IOT BASED WASTE MANAGEMENT SYSTEM

MINI PROJECT

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CONTENTS

INTRODUCTION

- Waste generation not adequately managed- health and environmental problems
- Caused due to lack of awareness,insufficient laws and policy
- Smart waste management system embedded with IoT technology
  - make the cities greener, safer, and more efficient
  - with sensors- can read, collect, and transmit huge volume of data over the Internet.
  - Real time monitoring along with route optimisation - reduce cost and time

MOTIVATION

- Environmental crisis-threatening ecosystems and biodiversity
- Health risk
- Inefficiencies and resource wastage.
- Overflowing waste bins, due to delayed collection
- increased operational costs and time
- Aesthetic degradation
- Increase in urbanisation trend

PROBLEM STATEMENT

Overflowing traditional waste bins lead to littering, odors, and health hazards due to waste management struggles with inefficient collection, monitoring, and resource use.

These challenges worsen environmental degradation, health risks, and resource depletion, emphasizing the urgent need for innovative waste management solutions promoting sustainability.

LITERATURE REVIEW

Serial No	Title of Research Paper	Author(s)	Highlights	Drawbacks
1	Smart Waste Management System using IOT, April-2020	Tejasree Kadus, Pawankumar Nirmal, Kartikee Kulkarni	Smart Netbin, Wifi facilities (Reward system, Load Sensors,IR Sensors, Mechanical Shredder	Lack of discussion on Economic Feasibility, Scalability, Maintenance,Data Security, Adaptive Capacity .
2	Design of a Convolutional Neural Network Based Smart Waste Disposal System (ICASEERT 2019).	Ekhlas Hossain Md. Samiul Haque Sunny Debopriya Roy Dipta Shifat Hossain	CNN Based System-Recognition,Classification. Implements waste exchange system with equivalent price calculation. Discusses waste management challenges faced in Bangladesh	Reliance on Technology(CNN) Complexity involved in CNN training and implementation . Cost, Affordability Waste Categorization-Overlooking into Waste Composition.

LITERATURE REVIEW

Serial No	Title of Research Paper	Author(s)	Highlights	Drawbacks
4	Iot based Smart Garbage Collection using RFID and Sensors , 2021	P. Ranjana, Varsha.S, Sherin Eliyas	RFID Tags :Value points added, Gas(Detect Odour,Toxic gases) ,Humidity ,IR sensors, GPS (Location)	Data Security ,Privacy(RFID tags) Uncertainty in User engagement, Regulatory ,Policy considerations
5	Arduino based Automatic Waste Segregation,August 2022	Mr.T.Muthuraja , Mrs.K.Jothilakshmi , Dr.R.Natarajan	Conveyor Belts,Arduino Controller Sensors: Gas ,proximity,conductivity	Reliability on Sensors, No color detection, Mechanical issues,Potential breakdown of Conveyor belt.

RESEARCH GAPS

- **Scalability, Interoperability** : Deployment and integration in various Environments.
- **Optimization Algorithms** : Considering Traffic patterns, Real time changes.
- **Sensor Technology and Reliability** : Improve Reliability, Accuracy and Durability of sensors.
- **Energy efficiency** :Iot devices that can operate on renewable energy, harvest energy from surrounding environment.
- **Data privacy, Security** :data encryption, authentication, and access control mechanisms .
- **Behavioural Insights and User Engagement** :Analysing waste generation patterns to understand Human behaviour.Engaging ,incentivizing citizens to participate
- **Cost -Benefit Analysis** :Evaluate Long term Viability and return of Investment.
- **Regulatory and Policy considerations :**Identify and address regulatory challenges

OBJECTIVES

- **Real time monitoring** : Using ultrasonic or infrared sensors . This data is transmitted in real-time to the waste management software
- **Route Optimization**: Integrate the software with GPS technology to dynamically optimize waste collection routes based on real-time fill levels. This ensures that collection vehicles are directed to bins requiring immediate attention.
- **Improving Efficiency**
- **Sustainability** : To promote sustainability by incorporating eco-friendly practices within the Waste Management System
- **Predictive Analytics**: Utilize ML algorithms to analyze historical data and predict future waste generation patterns.

OBJECTIVES

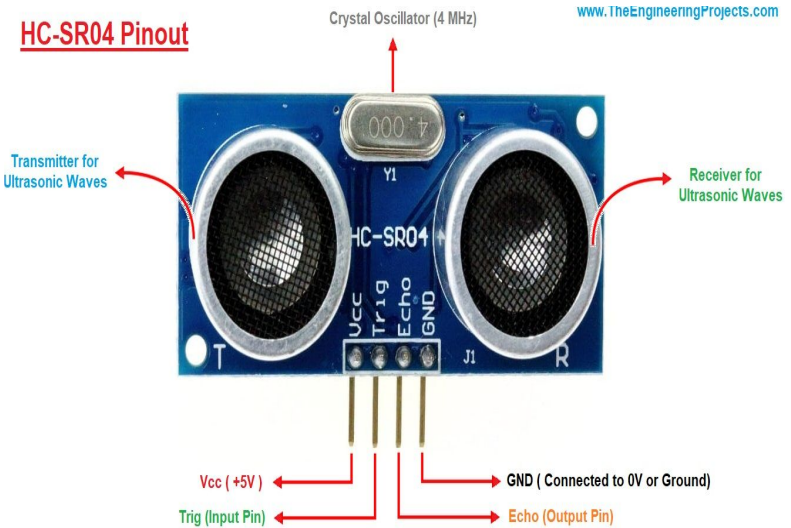
- **Community Engagement :**Using feedback mechanisms, and incentivizing responsible waste disposal behavior through IoT-enabled platform
- **Payment** : Establish a mechanism for weighing and pricing the collected garbage.
- **Improved Service Quality**

