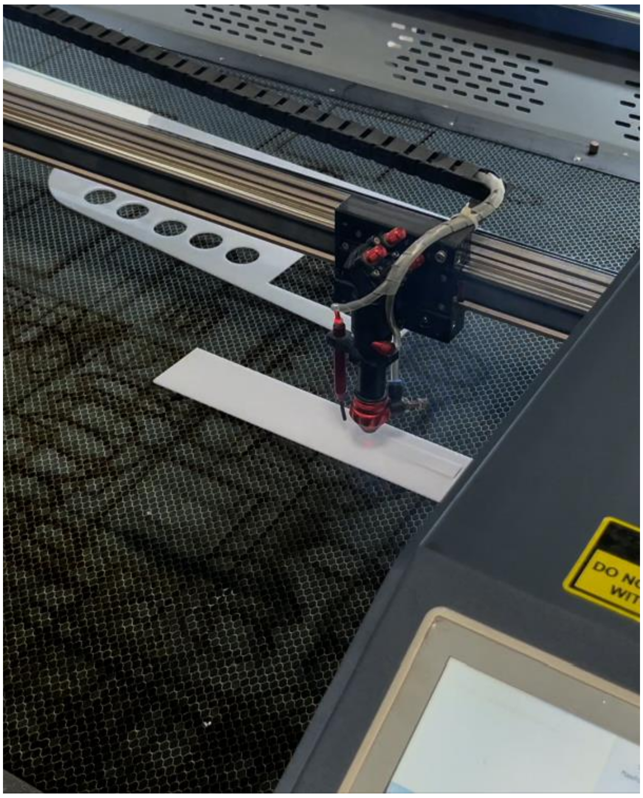
1. **<u>3D Design and Prototyping with Fusion 360 :</u>**

- Software Fundamentals: Introduction to Fusion 360's interface, basic navigation, and core design tools like sketching, extrusion, and revolution.
- Waste Bin Modelling: Detailed training on creating a 3D model of the sensor-equipped waste bin, including incorporating necessary components like the sensor housing and lid mechanisms.
- Design for 3D Printing: Understanding design constraints for successful 3D printing, such as wall thickness, overhangs, and support structures.
- Prototype Preparation: Exporting the final design in the appropriate format for 3D printing.

2. **3D Printing :**

- Printer Operation: Familiarisation with the 3D printer used, including loading filament, bed levelling, and initiating prints.
- Material Selection: Guidance on choosing suitable filament materials based on the bin's functional requirements and aesthetic considerations.
- Post-Processing: Techniques for removing support structures, cleaning, and finishing the 3D printed prototype.

Figure 4.1 Hands on Experience of 3D Printing at AICTE Idea Lab



3. **Laser Engraving :**

- Engraver Operation: Training on safely operating the laser engraver, setting parameters like power and speed for different materials.
- Bin Customization: Applying laser engraving to add labels, markings, or decorative elements to the 3D printed bin.

Figure 4.2 Hands on Experience using Laser Engraver for our Project at Idea Lab

4. **Microcontroller Programming :**

- Microcontroller Basics: Introduction to the microcontroller used (e.g., Arduino), its pinouts, and basic programming concepts.
- Sensor Integration: Connecting and interfacing sensors (e.g., ultrasonic distance sensors) with the microcontroller.
- Data Acquisition and Processing: Writing code to read sensor data, process it, and trigger actions like sending alerts when the bin is full.

5. **IoT Connectivity** :

- Communication Protocols: Understanding communication protocols like Wi-Fi or LoRaWAN for connecting the bin to the central monitoring system.
- Data Transmission: Implementing code to send sensor data from the bin to the cloud or a central server.

6. **Mobile App Development** :

- App Design: Introduction to mobile app design principles and user interface creation.
- Data Visualization: Implementing features to display real-time bin status and waste collection data in a user-friendly manner.

7. **LaTeX Documentation** :

- LaTeX Introduction: Overview of LaTeX, its advantages for technical and scientific writing, and basic syntax.
- Document Formatting: Training on creating structured documents with sections, headings, lists, tables, and figures.
- Mathematical Equations and Symbols: Learning to typeset complex mathematical equations and scientific symbols using LaTeX's powerful tools
- Project Report Preparation: Utilising LaTeX to create a professional final report, incorporating figures, tables, and equations generated during the project.

Literature Survey

The integration of Internet of Things (IoT) technology into waste management systems has garnered significant attention in recent years. Researchers and practitioners have explored various approaches, including sensor-based monitoring, data analytics, and route optimization algorithms, to enhance the efficiency and sustainability of waste collection processes. This literature survey highlights the advancements and potential benefits of IoT-based waste management solutions, with particular emphasis on sensor technology and data-driven optimization methods.

5.1 Sensor-Based Monitoring

Sensor-based monitoring is a cornerstone of modern IoT waste management systems. Ultrasonic sensors, for instance, have been widely studied for their ability to provide real-time data on waste levels in bins. A study by **Patil** [1] investigated the use of ultrasonic sensors for real-time waste level monitoring, revealing that these sensors offer accurate and reliable data, enabling timely waste collection and preventing bin overflow. The implementation of such sensors can significantly reduce the need for manual checks and enhance the overall efficiency of waste collection operations.

In the context of our project, the HC-SR04 ultrasonic sensor is employed to monitor fill levels in waste bins. When the bin reaches 90% to 100% capacity, it triggers automatic notifications to garbage collectors and dump yards via the GSM module. This proactive approach ensures that bins are emptied before they overflow, reducing the environmental and health risks associated with waste accumulation.

