Palestine Polytechnic University

College of Information Technology and Computer Engineering.

IoT Based Smart Trash Collection Management System

Team:
Reem Ghayadah
Rawand Taha

Supervisor:
Dr. Radwan Tahboub

Abstract

This project focuses on a new, smart, and easy way for the municipality to empty out trash cans in a more efficient and cost-effective way, based on IOT technology. With a rapidly growing city like Hebron, more and more trash cans are placed all over the city, and with an increasing population, the waste production increases. A new and innovative system would benefit the city as well as the citizens living in the it.

This project would benefit citizens by giving them a cleaner environment. It aims to make the city smarter by having the trash cans in the road, in the street or in the front of home emptied as soon as they are full. It would also help the government save money by sending the closest garbage trucks to the right places and in the shortest amount of time possible using a Dijkstra's algorithm (short path algorithm).

With a problem that is just going to increase as time goes by, our project helps to put a solution by introducing new technology and integrate it with the traditional way of cleaning waste. Making the waste cleaning IoT based, which would make the process more efficient, and lead the city to be more technologically advanced, and be on its way to become a smart city.

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Chapter 1
Introduction

1.1overview of the project:

Smart trash disposal and management is a smart way to dispose of trash in an innovative and efficiently manner. Adopting IoT concepts, we strive to create a smart way to save time and money in emptying trash cans, while also helping communities stay clean, and to make the city smarter.

We have created a complete smart system through which the trash within the city is managed in a smart way.

The system starts from the trash can that can separate the trash into wet or dry, and then information about the trash can is sent to the controller in the municipality through which the shortest path algorithm is run and the status of the basket is clear through a web Application , and the map that contains the trash can is sent The shortest path to reach it via a web Application dedicated to the truck driver.

1.2Description:

Technology has entered great areas in our lives until the term Internet of Things (IoT) or otherwise, the Internet of Everything (IoE), is a very common topic and is used in everything around us.

As a result of our concern for our society and our knowledge of the importance of new technologies to solve problems, we decided to employ of things to solve a basic problem within the city of Hebron.

The trash can contain IR sensor used to detect when something is placed in the surface of trash can, then the moisture sensor run to measure the moisture level of what is placed. Which would trigger a servo motor to move the trash either to the dry or wet container. The trash can would also have an LED on it that would indicate how much trash there is in the bin.

Then the status of trash can sent to controller on municipality and be appear on web Application, now in controller run the Dijkstra algorithm using MATLAB to find the shortest path to reach the full trash cans.

Now the tuck driver can see the shortest path via web Application.

1.3 Motivation

This project is to help the city move towards a technological future, even with a small step like our project. We also want to help the city save money and effort, by helping them empty trash cans in a more affiant manner and help them save money by letting the truck drivers only go to the full trash cans.

Our project also helps the environment by separating the wet from the dry waste, since wet trash is usually food, which is dissolvable, and separating it would reduce the amount of waste sent to the landfills, and instead, it would get sent to its own place where it can dissolve in the ground.

With a city growing rapidly like Hebron, it's very important to move towards technology to help us keep up with the demands of keeping the city clean. Moving towards becoming a smart city would greatly benefit us as citizens and the city in general.

1.4 Objectives

The main objective of our project is the use of IoT to achieve a cleaner and efficient way in cleaning the garbage.

- Can measure the waste inside each trash can.
- Give the drivers the shortest way possible to each trash can.
- Give management an elegant way of monitoring the system.
- Save time and money in getting the closest driver go to the full trash cans.
- Keep the environment clean.
- Provide a way to separate wet from dry waste.
- Give private citizens a way to keep track of their trash cans.

1.5 The available choices:

To apply this idea, we can use a GSM piece Instead of IOT piece. It can send the status of the garbage bin using a web server, but we will work on mobile application to make the system more interactive.

1.6 Scope:

This project will work on trash cans on the street or in front of residential communities, in other words, any trash can that the municipality is responsible for cleaning. The project also works on private owned trash cans like mall or in homes, where there would be an application for the owner.

1.7 Problem analysis:

The issue found in our country is that most of time, there is no working system for clearing them, sometimes empty cans that are not full, and sometimes the trash cans would be full for days, which would cause the residents to burn them, which would cause pollution. And it's also not efficient enough, which causes the city to pay more money.

1.8 Previous study:

There are different projects that are developed of a smart garbage monitoring system. There is project which is named (Smart Garbage Monitoring System for Waste Management Developed by

1. Norfadzlia Mohd Yusof1,*, Aiman Zakwan Jidin1 , and Muhammad Izzat Rahim1 1Faculty of Engineering Technology, Universiti Teknikal Malaysia Melaka, Malaysia)

Name of Project	**Smart Garbage Monitoring System for Waste Management**	**IoT Based Smart Garbage Collection Management System**
Aim	This system will automatically monitor the garbage level at each bin and will alert the municipality in the case where the bins are almost full.	Separate dry and wet waste. Monitoring the level of trash in cans. Management the trash collection by the smart system
Microcontroller	Arduino Uno	ESP-wroom32
Data Transition	GSM	WI-FI module (ESP-wroom32)
Result	when trash can full red LED is turning ON (while the green LED is turned OFF), and the second warning SMS is sent, telling the municipality to immediately collect the waste disposal	Separate wet and dry trash. A Wi-Fi module was used to send the trash can status to the municipality and then send the shortest route to the worker's phone

Table 1 Previous study

2. SMART GARBAGE COLLECTING BIN FOR MUNICIPAL SOLID WASTE:

(Arunkumar.G, Bhanu Priya.G, Prof.R.Santhosh Kumar)

(Environmental Engineering, Anna University Chennai, India, arunganesh.trec@gmail.com) , (Department of Life Science, Avinashilingham University, Coimbatore, India, gbhanuaducbe@gmail.com)

In our daily life, we see the pictures of garbage bins being overfull and all the garbage spills out resulting in pollution. This also increases number of diseases as large number of insects and mosquitoes breed on it. Hence our problem statement is to design a System for collecting the garbage from a particular area the area whose public Garbage Bins are overflowing with prior concern. A big Challenge in the urban cities is Solid waste management, not only in India but for most of the countries in the world. The project gives us one of the most efficient ways to keep our environment clean and green.

Global System for Mobile Communication (GSM) is the latest trends and are one of the best combinations to be used in the project. Hence, a combination of both of these technologies is used in the project. To give a brief description of the project, the sensors are placed in the common garbage bins placed at the public places. When the garbage reaches the level of the sensor, then that indication will be given to ARM 7 Controller. The controller will give indication to the driver of garbage collection truck as to which garbage bin is completely filled and needs urgent attention. ARM 7 will give indication by sending SMS using GSM technology.

The using project hard ware compent :

1. Microcontroller:

To solve this problem microprocessor system is implemented with a single chip microcontroller. This could be called microcomputer, as all the major parts are in the IC. Most frequently they are called microcontroller because they are used they are used to perform control functions. The microcontroller contains full implementation of a standard MICROPROCESSOR, ROM, RAM, I/0, CLOCK, TIMERS, and also SERIAL PORTS. Microcontroller also called "system on a chip" or "single chip microprocessor system" or "computer on a chip

2. Liquid Crystal Display:

The LCD does not generate light and so light is needed to read the display

3. GSM Technology : Global System for Mobile Communications.

Results

After dilution, the bacterial colonies were counted and used to quantify the number of cells in the waste. The data obtained from the graph clearly shows that the microbial population increases significantly when the waste was left open for 7 days compared to 3 days. More the microbial cell numbers multiply easier it will infect animals and humans. Decomposition is must but it has to be performed in a controlled environment.

1.9List of requirements:

System requirement:

- Can measure the waste inside each trash can using ultrasonic sensor
- Give the drivers the shortest path possible to each trash can using the Dijkstra algorithm (short path algorithm) running on the computer using MATLAB.
- Give management and smart way of monitoring the system. Using a MATLAB that shows the location of all the truck cans in the city, and sending the shortest path to driver's mobiles via web Application.
- Save time and money in getting the closest driver go to the full trash cans by sending the shortest path to the web Application on the driver's phone.
- Keep the environment clean by cleaning the trash cans as soon as they are full.

Hardware equipment:

- IR sensor to detect if any new trash or not.
- Moisture sensor to determine whether the waste is wet or dry.
- Servo motor to move the trash can surface to right or to left.
- Ultrasonic sensor to measure the level of trash in the trash can.
- ESP-wroom32 to read the ultrasonic sensor signals.
- PC in the municipality to monitor the system.
- A smartphone for the drivers uses it to get to the trash cans status.