METHODOLOGY

HARDWARE REQUIREMENTS

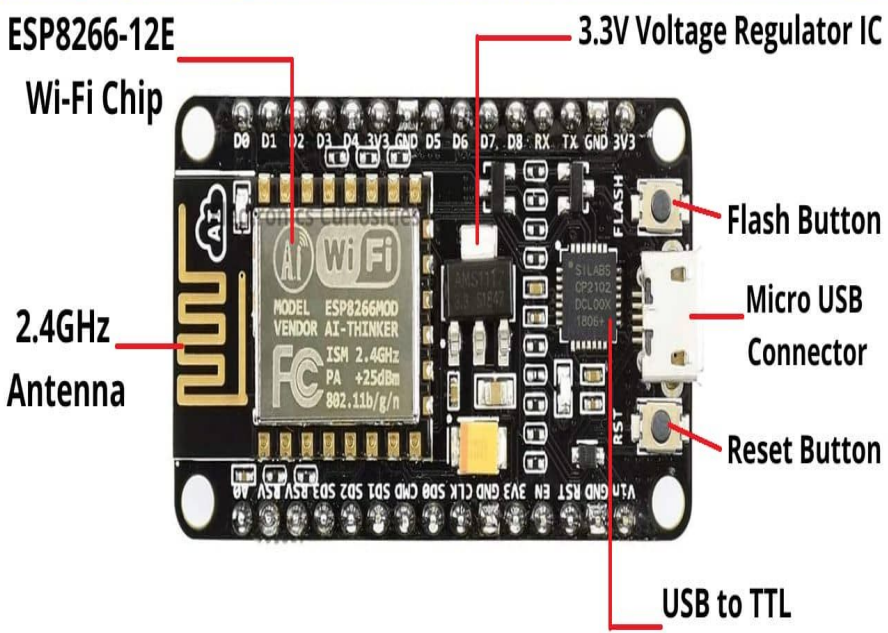
Ultrasonic Sensor:

- In IOT an ultrasonic sensor is an electronic device
- Measures the distance of a target object by emitting ultrasonic sound wave
- Converts the reflected sound into an electrical signals
- IOT ultrasonic sensors are designed for non-contact detection of solid and liquid objects



NodeMCU ESP8266:

- NodeMCU (*N*ode *M*icro*C*ontroller *U*nit) has built in WiFi.
- Open-source software and hardware development environment.
- Built around an inexpensive System-on-a-Chip (SoC) called the ESP8266.
- Contains the crucial elements of a computer:
  - CPU
  - RAM
  - networking (WiFi)
  - modern operating system



Power Adaptor:

- Device which provide electrical power to electronic devices.
- Also known as an AC/DC adapter.
- Provides interface between the electrical outlet (AC power) and the specific requirements of the device (DC power).
- It ensures a reliable and standardized power supply

SOFTWARE REQUIREMENTS

- Front End-Flutter
- Platform-Android,iOS
- Database - Google Firebase
  - Firebase Realtime Database used for data storage and synchronization.
  - Install Firebase Arduino library in Arduino IDE.
  - Allows easy communication between NodeMCU and Firebase.
  - Users can monitor and control NodeMCU remotely via Firebase console.

SOFTWARE MODULES

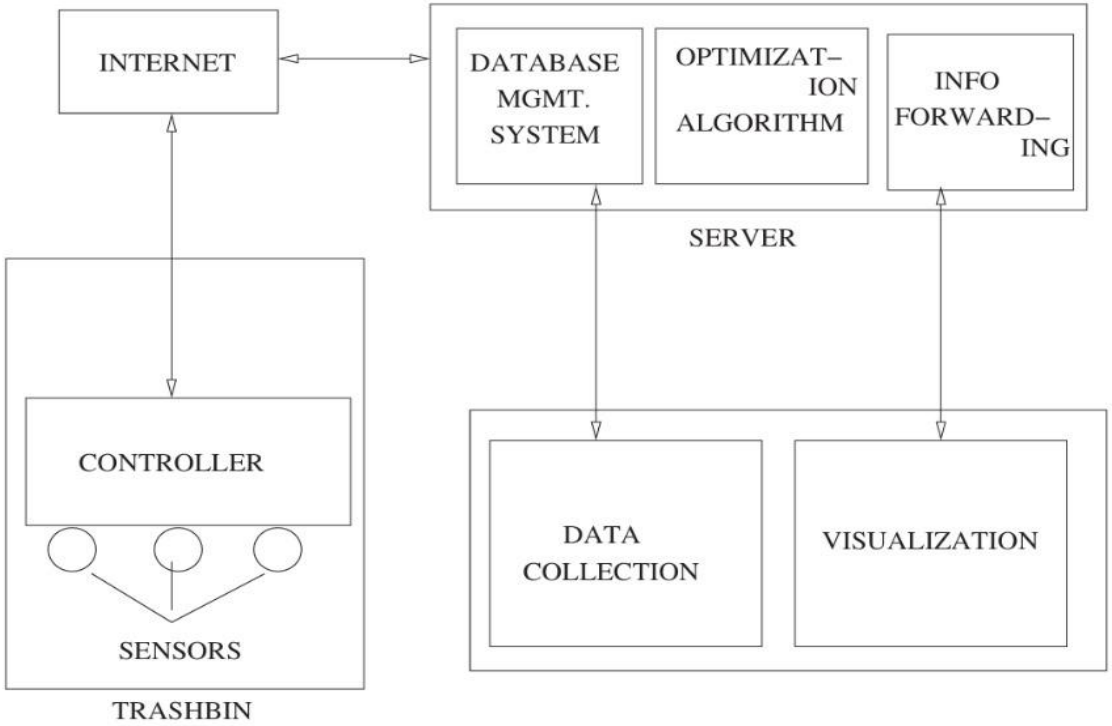
ADMIN INTERFACE FUNCTIONALITY:

- Overall Management and Monitoring
- Bin Management
- Driver Management
- Complaint Resolution
- Salary Distribution
- Performance Analysis
- Emergency Response
- User Support

DRIVER INTERFACE FUNCTIONALITY:

- Optimized Route Visibility
- Vehicle Maintenance Requests
- Communication with Admin
- Performance Tracking
- Notification System

SYSTEM ARCHITECTURE



ALGORITHMS USED

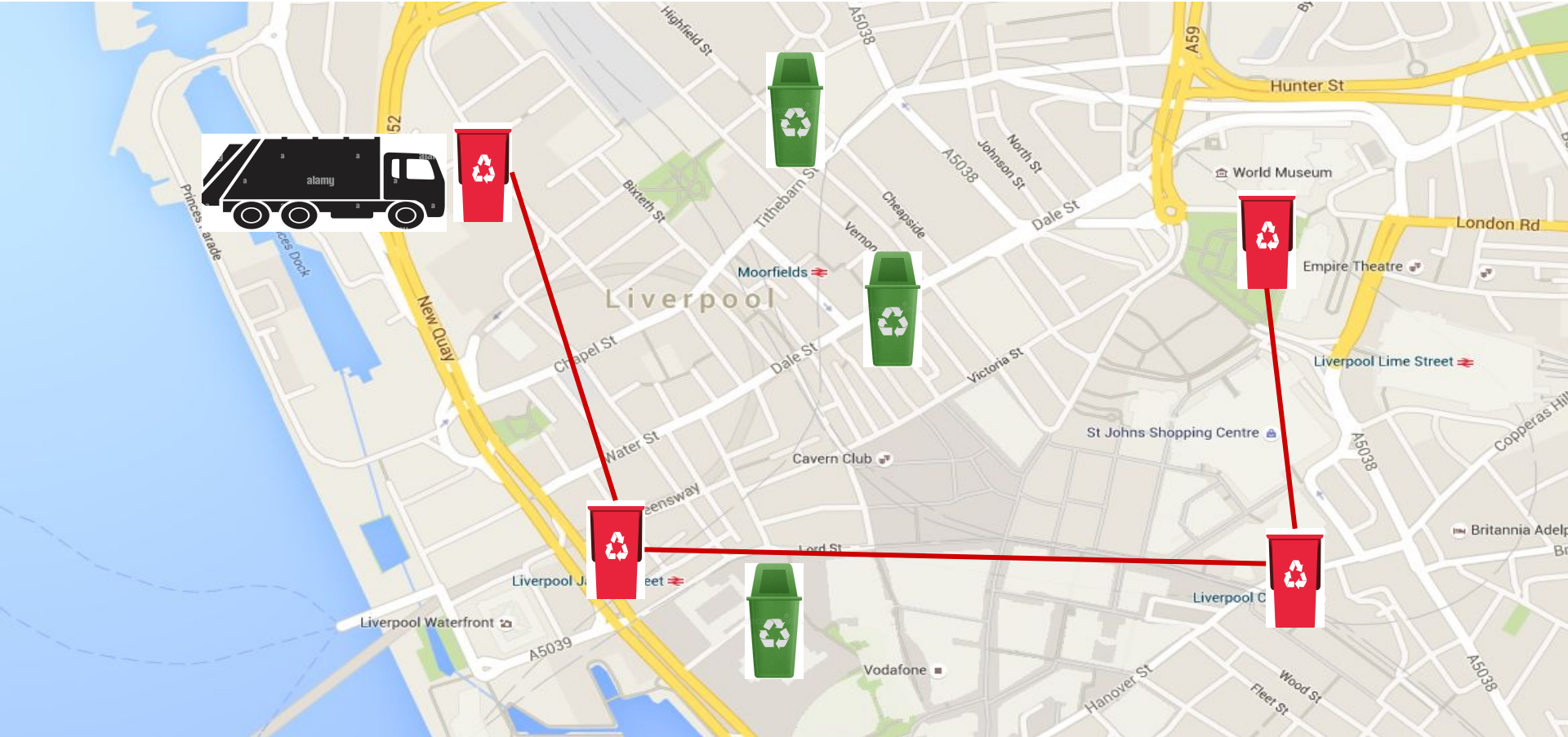
1.SMART WASTE MANAGEMENT ALGORITHM

- INSTALL IOT SENSORS IN WASTE BINS
- SET THRESHOLD VALUES
- COLLECT DATA
- SEND IT OVER INTERNET
- STORE AND PROCESS
- FIND OPTIMISED ROUTES FOR COLLECTION
- EMPTY THE WASTES

2.SHORTEST PATH SPANNING TREE ALGORITHM

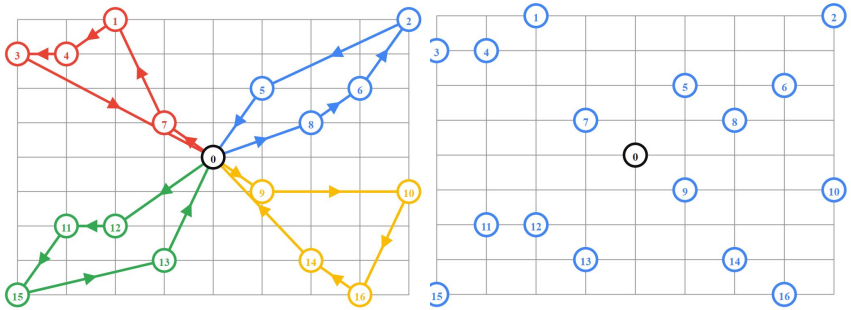
- SET THE FILLED WASTE BINS AS NODES
- CALCULATE SHORTEST DISTANCE BETWEEN TWO LOCATIONS
- CALCULATE DISTANCE FROM ONE TO ALL OTHER NODES
- DIJKSTRA’S ALGORITHM IS MADE USE OF
- ROUTE OPTIMISATION FOR DRIVERS IS FOUND