Table 5.1: Specification of Sensors

Component	HC-SR04 Ultrasonic Sensor	SG90 Servo Motor
Type	Ultrasonic Distance Sensor	Servo Motor
Model	HC-SR04	SG90
Operating Voltage	5V DC	4.8V to 6V DC
Current Draw	15 mA	10 mA (idle), 100-250 mA
Range	2 cm to 400 cm	0° to 180° (rotation)
Accuracy	±3 mm	±1°
Frequency	40 kHz	N/A
Echo Output Signal	Input TTL level signal,	N/A
Dimensions	45 mm x 20 mm x 15 mm	22.2 mm x 11.8 mm x 31 mm
Weight	15 g	9 g
Operating Temperature	-15°C to 70°C	0°C to 55°C

5.2 Data Analytics and Route Optimization

Data analytics plays a crucial role in transforming raw sensor data into actionable insights for optimising waste collection routes and schedules. Machine learning algorithms have been applied to analyze waste generation patterns and predict optimal collection times. A study by **W Xia** [2] explored the application of machine learning algorithms to optimise waste collection routes, demonstrating a substantial reduction in travel distances and fuel consumption, which leads to cost savings and reduced carbon emissions.

Our system features a central monitoring station that collects and analyses data from all bins, enabling proactive planning of col- lection routes and schedules based on real-time data insights. This data-driven approach minimises the operational costs associated with waste collection and enhances the sustainability of the waste management process.

5.3 Comparative Analysis

Comparing traditional waste collection methods with modern IoT- based systems underscores the advantages of integrating advanced technologies. Traditional methods often rely on fixed schedules regardless of bin fill levels, leading to inefficiencies such as overflowing bins or unnecessary collections. In contrast, IoT-based systems, like the one proposed in our project, utilise real-time data to trigger notifications and optimise collection operations. This not only reduces operational costs but also mitigates the environmental impact of waste collection activities.

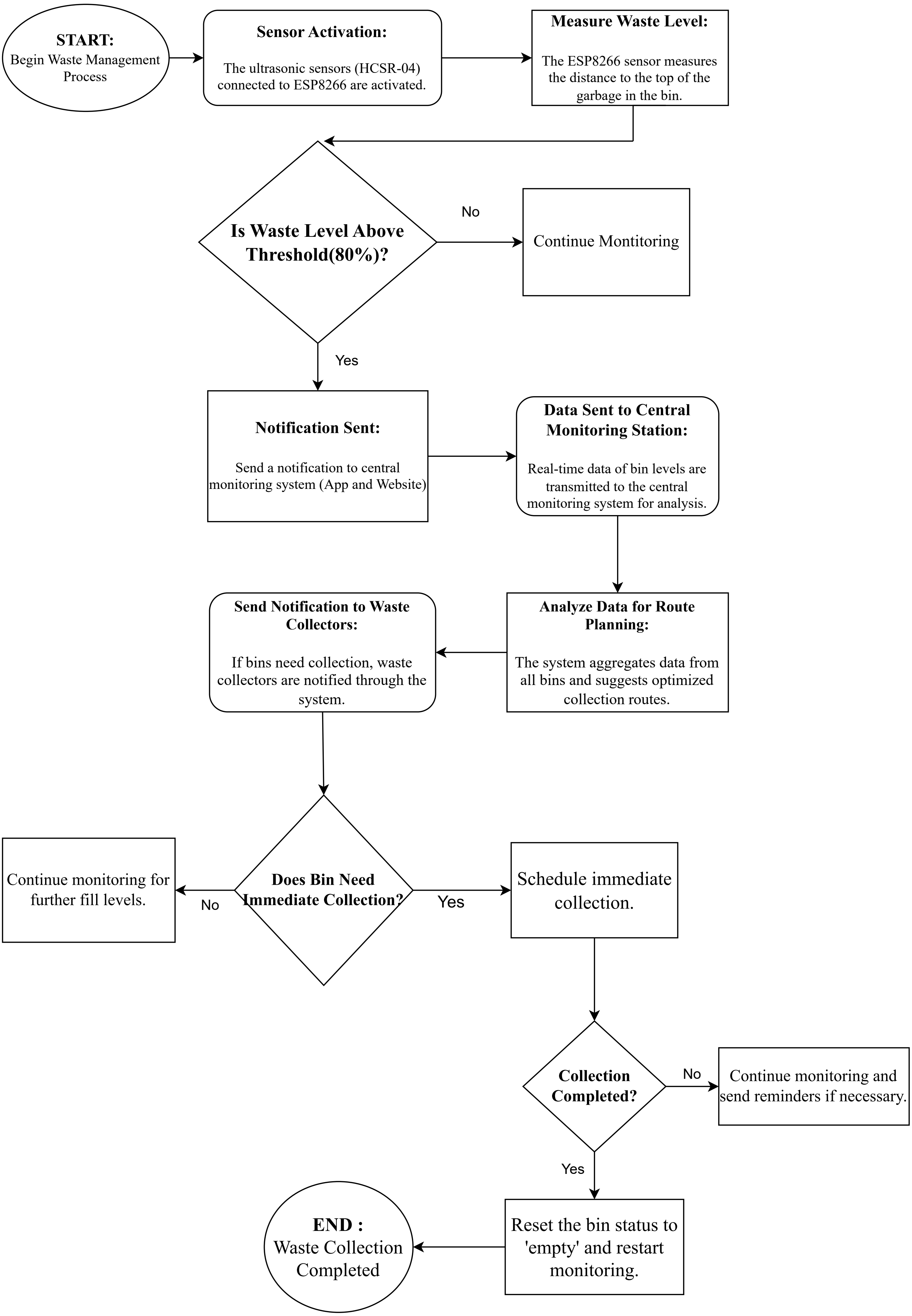
Table 5.2: Comparison of Traditional vs. IoT-Based Waste Management Methods

Aspect	Traditional Methods	IoT-Based Methods
Monitoring	Manual inspection	Automated monitoring using sensors
Data Collection	Infrequent and manual	Continuous through IoT devices
Collection Scheduling	Fixed schedules	Dynamic based on real-time data
Operational Costs	Higher due to inefficiencies	Lower due to optimized operations
Maintenance	Reactive maintenance	Proactive and predictive maintenance