Software components:

- Arduino IDE to help write the code for the hardware
- MATLAB to run Dijkstra algorithm.
- PhpMyAdmin to save the data.
- WampServer to create dynamic Web applications.

system equipment:

- To measure the waste inside each trash can by using the ultrasonic sensor
- To give drivers the shortest path possible to each trash can the using Dijkstra algorithm
- To give management an elegant way of monitoring the system using IOT.
- to Save time and money in getting the closest driver go to the full
- trash cans using application contain Shortest path algorithm

Programming Language:

- C/C++ for programming Arduino
- C, C++, and Java for programing MATLAB
- C, C++, JavaScript and php to web Applications.

1.10 Expected results:

After implementing this project, we expect these results:

- Trash management will be smart.
- Trash cans statues can be clearly observed in tracks driver's phone.
- When a trash can is full, it would send change its status in the database to full.
- Drivers would be connected to the controller in the municipality.
- The closest driver in the area would get a notification to go empty that trash can.
- Management would have a map of all the driver's locations and the locations for every trash can in the city.

1.11 System constrains

One of the most important constraints is the internet connection and the electricity for every trash can, if either one gets cut off, the entire system would shut down. Another problem with the system is that it relies on the truck drivers by having them accept the request to go pick up the trash can, if the driver far from the trash can accepts the request first, then the closer driver would not be able to go pick up that trash can.

Chapter 2
background

2.1 Overview

This chapter introduces the theoretical background of our project, short description of design options that will be used in the system, design specifications and constraints and some additional information about the system.

2.2 Theoretical background

Through this project we aim to provide an integrated system for trash management efficiently, without the need to monitor it, here is designed an integrated system to solve the problem of collection of traditional trash ineffective and disorganized, by designing a smart system based on the Internet of things. the level of each trash can be determined through a sensor and then send it to controller in a municipality after this run the Dijkstra algorithm to send the result to web Application on (driver mobile).

The message will be received via web Application, we will develop this interactive web Application, easy to use for track driver to receives the message or notification. Once the notification arrives the truck driver will also be able to get the shortest path arrived for trash can.

We will develop this system to also work on trash automated separation rather than manually separation. Through this system we will provide automatic wet and dry separation process, which will be mechanically separated in separate containers by sensors, to detect the presence of any wet or dry waste that can be detected using IR sensor, In the second step we will detect wet waste can use moisture sensor.

If only IR is detected motor will rotate in the direction of the dry waste container. If the two sensors detect the waste, it will rotate in the direction of the wet waste container.

2.3. Hardware components

a. Microcontrollers

There are two of microcontrollers and one microcomputer can be used in our project.

- First Design Option: Arduino, Arduino is an open-source platform used for building electronics projects. Arduino consists of both a physical programmable circuit board (often referred to as a microcontroller) and a piece of software, or IDE (Integrated Development Environment) that runs on your computer, used to write and upload computer code to the physical board. Arduino makes several different boards, each with different capabilities (Arduino Uno R3, Arduino Mega2560, Arduino Leonardo) and others [4].

- Second Design Option: Raspberry pi a small, single-board computer, has a 64-bit 2quad-core ARMv8 processor and uses a Raspbian distribution of Linux for its default operating system (OS), the Raspberry Pi computer is essentially a wireless Internet capable system-on-a-chip (Soc) with 1 GB RAM, connection ports, a Micro SD card slot, camera and display interfaces and an audio/video jack [5].

- Third Design Option: ESP3 is a series of low-cost, low-power system on a chip microcontroller with integrated Wi-Fi and dual-mode Bluetooth The ESP32 series employs a Ten silica Xtensa LX6 microprocessor in both dual-core and single-core variations and includes built-in antenna switches, RF balun, power amplifier, low-noise receive amplifier, filters, and power-management modules ESP32 is created and developed by Espressif Systems, a Shanghai-based Chinese company, and is manufactured by TSMC using their 40 nm process.[2] It is a successor to the ESP8266 microcontroller2.

  •We will choose an ESP –wroom-32 , as shown in Figure 2.2 , That module nestled of this Feather contains a dual-core ESP32 chip, 4 MB of SPI Flash, tuned antenna, and all the passives you need to take advantage of this powerful new processor. The ESP32 has both Wi-Fi and Bluetooth Classic/LE support. That means it's perfect for just about any wireless or Internet-connected project, the ESP32 has way more GPIO, plenty of analog inputs, two analog outputs, multiple extra peripherals (like a spare UART), two cores

so you don't have to yield to the Wi-Fi manager, much higher-speed processor, Reduce the use of the number of tools

Figure 2.1 ESP-Wroom-32

ESP32 Module

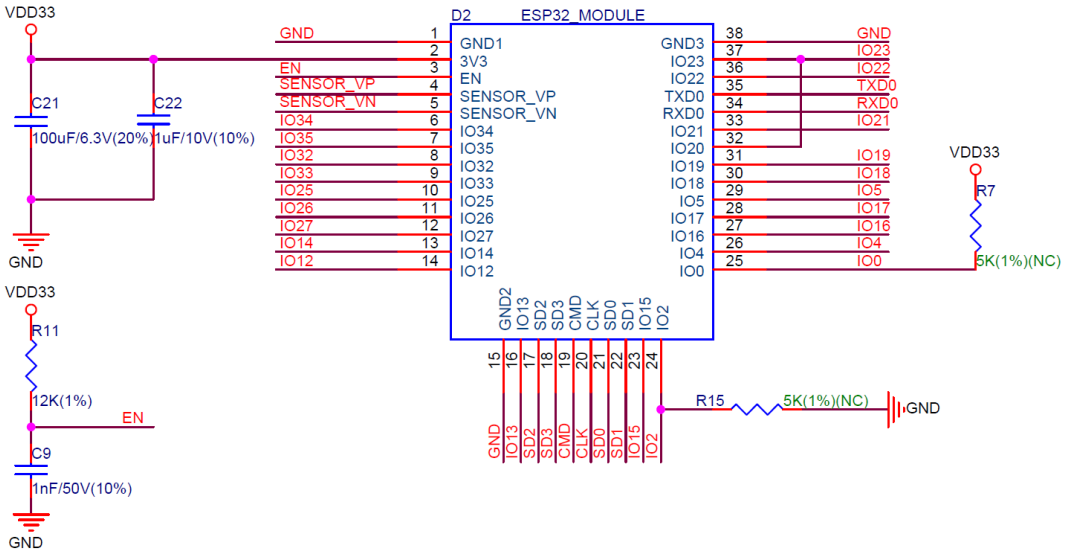


Figure 2.2 ESP-Wroom-32 schematic

b. Activation system

- (IR) Sensors:

Infrared sensors work on the principle of reflected light waves. Infrared light reflected from objects

Figure 2.3 IR sensor

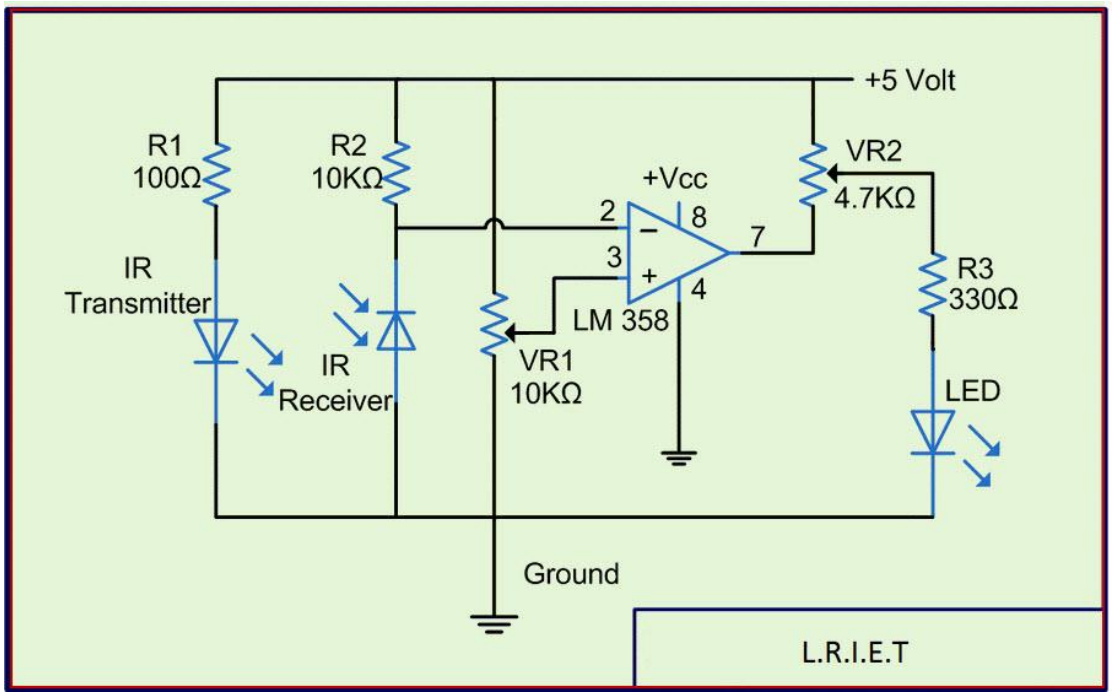


Figure 2.4 IR sensor schematic

- Advantages:

  1. Infrared sensors are also used to measure distance or proximity.

2. The reflected light is detected and then an estimate of distance is calculated between sensor and object.

3. It's provided 100 cm to 500 cm measurements.

- Disadvantages:
  1. Strong light can affect the measurements.
  2. Transmission Data rate is slow.
  3. Limited range.

c. Waste level measurement

To detect the distance and measure the waste level in the trash can, there are some choices for using sensors:

- Ultrasonic sensor:

work on the principle of reflected sound waves and are used to measure distance, Sound waves are emitted by the ultrasonic sensor and they're reflected back if there is an object in front of it. The sensor detects these waves and measures the time it takes between transmitting and receiving those sound waves. Show figure 2.5

Figure 2.5 Ultrasonic sensor

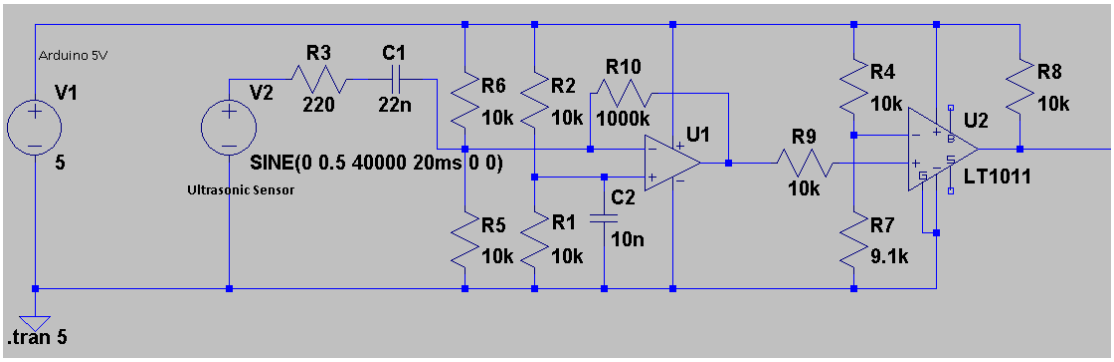


Figure 2.6 Ultrasonic sensor schematic

- Advantages:
  1. Distance is estimated by the time interval between sensor and object.

2. It has sensing capability to sense all the material types, this sensor is not affected due to atmospheric.
3. It can work in any adverse conditions.
4. It has higher sensing distance (in centimeters and inches) 2cm to 400cm measurement.
5. It provides good readings in sensing large sized objects with hard surfaces

- Disadvantages
  1. It has more difficulties in reading reflections from soft, curved, thin and small objects.

Chosen Design Option: The first approach was chosen, as shown in Figure 3, because it's the Most popular and is commonly used with microcontroller, Infrared sensors can't work in dark environments while Ultrasonic Sensors can, ultrasonic sensors are more reliable than IR sensors.

d. Motor:

To control the movement of the belt in the right direction:

First Design Option: DC motor is a two-wire continuous rotation motor and the two wires are power and ground. When the supply is applied, a DC motor will start rotating until that power is detached.

- Advantages:
  1. Simple, cheap drive design.
  2. Easy to control via computer with relays or electronic switches.
  3. With the gearbox, larger DC motors can power a 200-pound robot.

- Disadvantages:
  1. Requires gear reduction to provide torques needed for most robotic applications.
  2. Poor standards in sizing and mounting arrangements.

Second design options: Servo motor Generally the servo motor is an association of four things, namely a DC motor, a control circuit, a gearing set, and also a potentiometer usually a position sensor

- Advantages

1. Least expensive non-surplus source for gear motors.
2. Can be used for precise angular control, or for continuous rotation.

- Disadvantages:
  1. Requires modification for continuous rotation.
  2. Requires special driving circuit.

Chosen Design Option: We have chosen the Servo motor to control the surface of trash can , as shown in Figure 2.7 because it is a simple and strong motor, it is easy to control the speed and direction and Servo motor responses quickly to control signals, And it can rotate in both left and right directions, It was the best choice due to the rather heavy weight of the basket surface

Figure 2.7 Servo Motor

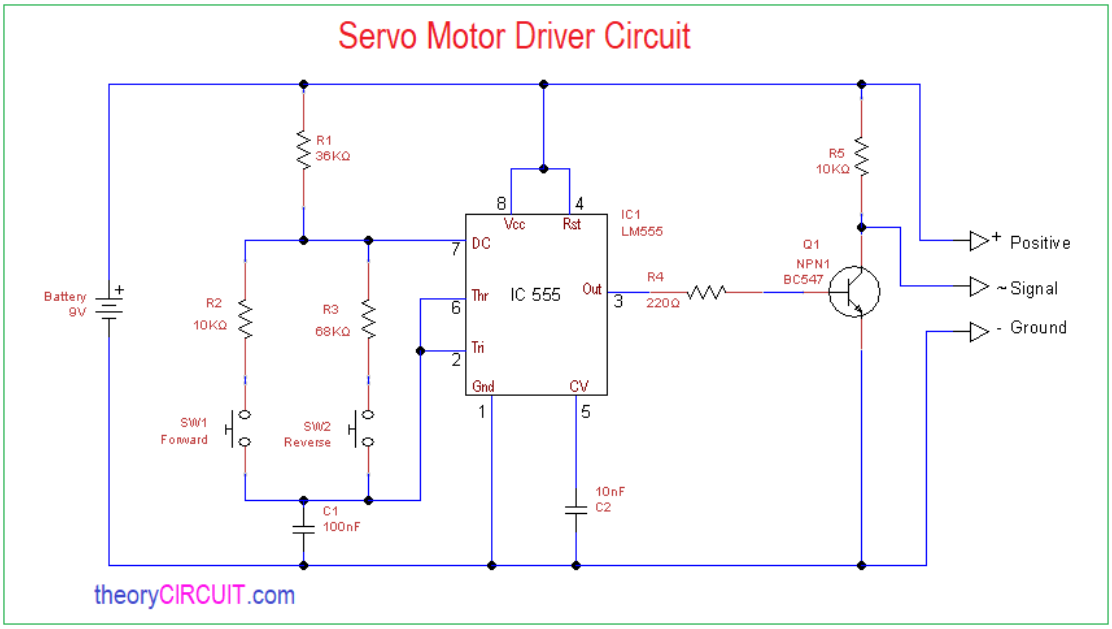


Figure 2.8 Servo Motor schematic

e. Motor Driver:

Use it to control the high voltage, most of the microcontrollers operate on very low voltage (5v) and current while the motors require higher voltages and current So, the microcontrollers cannot provide them such higher current. For this purpose, we use motor driver ICs. show figure 2.9