ROUTE OPTIMIZATION



VEHICLE ROUTING PROBLEM : OR TOOLS

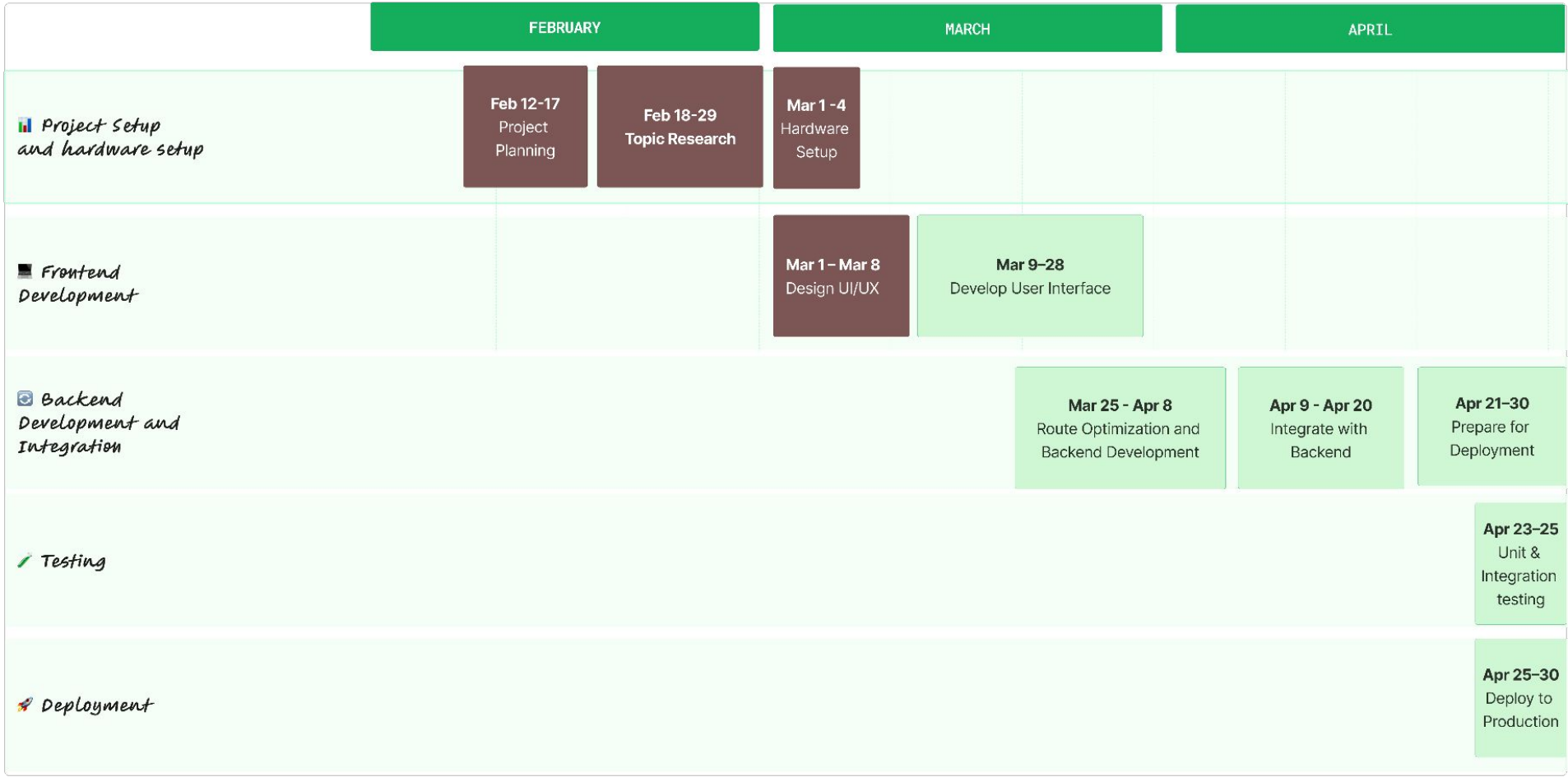
- **OR-Tools** is an open-source operations research software suite developed by Google. It provides various tools and algorithms for solving optimization problems, including linear programming, mixed-integer programming, constraint programming, and vehicle routing problems.
- **Vehicle Routing Problems (VRP)**: OR-Tools includes specialized algorithms and tools for solving vehicle routing problems, such as the Capacitated Vehicle Routing Problem (CVRP), the Vehicle Routing Problem with Time Windows (VRPTW), and the Vehicle Routing Problem with Pickup and Delivery (VRPPD).
- **Routing Optimization**: OR-Tools provides algorithms for solving routing optimization problems, including finding the shortest path, calculating distances between locations, and optimizing routes for multiple vehicles with various constraints.



SOLUTION APPROACH

- **Data Collection :** Gather information on customer addresses, delivery demands, vehicle capacities, and other relevant details.
- **Preprocessing :** Calculate the distance matrix between delivery locations using a distance API and organize the data into a suitable format for OR-Tools.
- **Model Formulation :** Formulate the problem as a VRP or its variants, specifying decision variables, an objective function, and any constraints.
- **Implementation using OR-Tools :** Utilize OR-Tools to construct a routing model, defining parameters such as vehicle capacities and applying solving techniques like local search or metaheuristics.
- **Post-Processing :** Analyze the optimized routes obtained from OR-Tools, and visualize them on a map using Python mapping libraries for further insights and verification.