Table 5.3: Comparison of Waste Collection Efficiency

Aspect	Before IoT	After IoT
Collection Freq.	Fixed schedule	Dynamic, real-time
Overflows	Frequent	Rare
Fuel Use	High	Reduced
Labour Costs	Higher (manual)	Lower (automated)
Route Optimised	Not optimised	Highly optimised
Response Time	Delayed	Immediate
Env. Impact	Higher carbon footprint	Lower carbon footprint

Methodology Adopted - Flowchart



Description of Algorithms Used

Detailed Route Optimization

Route optimization is a crucial part of the Smart Waste Management System as it ensures that waste collection is performed in the most efficient and cost-effective manner. This is achieved by utilising real-time data collected from waste bins, sensors, and external sources like traffic conditions. Here is a detailed breakdown:

1. Real-Time Data Collection

The system employs ultrasonic sensors (HC-SR04) to monitor the fill levels of the waste bins. These sensors provide continuous updates to the central system about the current capacity of each bin. As the bin reaches a critical threshold (typically between 90% and 100%), the system flags it for collection.

The ESP8266 microcontroller processes the data from the sensors and transmits it to the central monitoring station via a wireless network. This station aggregates data from all bins across the city or region, providing a comprehensive view of bin statuses.

2. Analysis of Waste Data

Once the fill levels are updated, the system prioritises bins that require immediate attention (i.e., those that are close to overflowing). The collected data is processed using data analytics algorithms, which help in determining which bins are full and where they are located.

This data-driven approach eliminates the need for static, pre-planned routes where waste collection vehicles service all bins regardless of their fill levels. Instead, it dynamically prioritises bins based on real-time conditions.

3. Dynamic Route Planning

After the bins that require collection are identified, the system uses advanced algorithms to calculate the most efficient route for the collection vehicles. The factors considered in this optimization process include:

- Bin Locations: The system identifies the bins closest to the vehicle's starting point and plans a route that minimises the total travel distance.
- Fill Levels: Bins that are nearly full are given higher priority over less full bins, ensuring that overflowing is prevented.
- Traffic Data: Using real-time traffic data, the system avoids congested areas to save time and fuel. Traffic data may be sourced from public or private APIs that provide live updates on traffic conditions.
- Weather Pattern: In some cases, the system can also account for weather conditions (e.g., heavy rains or storms) that might affect road accessibility or travel speed.

The optimised route is then transmitted to the waste collection vehicles in real-time through a mobile or web application, ensuring that drivers follow the most efficient path.

4. Benefits of Route Optimization

The route optimization process offers multiple benefits:

- Fuel Efficiency: By reducing unnecessary travel, fuel consumption is minimised, leading to cost savings and lower carbon emissions.
- Time Efficiency: Collection vehicles can service more bins in less time, improving overall efficiency.
- Operational Costs: With fewer trips and optimised routes, the overall operational costs of waste collection are significantly reduced.
- Environmental Impact: The system lowers the environmental impact by reducing the carbon footprint of waste collection vehicles.

Real-Time Monitoring and Reporting

The system also includes a robust real-time monitoring and reporting feature that enables waste management authorities to maintain complete oversight of the waste collection process.

1. Real-Time Dashboard

The central monitoring station is equipped with a real-time dashboard that provides an intuitive interface for monitoring the status of waste bins and vehicles. This dashboard displays:

- Bin Fill Levels: Each bin is represented on the map, colour-coded to indicate its fill level (e.g., green for empty, yellow for half-full, red for full).
- Bin Locations: The exact geographic location of each bin is displayed, allowing the authorities to track bins across different neighbourhoods or regions.
- Collection Status: The dashboard also provides the status of ongoing collection activities, showing which bins have been serviced and which still require attention.

This centralised view enables waste management teams to make informed decisions in real-time, optimising resource allocation and adjusting strategies based on current conditions.

2. Proactive Alerts and Notifications

The system sends automated alerts to waste collection teams and supervisors when bins are nearing capacity or when sensor malfunctions are detected. This ensures that bins are emptied before they overflow and that any system issues are resolved promptly.

Alerts are also triggered in case of any unexpected situations, such as:

- Malfunctioning Sensors: If a sensor stops working or provides erroneous readings, the system alerts the relevant personnel.
- Overflowing Bins: If a bin has not been collected in time and is overflowing, an urgent notification is sent to prioritise that location.
- Route Changes: In case of real-time traffic or weather disruptions, the system can alert drivers to follow alternate routes.

These notifications ensure that waste collection is performed without delays, improving service reliability.

3. Data Reporting and Analysis

In addition to real-time monitoring, the system can generate detailed reports that provide insights into various aspects of waste collection. These reports can be used for:

- Historical Data Analysis: Analysing past trends in waste generation, which can help authorities plan for future needs.
- Performance Metrics: Tracking the performance of waste collection teams, including response times and collection frequency.
- Cost Analysis: Evaluating the financial impact of the system, including fuel savings, labour costs, and reduced wear and tear on vehicles.