Figure 2.9 Motor Driver

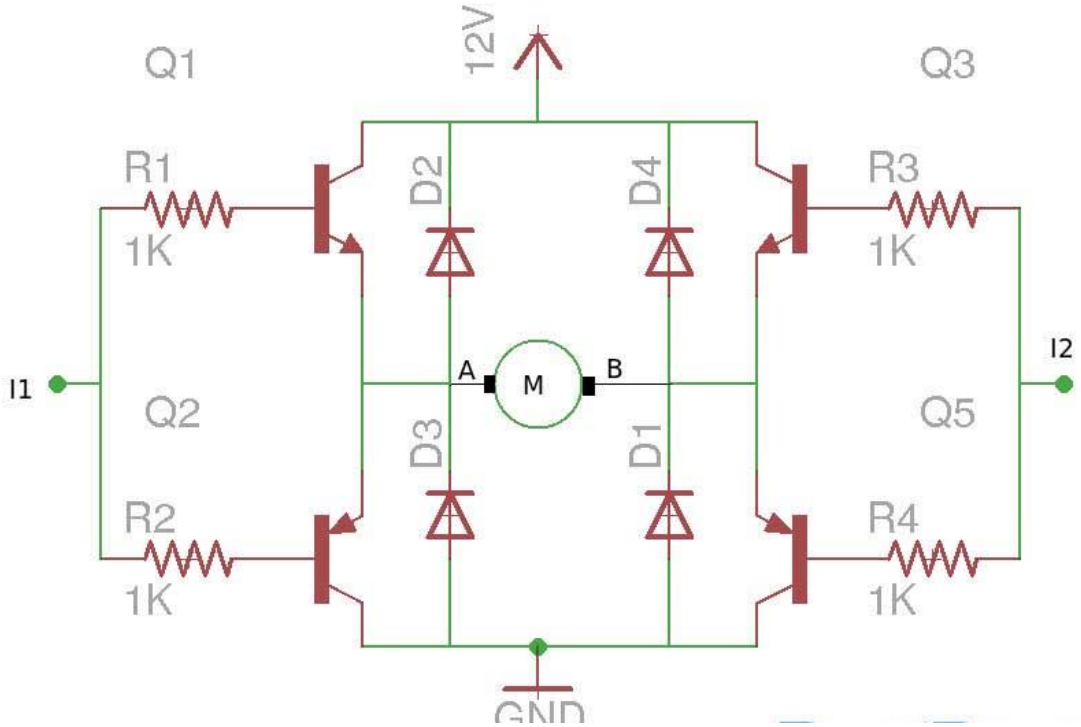


Figure 2.10 Motor Driver schematic

f. moisture sensor:

To determine wither the waste is wet or dry. The moisture sensor consists of two probes that measure the volume of water. The two probes allow the electric current to pass through, and according to its resistance, the level of the moisture level is measured.

We have chosen the moisture sensor to determine whether the waste is wet or dry, as shown in figure 2.11 because its what's available to use with the esp-wroom-32 for this project.

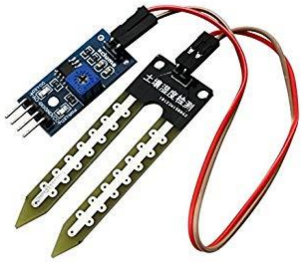


Figure 2.11 Moisture Sensor

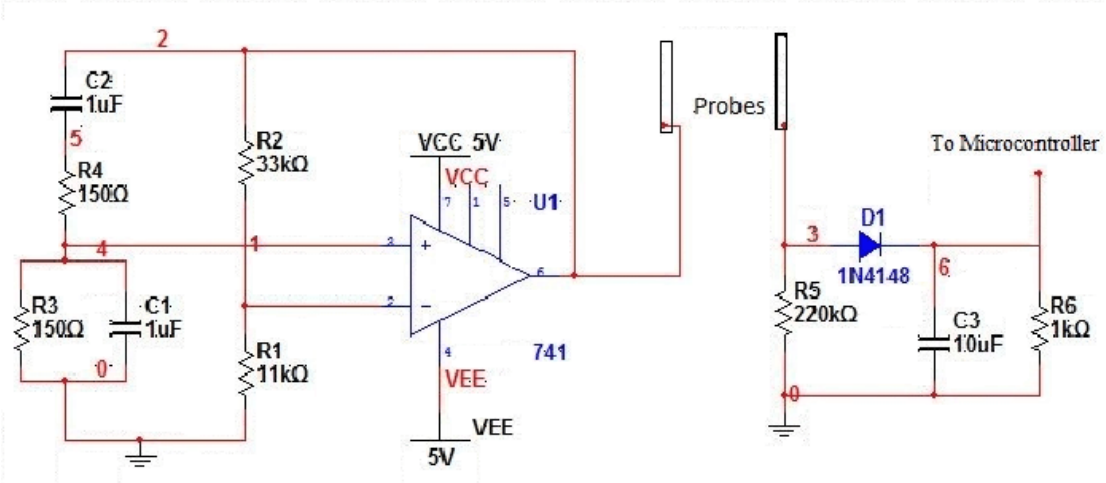


Figure 2.12 Moisture Sensor schematic

g. AC/DC Adaptor

AC adapters are used with electrical devices that require power but do not contain internal components to derive the required voltage and power from mains power. The internal circuitry of an external power supply is very similar to the design that would be used for a built-in or internal supply.

Figure 2.13 AC/DC Adaptor

2.4. Software components

a. Web Applications:

in our project there are two web Applications

- First web Application: this web Application for pc run on municipality's controller, show the level of trash on each trash can (show which is full or not).
- Second web Application: this web Application for mobile run on truck driver's mobile, show the map contains shortest path, this page helps him to start work. Show figure 2.14

Figure 2.14 Web Application for mobile

b. MATLAB:

use MATLAB to run Dijkstra algorithm, each trash can in city put as a node on MATLAB, when one trash can filled up directly send it to the MATLAB and this shows on controller's web Application, and then MATLAB find the shortest path for all full trash can. And then send the result to truck driver via web Application.

Dijkstra's algorithm: is an algorithm for finding the shortest paths between nodes in a graph, For a given source node in the graph, the algorithm finds the shortest path between that node and every other. It can also be used for finding the shortest paths from a single node to a single destination node by stopping the algorithm once the shortest path to the destination node has been determined.

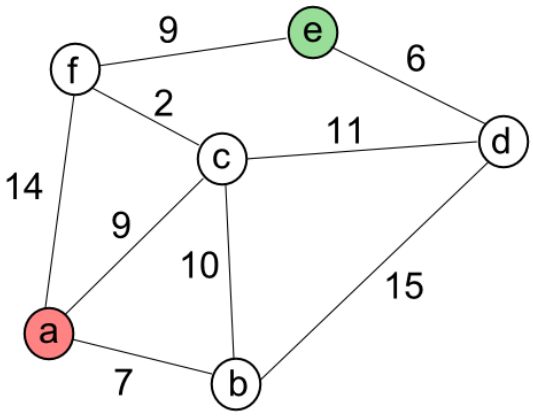


Figure 2.15 Dijkstra Algorithm

c. WampServer:

is a Web development platform on Windows that allows you to create dynamic Web applications with Apache2, PHP, MySQL and MariaDB.

Chapter 3

Design

3.1 Overview:

This chapter discusses the conceptual design of the system, it shows the system requirement analysis, a block diagram of the system, structural diagram, flow chart, detailed design, schematic diagrams.

3.2 Detailed system description:

The trash can is made of tow trash containers, one for dry trash and one for wet trash. An Infrared sensor reads if there is trash placed in the trash can, which triggers the moisture sensor if there is trash, the sensor then sends the data to ESP-wroom-32(Wi-Fi module).

The Wi-Fi module controls the servo motor to move the surface of trash can, depending on the data gotten from the moisture sensor, the motor rotates in either the direction of the wet waste can, or the dry waste can. There is also an ultrasonic sensor in both trash cans to measure the level of waste in each one.

Each trash can shows as a node on municipality's controller (on MATLAB), When one trash can filled up send notification to MATLAB, on it we run the Dijkstra's algorithm is an algorithm for finding the shortest paths between nodes(trash cans) in a graph (map),

And then send the picture of map with shortest path to truck driver via web application.