WORK PLAN

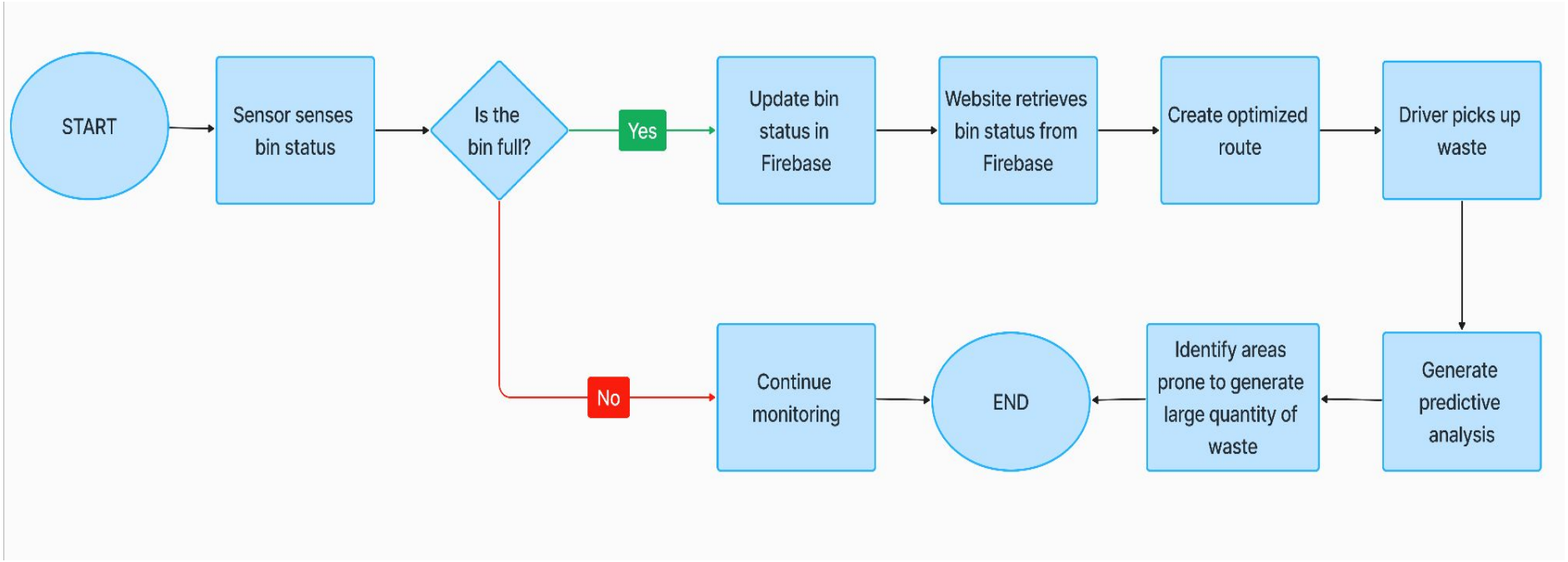

FEBRUARY
MARCH
APRIL
Project Setup and hardware setup
Feb 12-17 Project Planning
Feb 18-29 Topic Research
Mar 1 -4 Hardware Setup
Frontend Development
Mar 1 – Mar 8 Design UI/UX
Mar 9–28 Develop User Interface
Backend Development and Integration
Mar 25 - Apr 8 Route Optimization and Backend Development
Apr 9 - Apr 20 Integrate with Backend
Apr 21–30 Prepare for Deployment
Testing
Apr 23–25 Unit & Integration testing
Deployment
Apr 25–30 Deploy to Production

WORK DONE

1.PROJECT PLANNING

- Requirement analysis is gathered.
- A comprehensive flowchart of the project is planned.
- The data flow pertaining to the information gathering is decided.
- Gathered information regarding hardware component connection

COMPREHENSIVE FLOWCHART



2. TOPIC RESEARCH

- Referred research papers (mentioned in literature review)
- Various route optimisation algorithm;
  - Shortest Spanning Tree Algorithm
  - Dijkstra's
  - A* Algorithm
  - OR Tools
- Existing waste management systems and its drawbacks
- Sustainability concepts in waste management
- Challenges people face in managing waste
- Working of :
  - Nodemcu ESP8266
  - Arduino IDE
  - Ultrasonic sensor
- Iot Based devices and network s