Hardware & Software Requirements

Opening the Lid using the SG 90 Servo Motor

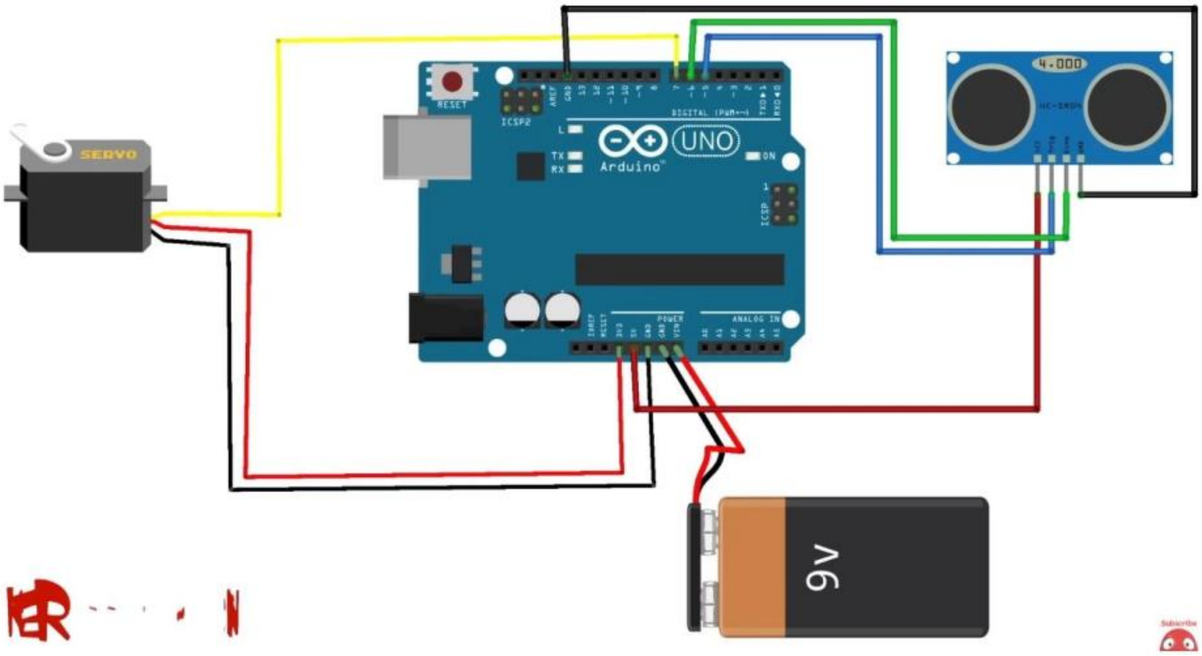


Figure 8.1 Circuit Diagram of Arduino Uno connected with Servo Motor and HCSR04

In the above diagram, the connections for the Arduino-based setup are as follows :

- **Ultrasonic Sensor (HC-SR04):**
  - The VCC pin of the HC-SR04 is connected to the 5V pin on the Arduino to provide power.
  - The GND pin of the HC-SR04 is connected to the GND pin on the Arduino to complete the circuit.
  - The Trig pin of the HC-SR04 is connected to digital pin 9 on the Arduino which will be used to send the trigger signal.
  - The Echo pin of the HC-SR04 is connected to digital pin 10 on the Arduino which will receive the signal reflected back.

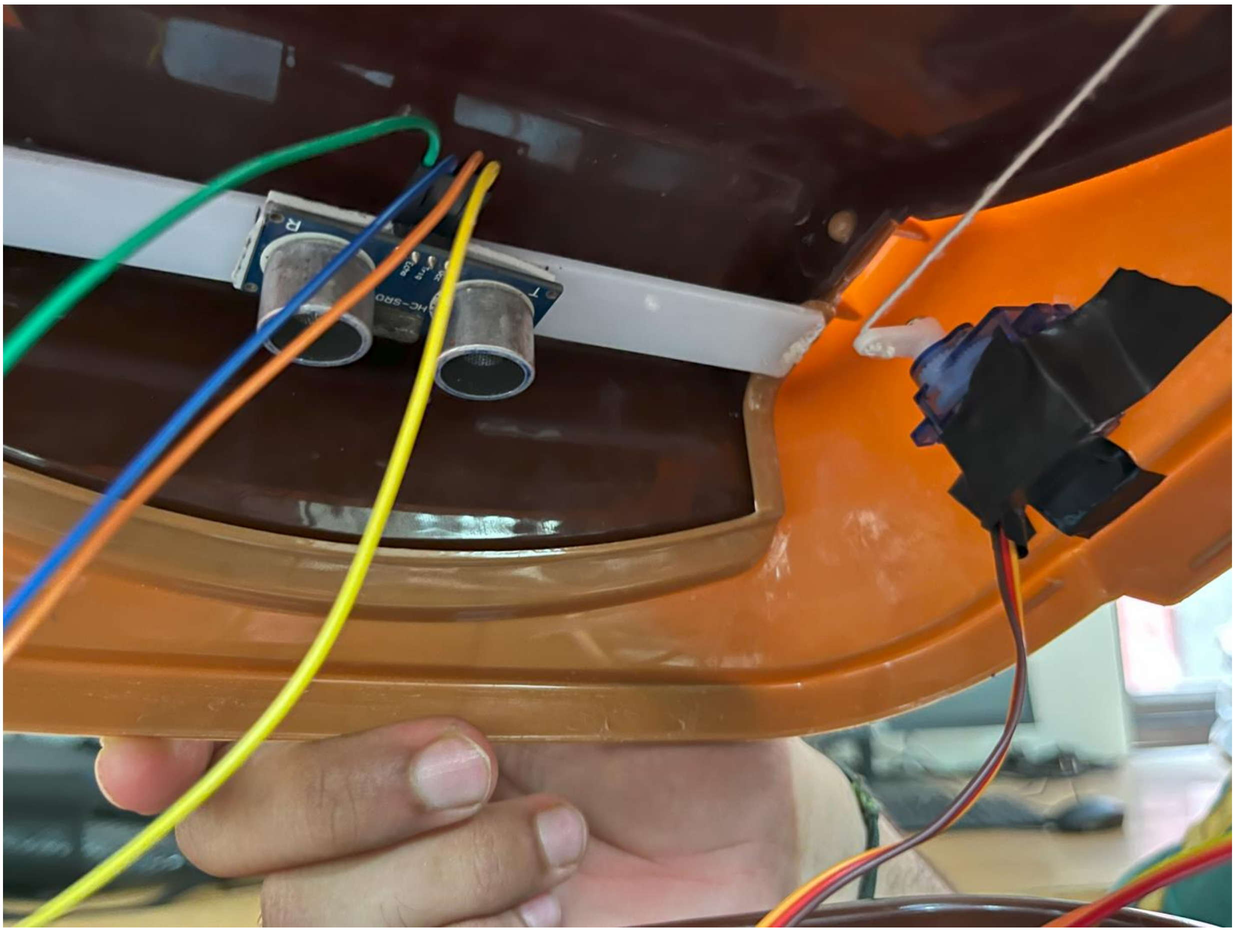


Figure 8.2 HCSR04 & SG90 Servo Motor attached to Lid

- Servo Motor :
    - The power (red) wire of the servo motor is connected to the 5V pin on the Arduino to provide power.
    - The ground (black) wire of the servo motor is connected to the GND pin on the Arduino to complete the circuit.
    - The signal (yellow) wire of the servo motor is connected to digital pin 8 on the Arduino which will control the servo motor's movement.
- Power Supply :
    - A 9V battery is used to power the Arduino.
    - The positive terminal of the 9V battery is connected to the Vin pin on the Arduino supplying power to the board.
    - The negative terminal of the 9V battery is connected to the GND pin on the Arduino to complete the power circuit.