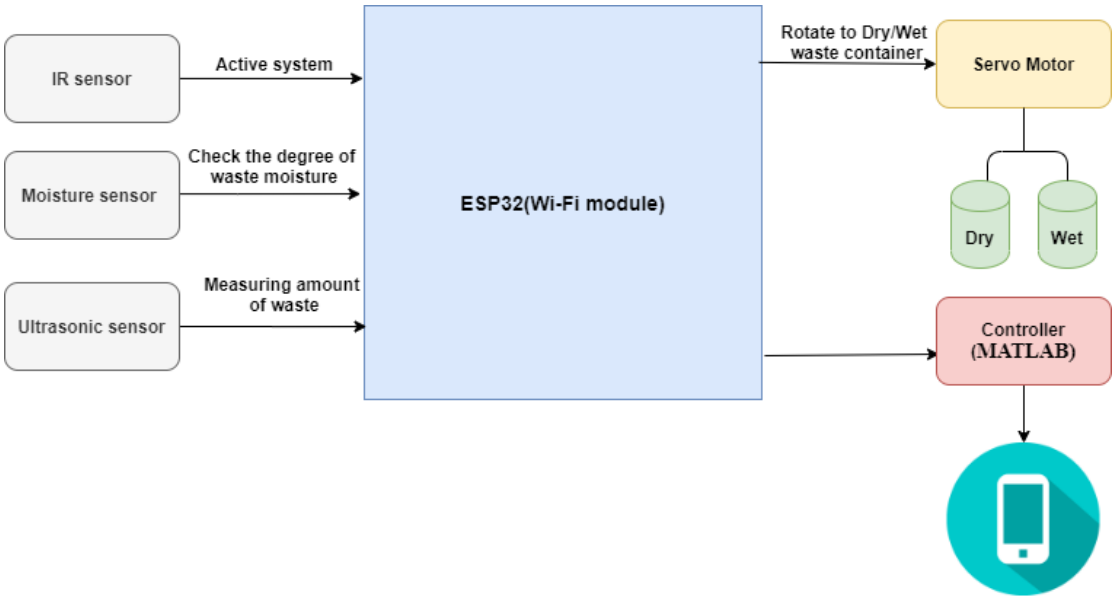
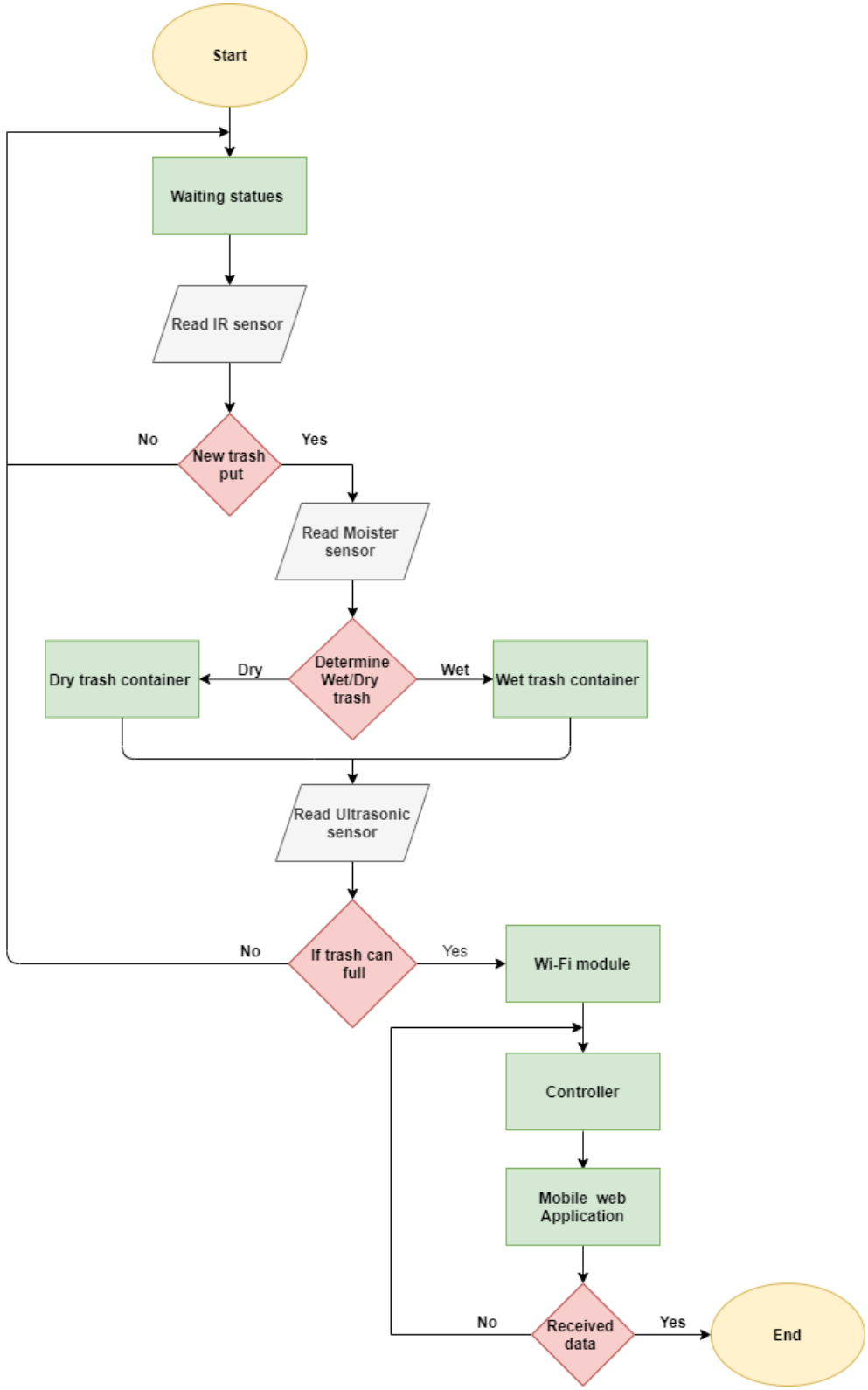


Figure 3. 1 System Block Diagram

3.3 System activity

Figure 3.2 represent System Activists float chart.

Figure 3.3 represent Wi-Fi module, controller and Mobile interactive



System Activation Float chart 2 .Figure 3

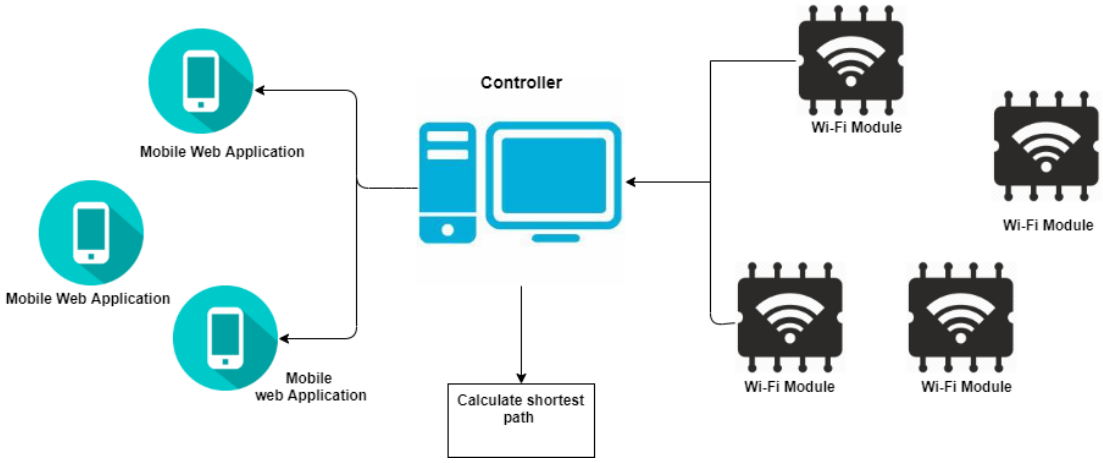


Figure 3. 3 Wi-Fi module, controller and Mobile interactive

At the beginning of each day:

- The statues of all trash cans are clear on controller (on MATLAB and web Application).
- Full trash can send a notification to controller shows their status.
- Calculating shortest path using Dijkstra's algorithm.
- Send short path track drivers' mobile (via web Application).
- The mobile's web Application receives a picture of map with shortest path.