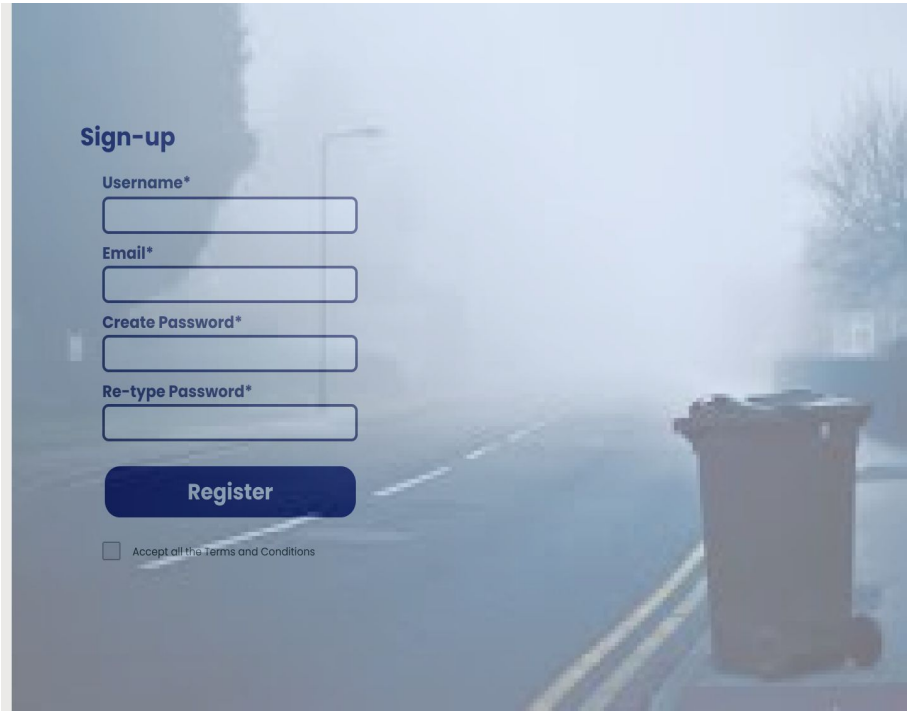
3. UI DESIGN

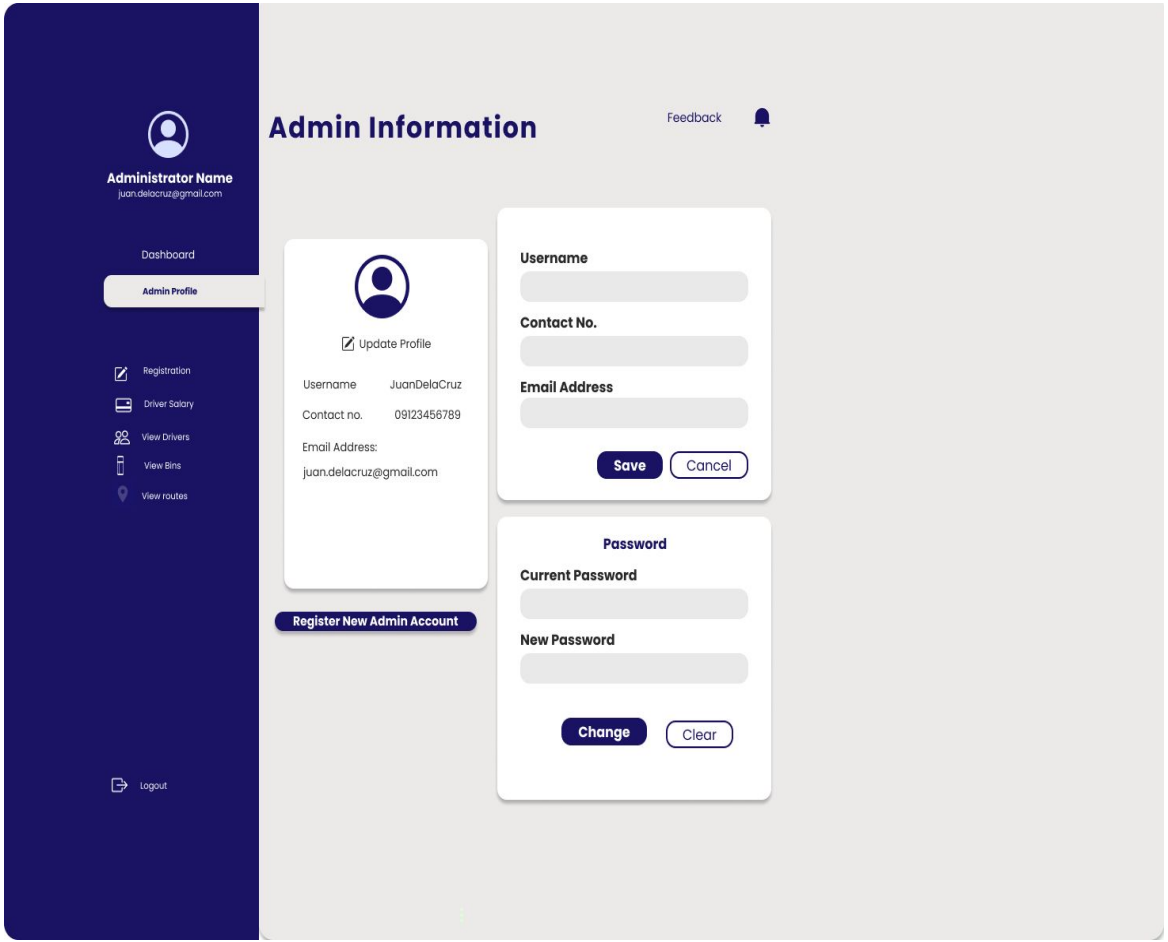
The following user interface components has been designed using Figma:

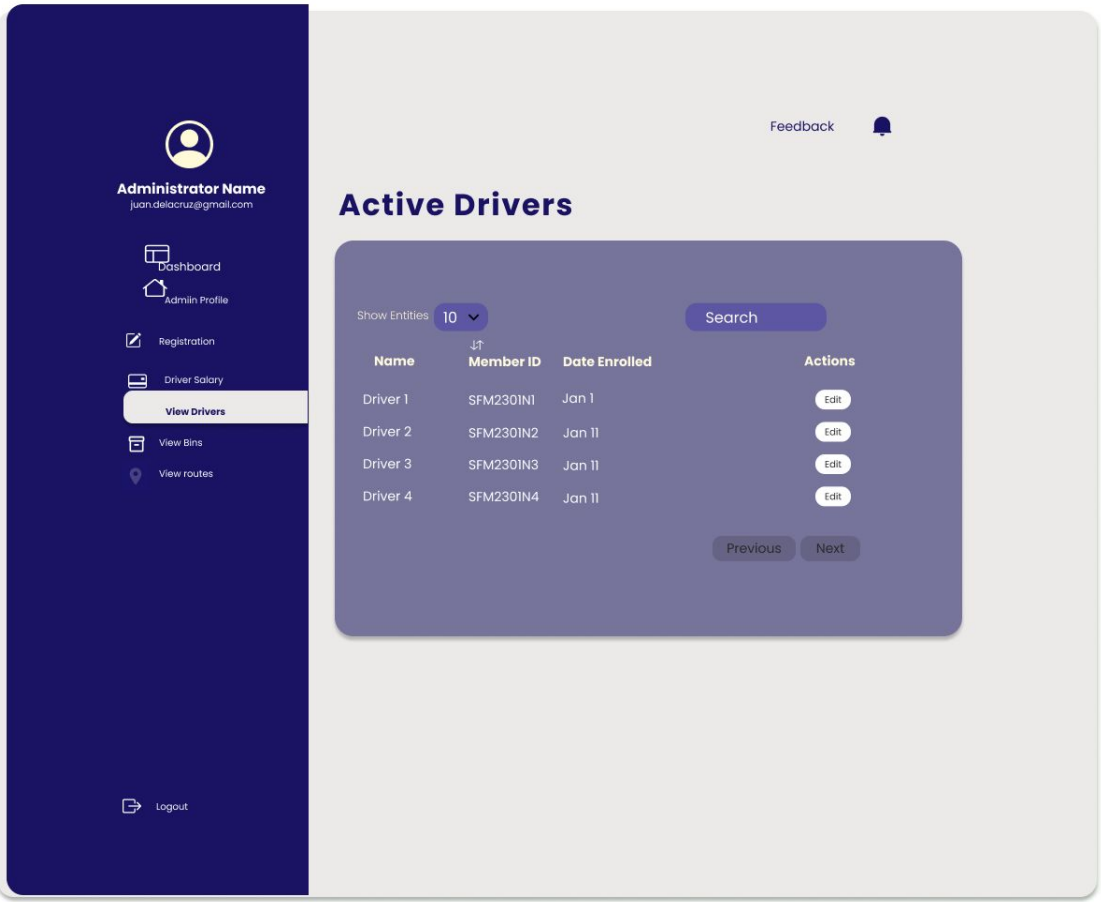
- Sign up page for drivers
- Login page for drivers
- Admin dashboard
- Driver information
- Optimised route display interface