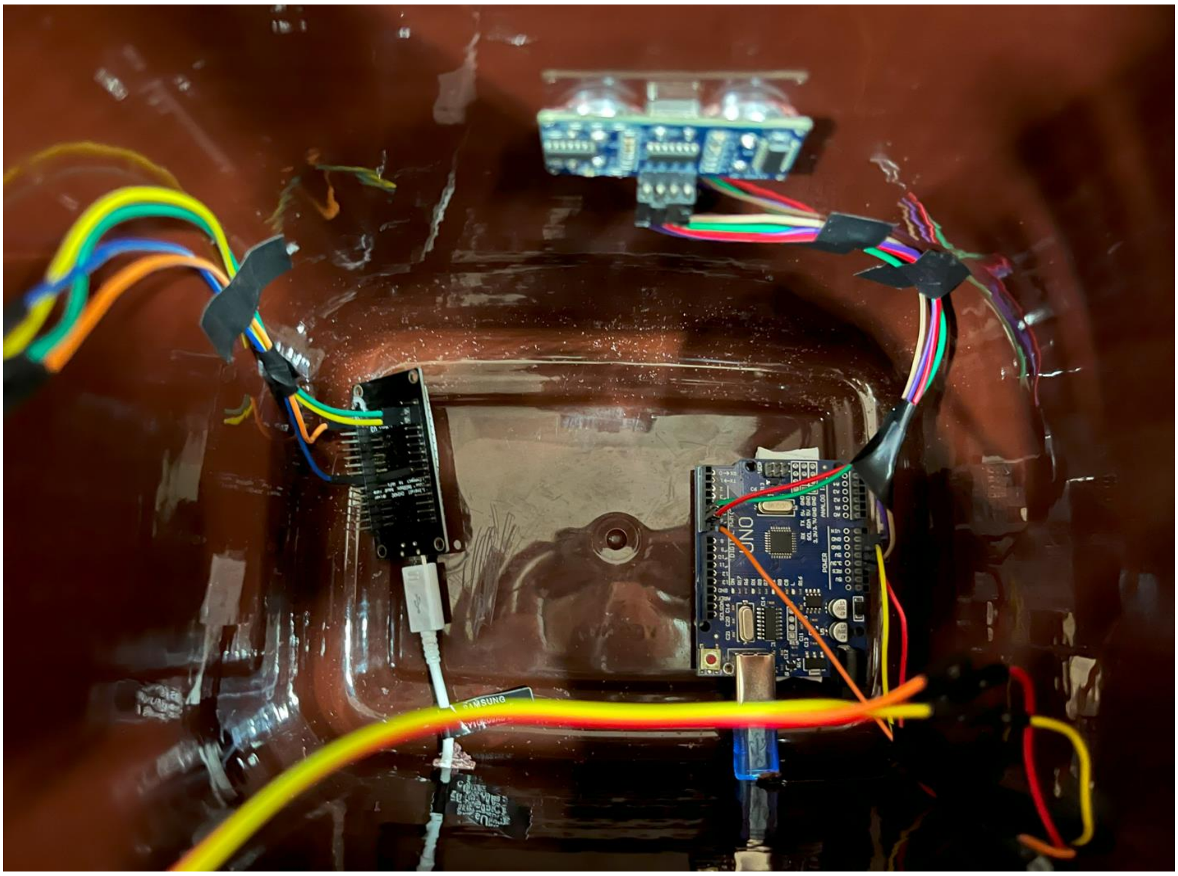


Figure 8.3 ESP8266 attached to HCSR04 Sensor

Code : The code for Arduino connection is given below:

```
#include <Servo.h>
Servo myservo;
int trigPin = 5;
int echoPin = 6;
int servoPin = 7;
int led = 10;
long duration, dist, average;
long aver[3];
int pos = 140;
void setup() {
Serial.begin(9600);
myservo.attach(servoPin);
pinMode(trigPin, OUTPUT);
pinMode(echoPin, INPUT);
pinMode(led, OUTPUT);
digitalWrite(led, LOW);
  }
```

```
void measure() {
digitalWrite(trigPin, LOW);
delayMicroseconds(5);
digitalWrite(trigPin, HIGH);
delayMicroseconds(15);
digitalWrite(trigPin, LOW);
duration = pulseIn(echoPin, HIGH);
dist = (duration / 2) / 29.1;
}
void moveServo() {
for (pos = 140; pos >= 40; pos -= 5) {
myservo.write(pos);
delay(15);
}
delay(3000);
for (pos = 40; pos <= 140; pos += 5) {
myservo.write(pos);
delay(15);
}
delay(3000);
}
void loop() {
  for (int i = 0; i <= 2; i++) {
      measure();
    aver[i] = dist;
delay(10);
}
dist = (aver[0] + aver[1] + aver[2]) / 3;
if (dist < 50) {
```

```
digitalWrite(led, HIGH); // Indicate servo movement
moveServo();
digitalWrite(led, LOW);
  }
Serial.print(dist);
Serial.println(" cm"); // Better readability in the serial output
}
```

Code Structure

This Arduino code is designed to control a servo motor and an LED based on distance measurements from an ultrasonic sensor. It utilises the Servo library to manage the servo motor and includes variables for the ultrasonic sensor's trigger and echo pins, the servo motor's pin, and the LED pin. In the setup function, serial communication is initialised and the necessary pins are configured. The measure function sends a pulse from the trigger pin and measures the duration of the echo received back to calculate the distance in centimetres. The move Servo function moves the servo motor between two positions (from 140 to 40 degrees and back) with pauses to allow the motor to reach each position. In the loop function, the distance is measured three times and the average distance is calculated. If this average distance is less than 50 centimetres, the LED is turned on and the servo motor is moved through its sequence to indicate an action based on proximity. After the servo movement, the LED is turned off. The measured distance is continuously printed to the serial monitor for real-time monitoring.