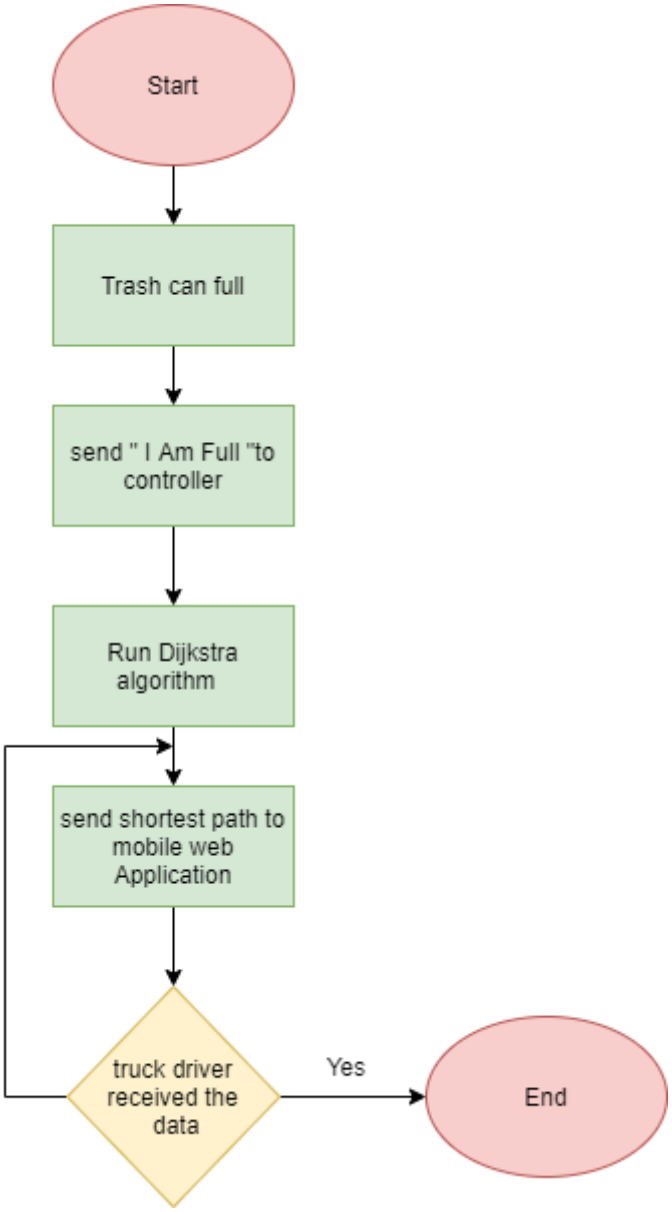


Figure 3. 4 System and Truck driver activity float chart

3.4 Detailed and Schematic diagrams

a. Ultrasonic sensor:

In our project, we will use to detect the distance and measure the waste level in the trash can, The HC-SR04 Provide fast response time and information on the distance and direction to the target to avoid the obstacles. figure 3.5 shows the detail design for ultrasonic sensor. It has 4 pins, Ground, VCC, Trig and Echo. The Ground and the VCC pins of the module needs to be connected to the Ground and the 5volt pins on the esp-wroom-32 board respectively, the trig and echo pins to any Digital I/O pin on the esp-wroom-32 board as shown in the schematic diagram in figure 3.6

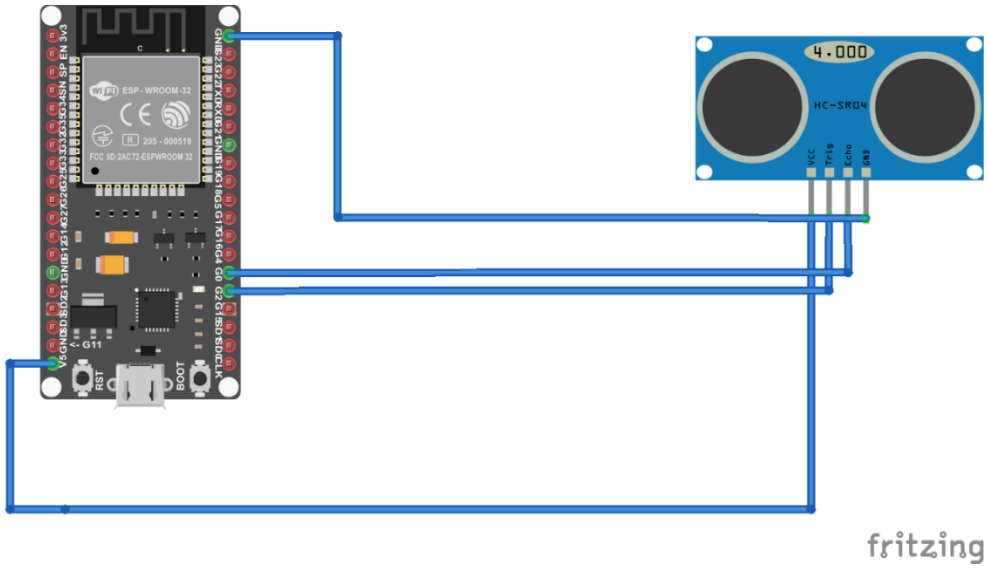


Figure 3. 5 Ultrasonic sensor with ESP-wroom-32

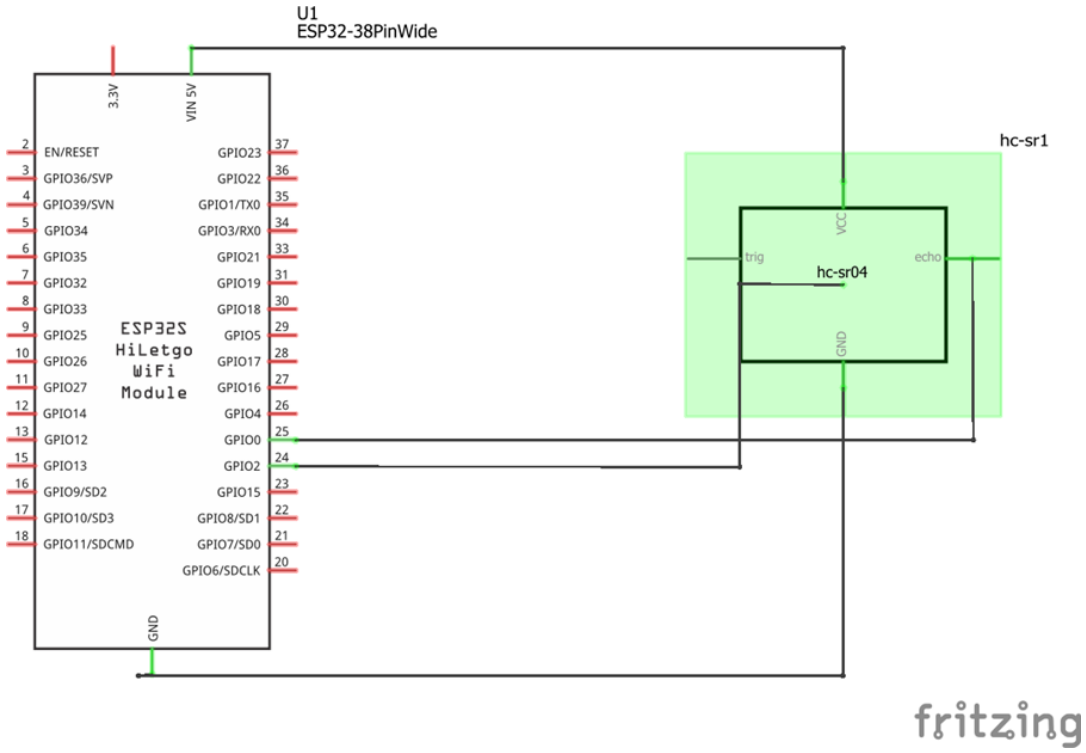


Figure 3. 6 Ultrasonic sensor with ESP-wroom-32 schematic

b. (IR) Sensors

In our project, we will use to detect if there is new trash can or not, an infrared sensor circuit is one of the basic and popular sensor modules in an electronic device. This sensor is analogous to human's visionary senses, which can be used to detect obstacles and it is one of the common applications in real-time. This circuit comprises of the following components.