UI/UX DESIGN


Sign-in
Email*
Password*
Remember me
Forgot Password?
Login


Sign-up
Username*
Email*
Create Password*
Re-type Password*
Register
Accept all the Terms and Conditions


Administrator Name
juan.delacruz@gmail.com
Dashboard
Admin Profile
Registration
Driver Salary
View Drivers
View Bins
View routes
Logout
Admin Information
Feedback
Update Profile
Username JuanDelaCruz
Contact no. 09123456789
Email Address:
juan.delacruz@gmail.com
Register New Admin Account
Username
Contact No.
Email Address
Save
Cancel
Password
Current Password
New Password
Change
Clear


Administrator Name
juan.delacruz@gmail.com
Dashboard
Admiin Profile
Registration
Driver Salary
View Drivers
View Bins
View routes
Logout
Feedback
Active Drivers
Show Entities
10
Search
Name
Member ID
Date Enrolled
Actions
Driver 1
SFM2301N1
Jan 1
Edit
Driver 2
SFM2301N2
Jan 11
Edit
Driver 3
SFM2301N3
Jan 11
Edit
Driver 4
SFM2301N4
Jan 11
Edit
Previous
Next

DRIVER NAME
juan.delacruz@gmail.com

Dashboard

Admin communication

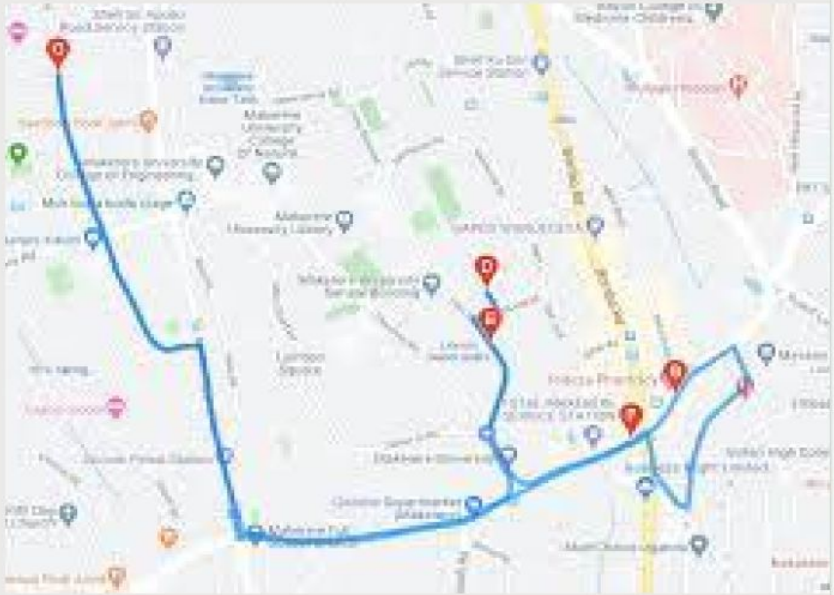
Route

Vehicle Maintanance Request

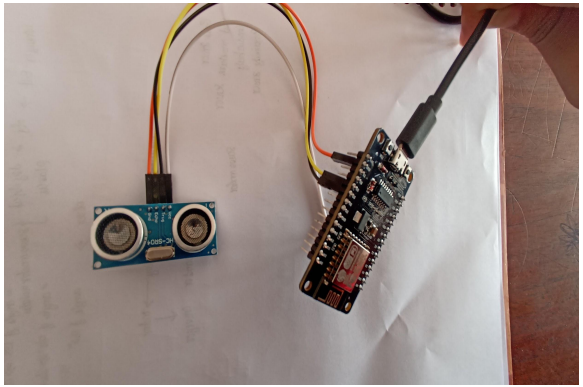
Logout

Feedback

Optimized Route

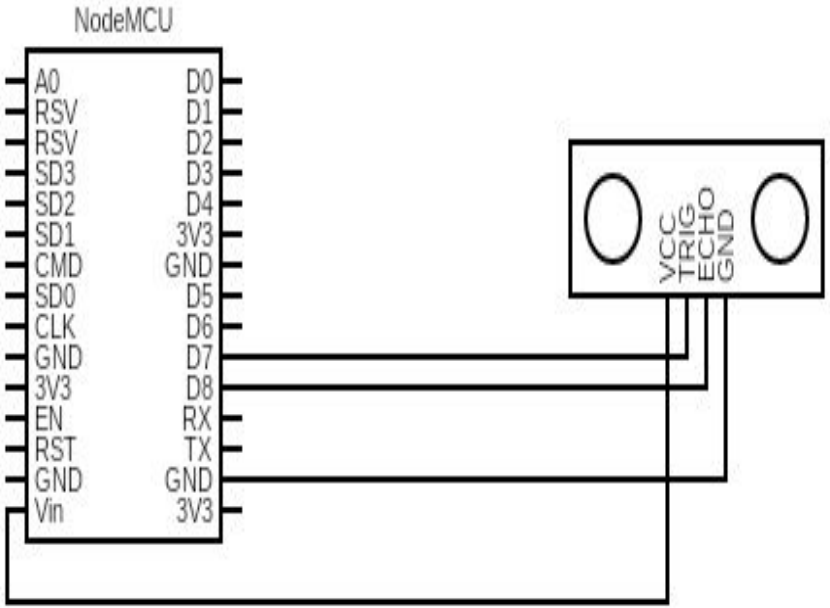


4.HARDWARE SETUP



Connection of nodemcu 8266 with ultrasonic sensors

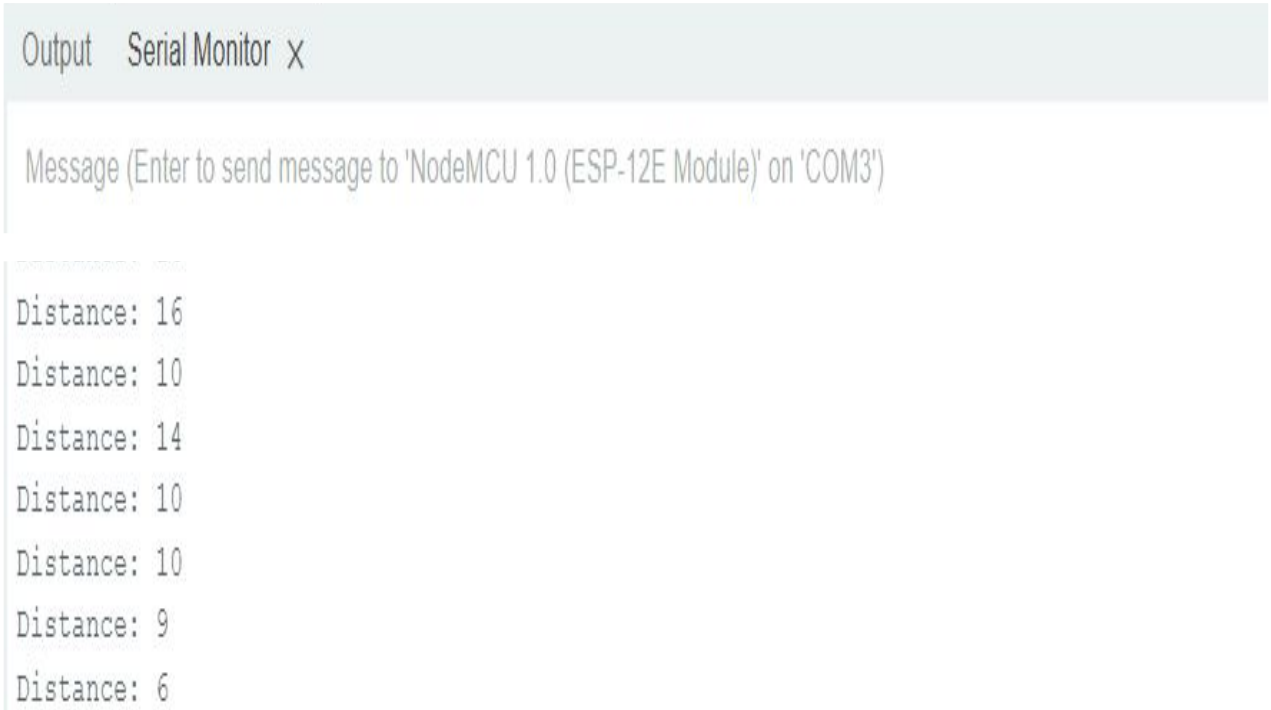
HARDWARE CONNECTION



CODE

```
// defines pins numbers
const int trigPin = 13;  //D4
const int echoPin = 15;  //D3

// defines variables
long duration;
int distance;

void setup() {
pinMode(trigPin, OUTPUT); // Sets the trigPin as an Output
pinMode(echoPin, INPUT); // Sets the echoPin as an Input