Sending Garbage Level to the Cloud using Blynk HTTPs RESTful API

The image above shows the connections between an ESP8266 NodeMCU and an HC-SR04 ultrasonic sensor. Here are the detailed connections:

- VCC (HC-SR04) to 3V3 (ESP8266): The VCC pin of the HCSR04 is connected to the 3.3V pin (3V3) of the ESP8266 to power the sensor.
- Trig (HC-SR04) to D5 (GPIO 14) (ESP8266): The Trig pin of the HC-SR04 is connected to digital pin D5 (GPIO 14) of the ESP8266.
- Echo (HC-SR04) to D6 (GPIO 12) (ESP8266): The Echo pin of the HC-SR04 is connected to digital pin D6 (GPIO 12) of the ESP8266.
- GND (HC-SR04) to G (GND) (ESP8266): The GND pin of the HC-SR04 is connected to the ground pin (G) of the ESP8266.

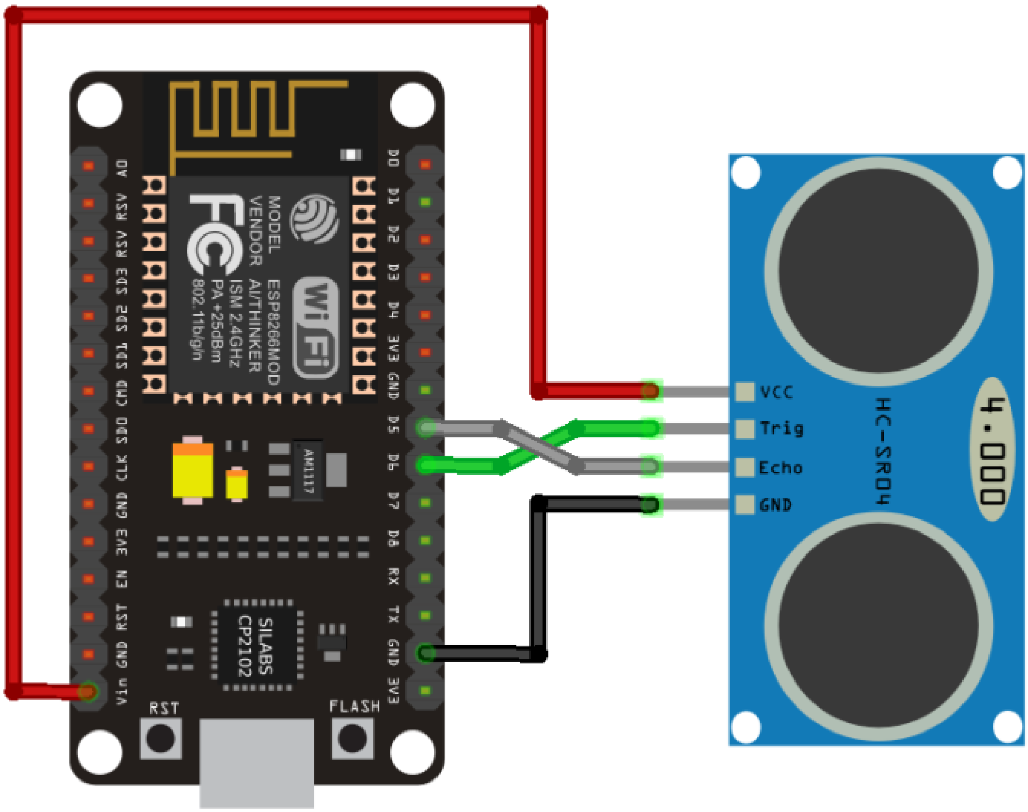


Figure 8.4 Circuit Diagram for ESP-32 connected with Ultrasonic Sensor

These connections allow the ESP8266 to send a trigger pulse to the HC-SR04 to initiate distance measurement and receive the echo pulse to determine the time taken for the echo to return, thus calculating the distance to an object.

Code

```
#define BLYNK_TEMPLATE_ID "TMPL3fbtYn2Ss"
#define BLYNK_TEMPLATE_NAME "AICTE Smart Dustbin"
#define BLYNK_AUTH_TOKEN "4yFXy40Q6q70rzh5HoTSlV3jP4mkbPB8"
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>
#include <NewPing.h>
char auth[] = BLYNK_AUTH_TOKEN;
const int trigPin = 5;
const int echoPin = 12;
#define MAX_DISTANCE 200
const int ledPin = 2; // GPIO2 (or adjust to your LED pin)
char ssid[] = "Shubham"
char pass[] = "9278348561";
BlynkTimer timer;
NewPing sonar(trigPin, echoPin, MAX_DISTANCE);
```

```
int sensorThres = 100;
int distanceCm;
int resetDistance;
void setup() {
        Serial.begin(9600);
        Blynk.begin(auth, ssid, pass);
        timer.setInterval(2500L, sendSensor);
        pinMode(ledPin, OUTPUT);
    }
void loop() {
// Wi-Fi Status LED
        if (WiFi.status() == WL_CONNECTED) {
        digitalWrite(ledPin, HIGH); // LED on when connected
        delay(100);
        digitalWrite(ledPin, LOW); // LED off for a brief moment
        delay(100);
        } else {
        digitalWrite(ledPin, LOW); // LED off when disconnected
    }
        // Sensor readings and Serial output (always active)
        delay(50);
        distanceCm = sonar.ping_cm();
        resetDistance = distanceCm;
        // Continuous Serial Output (always print distance)
```

```
        Serial.print("Distance: ");
        Serial.print(distanceCm);
        Serial.println(" cm");
        Blynk.run(); // Keep Blynk running (data will be sent if connected)
        timer.run();
    }
void sendSensor() {
        Serial.print("Sending to Blynk: ");
        Serial.println(resetDistance);
        if (Blynk.connected()) { // Check for Blynk connection
        Blynk.virtualWrite(V0, resetDistance);
    }
}
```