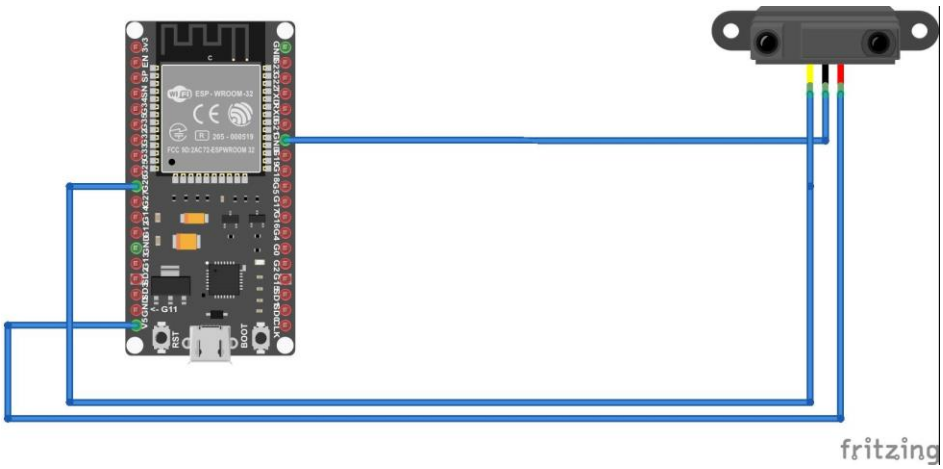


Figure 3. 7 IR Sensor with ESP-wroom-32

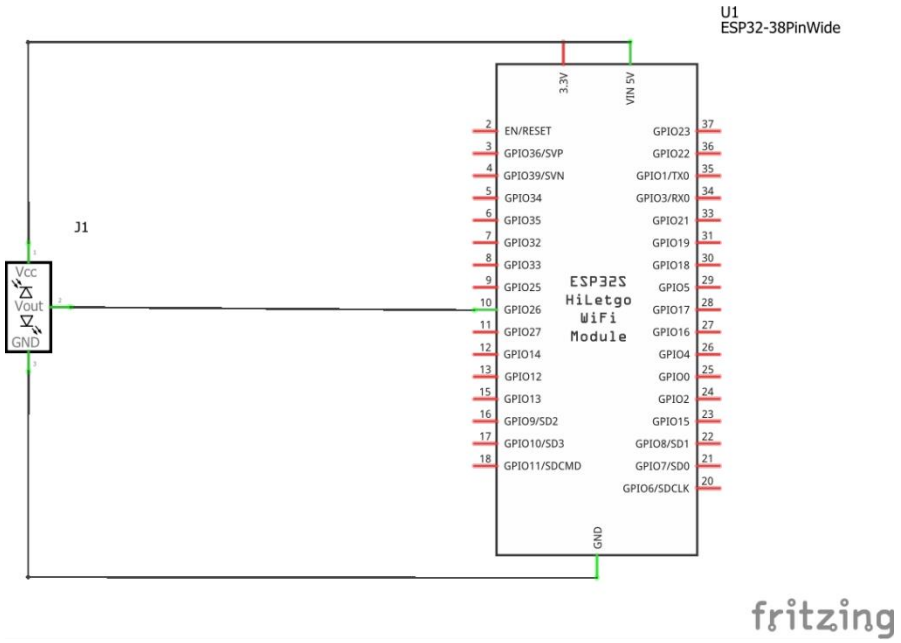


Figure 3. 8 IR Sensor with ESP-wroom-32 schematic

c. servo Motor:

As we mentioned in chapter 2, The L298D motor driver controller, consists of 4 inputs and 4 outputs to control two servo motors as , in our project, we will use four servo Motors (two on the left and two on the right) to Controls the direction of the motor, whether it is right or left, according to its reader's moisture sensor, so we will use one motor Drivers. The four inputs connect to the digital pin of (D8, D9, D10 and D11.) on A esp-wroom-32 board as shown in the schematic diagram in figure 3.10

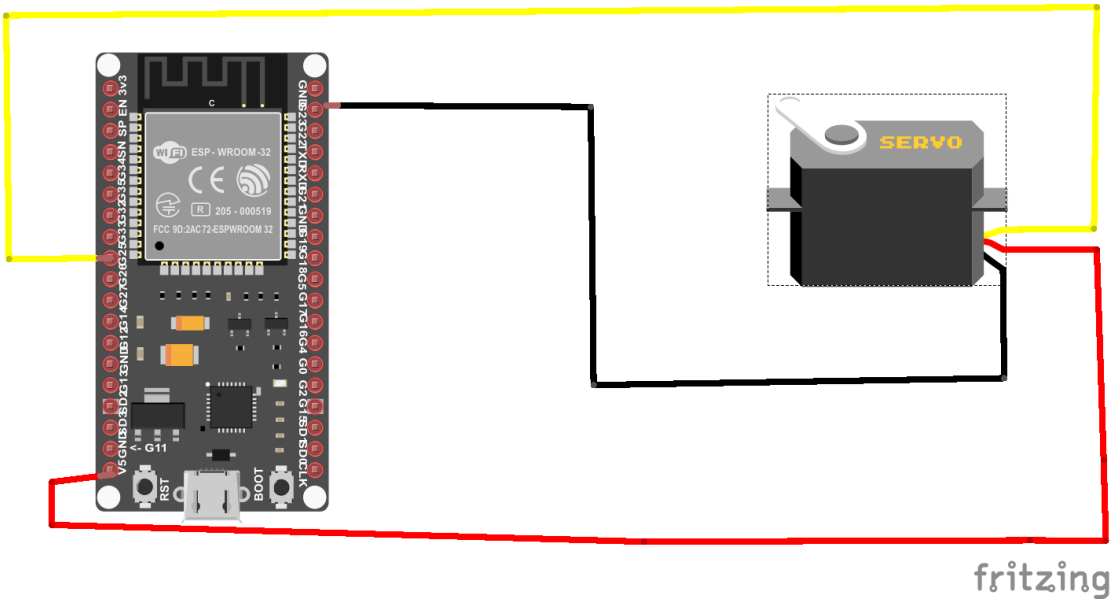


Figure 3. 9 Servo Motor with ESP-wroom-32

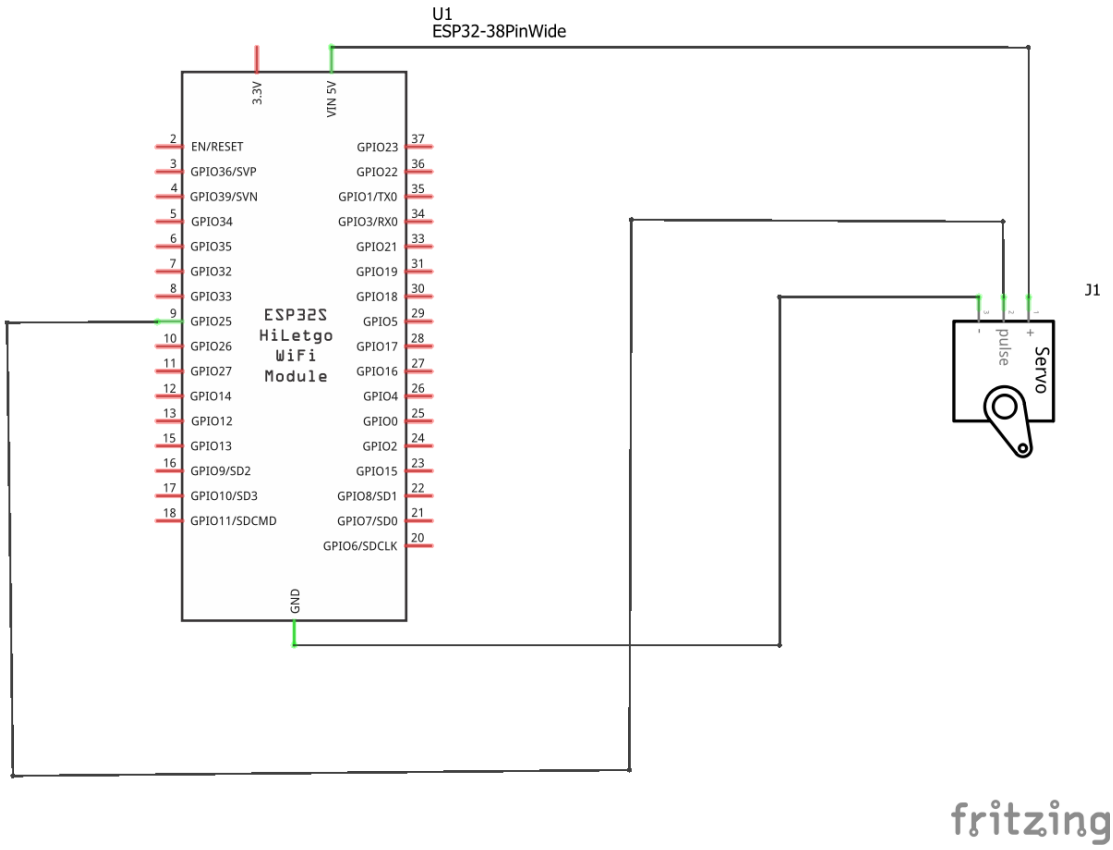


Figure 3. 10 Servo Motor with ESP-wroom-32 schematic

d. moisture sensor:

In our project, we will use to detect trash can dry or wet, Soil moisture sensors measure the volumetric water content in soil. Since the direct gravimetric measurement of free-soil moisture requires removing, drying, and weighing of a sample, soil moisture sensors measure the volumetric water content indirectly by using some other property of the soil, such as electrical resistance, dielectric constant, or interaction with neutrons, as a proxy for the moisture content