Serial.begin(9600); // Starts the serial communication
}

void loop() {
// Clears the trigPin
digitalWrite(trigPin, LOW);
delayMicroseconds(2);

// Sets the trigPin on HIGH state for 10 micro seconds
digitalWrite(trigPin, HIGH);
delayMicroseconds(10);
digitalWrite(trigPin, LOW);

// Reads the echoPin, returns the sound wave travel time in microseconds
duration = pulseIn(echoPin, HIGH);

// Calculating the distance
distance= duration*0.034/2;
// Prints the distance on the Serial Monitor
Serial.print("Distance: ");
Serial.println(distance);
delay(2000);
}

```

OUTPUT


Output
Serial Monitor
Message (Enter to send message to 'NodeMCU 1.0 (ESP-12E Module)' on 'COM3')
Distance: 16
Distance: 10
Distance: 14
Distance: 10
Distance: 10
Distance: 9
Distance: 6

WORK TO BE DONE

1.USER INTERFACE DEVELOPMENT

2.ROUTE OPTIMISATION AND BACKEND DEVELOPMENT

3.INTEGRATION WITH BACKEND

4.DEPLOYMENT

5.TESTING

RESULT AND CONCLUSION MADE SO FAR

- Implemented hardware connection of ultrasonic sensor and nodemcu esp8266
- Code for distance measurement had been run on Arduino IDE
- Successfully measured the waste level using sensor and the output is obtained
- UI design for website is created

REFERENCES

“Design of a Convolutional Neural Network Based Smart Waste Disposal System (ICASEERT 2019)” . By Ekhlas Hossain.

“Smart Waste Management System using IOT, April-2020” ,By Tejasree Kadus, Pawankumar Nirmal,Kartikee Kulkarni.

“Iot based Smart Garbage Collection using RFID and Sensors , 2021” , By P. Ranjana, Varsha.S, Sherin Eliyas.

“Arduino based Automatic Waste Segregation,August 2022” ByMr.T.Muthuraja, Mrs.K.Jothilakshmi, Dr.R.Natarajan.