Code Structure

- Header and Definitions
    - #define statements: Set your Blynk template ID, name, and authentication token (replace placeholders with your actual values).
    - #include statements: Include necessary libraries for ESP8266 WiFi, Blynk, and ultrasonic distance measurement (NewPing).
    - Variable declarations:
        - auth: Stores Blynk authentication token.
        - trigPin, echoPin: Pins for ultrasonic sensor.
        - MAXDISTANCE : Maximummeasurabledistance.ledPin : PinforstatusLED.
        - ssid, pass: Your Wi-Fi network credentials.
        - timer: Blynk timer for sending data periodically.
        - sonar: Ultrasonic sensor object.
        - sensorThres: Threshold distance (unused in this version).
        - distanceCm, resetDistance: Distance variables.
- setup() Function:
    - Initialises serial communication (for debugging).
    - Start a Blynk connection with your credentials.
    - Sets up a timer to call sendSensor() every 2.5 seconds.
    - Configures the LED pin as an output.
- loop() Function:
    - Wi-Fi Status LED:
        - ★ Blinks the LED when connected to Wi-Fi, stays off when disconnected.
    - Sensor Reading:
        - ★ Measures distance using the ultrasonic sensor (sonar.ping_cm())
        - ★ Calculates resetDistance, effectively just assigning the measured distance to it.
        - ★ Prints the distance to the serial monitor.
    - Blynk Timer :
        - ★ Runs Blynk operations (e.g., checking for messages, updating widgets).
        - ★ Runs the timer that triggers data sending.

- sendSensor() Function:
    - Prints a message indicating data is being sent.
    - Checks if the ESP8266 is connected to Blynk.
    - If connected, sends the resetDistance value to virtual pin V0 on the Blynk app.

How to Use the Prototype

- **Blynk Setup:**
    - Create a Blynk project using the" AICTE Smart Dustbin" template.
    - Add a data display widget (e.g., Gauge or Value Display) linked to virtual pin V0.
- **Code Modification:**
    - Replace placeholder values with your actual Blynk authentication token and Wi-Fi credentials.
    - Double-check the pin assignments for the sensor and LED.
- **Upload and Monitor:**
    - Upload the code to your ESP8266 board.
    - Open the Blynk app and observe the distance readings in the widget .Create additional logic in the Blynk app to trigger alerts or actions based on the distance (e.g. , a notification when the dustbin is full).

Snapshot of Web Portal & Prototype

Figure 9.1 Front Page of Website

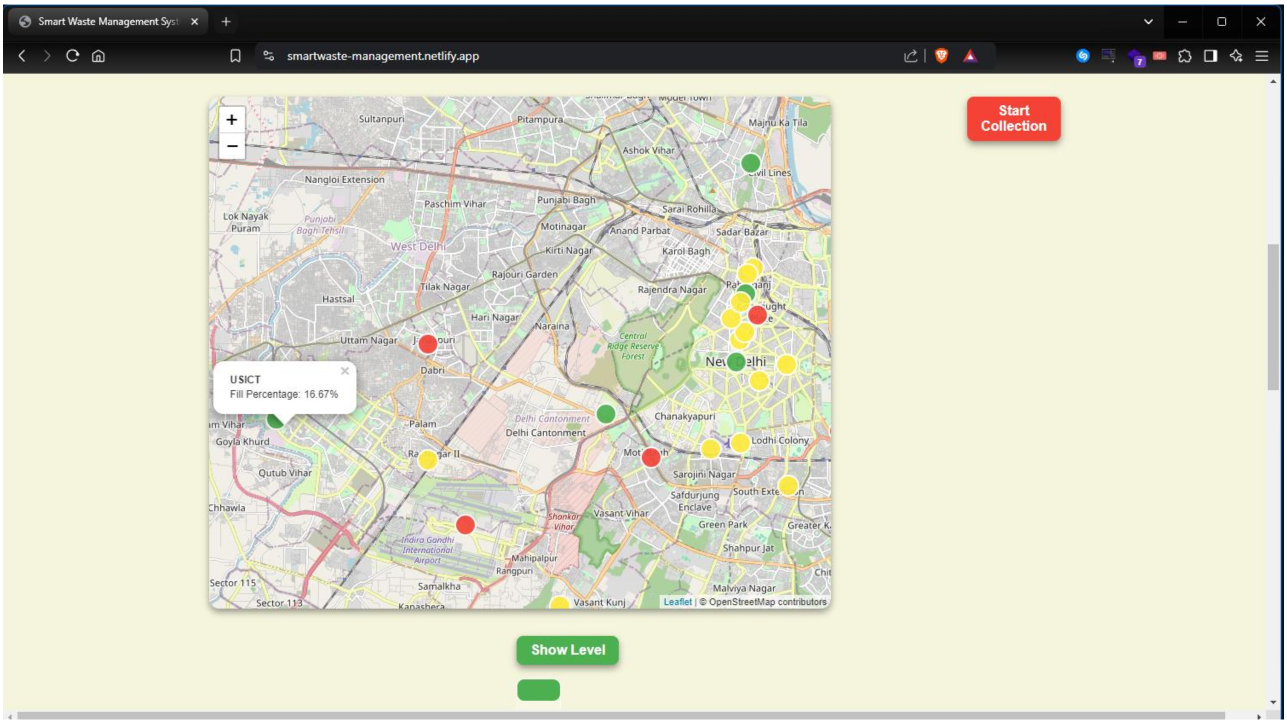


Figure 9.2 Real Time Garbage Level on Map

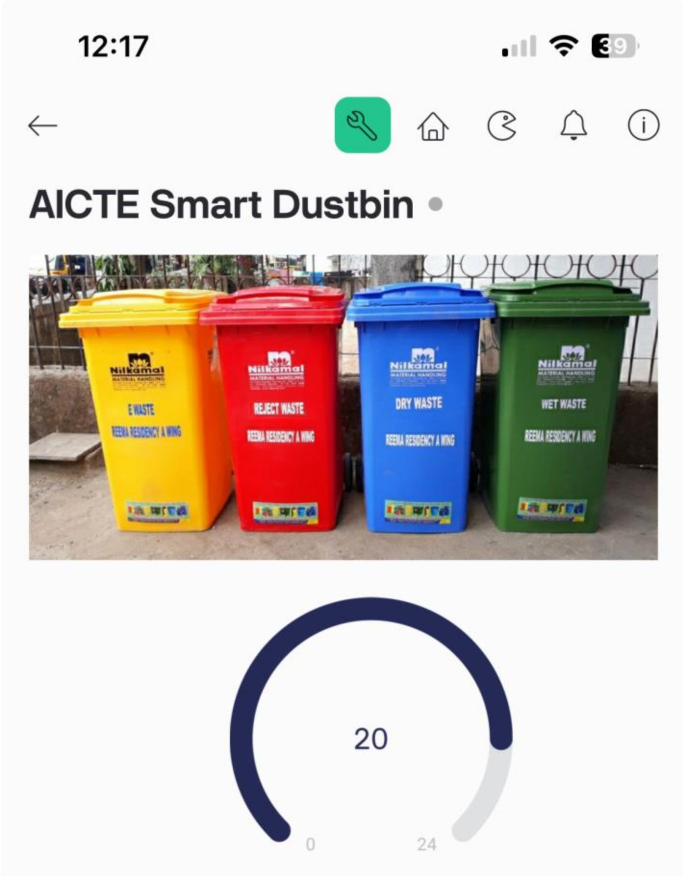


Figure 9.3 Mobile App showing garbage level in centimetres

Figure 9.4 Working Prototype of a Smart Dustbin

Results Obtained

- Preemptive Waste Collection and Environmental Preservation: The system's ability to continuously monitor bin fill levels in real-time has proven to be a game-changer. By proactively identifying bins nearing capacity, waste collection can be scheduled precisely when needed, effectively preventing over- flowing bins. This not only enhances the aesthetic appeal of public spaces but also mitigates potential environmental hazards associated with overflowing waste, such as foul odours, pest infestations, contamination of surrounding areas, and potential spread of diseases.
- Streamlined Resource Allocation and Operational Efficiency: The automation of collection notifications has revolutionised the way waste collection is managed. Instead of relying on manual inspections or fixed schedules, the system intelligently triggers alerts when bins reach predetermined thresholds. This eliminates unnecessary collection trips, optimises the allocation of personnel and vehicles, and ultimately reduces fuel consumption and operational costs, leading to significant financial savings for municipalities.
- Data-Driven Route Optimization and Sustainability: Through the collection and analysis of vast amounts of data from various sensors and bins, the system's central monitoring station enables sophisticated route planning. By considering factors such as bin locations, fill levels, traffic conditions, and even weather patterns, the system can dynamically generate the most efficient collection routes. This not only minimizes travel distances and time but also significantly reduces the carbon footprint associated with waste collection vehicles, contributing to a more sustainable waste management approach.
- Empowered Decision-Making and Real-Time Control: The implementation of a user-friendly web application has provided waste management authorities with unprecedented visibility and control over their operations. The application offers a comprehensive dashboard displaying real-time information on bin status, collection progress, potential issues such as sensor malfunctions or blockages, and historical data for trend analysis. This empowers authorities to make informed decisions promptly, adjust collection strategies as needed, proactively address any emerging challenges, and continuously improve the efficiency of their waste management processes.

- Sustainable Infrastructure and Long-Term Cost Reduction: The system's incorporation of solar panels to power its various components showcases a commitment to sustainability and resource conservation. By harnessing renewable energy, the system significantly reduces its reliance on the power grid, lowering operational costs and contributing to a greener waste management infrastructure.
- Improved Public Health and Safety: By preventing overflowing bins and associated environmental hazards, the IoT- based waste management system indirectly contributes to improved public health and safety. Reduced exposure to potential contaminants and disease vectors can lead to lower rates of illness and a cleaner, safer environment for residents and visitors alike.
- Enhanced Citizen Engagement and Satisfaction: The system's transparency and real-time data availability can be leveraged to engage citizens in the waste management process. For instance, mobile applications could be developed to allow residents to report overflowing bins or check the status of their local waste collection. This not only fosters a sense of community involvement but also increases citizen satisfaction with waste management services.

Conclusion

The Smart Dustbin project successfully integrates multiple technologies to create a functional and intelligent waste management solution. The use of an SG90 servo motor for automated lid opening enhances user convenience and hygiene by minimising physical contact with the bin. The ultrasonic sensor accurately measures the distance to detect waste levels, ensuring timely alerts for emptying the bin. By leveraging the ESP8266 and the Blynk platform, the project provides real-time data monitoring and notifications through the cloud, allowing for efficient waste management. This project demonstrates the feasibility and effectiveness of combining microcontroller-based hardware with IoT platforms to solve everyday problems. The modular design and clear implementation make it adaptable for further enhancements, such as solar power integration, advanced sensors for waste type detection, and machine learning algorithms for predictive maintenance. In summary, the Smart Dustbin project is a step forward in the direction of smart city initiatives, offering a scalable and cost-effective solution to improve urban cleanliness and waste management practices. It lays a solid foundation for future advancements in smart waste management systems, contributing to a cleaner and more sustainable environment.

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