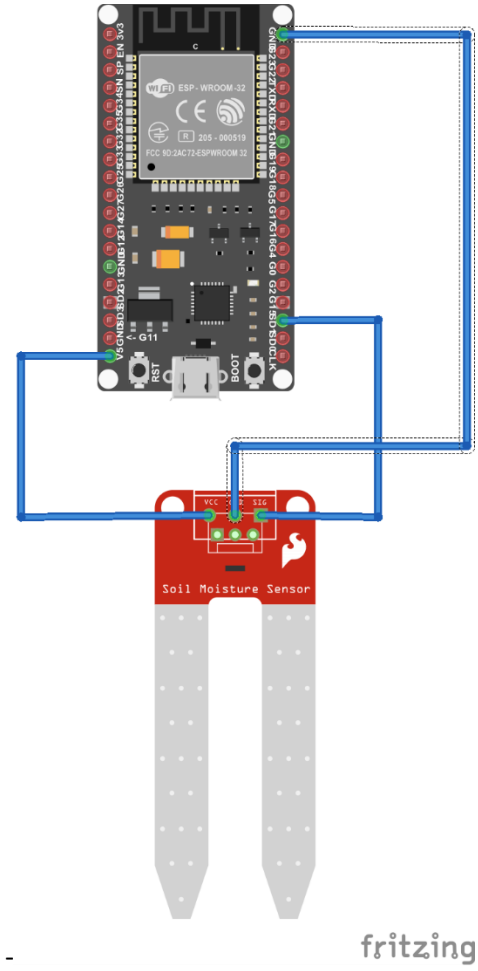


Figure 3. 11 Moisture Sensor with ESP-wroom-32

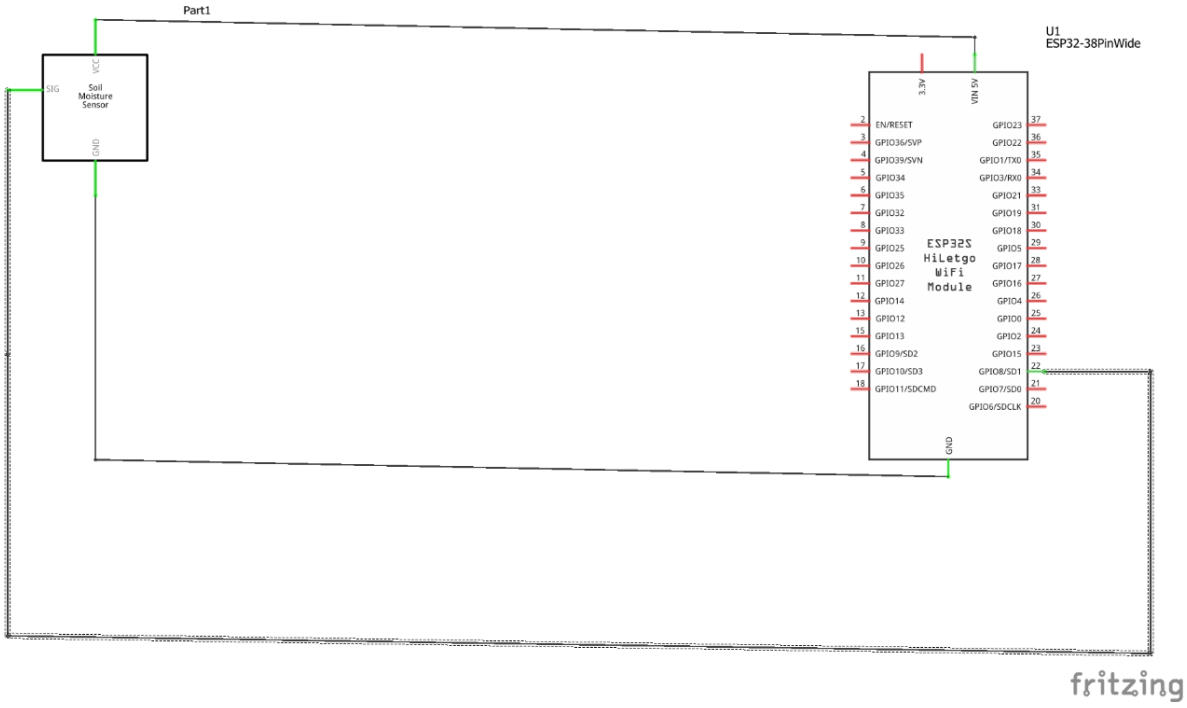


Figure 3. 12 Moisture Sensor with ESP-wroom-32 schematic

3.5 System Hardware:

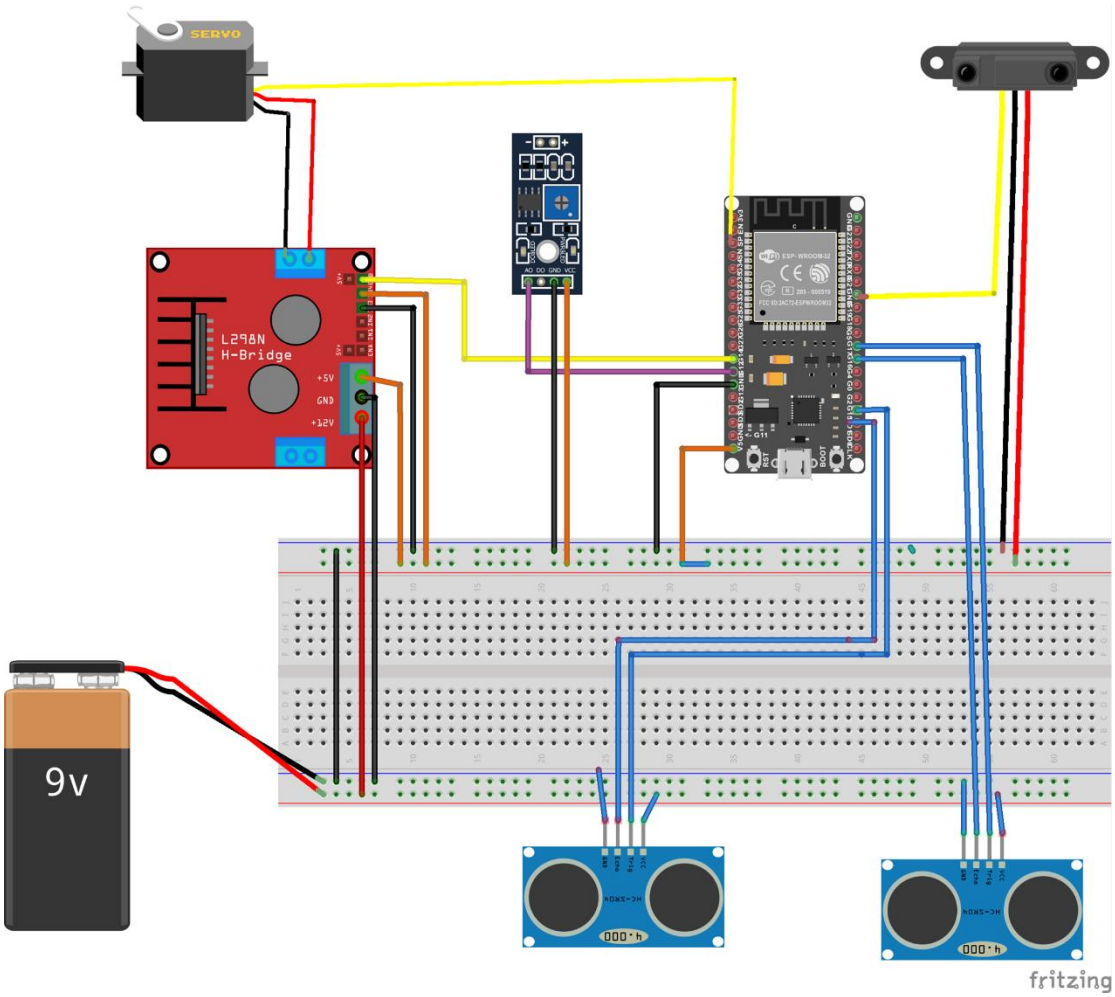


Figure 3. 13 System Hardware

Chapter 4
System Implementation and Validation

4.1 Overview

This chapter introduces the description of the implementation, implementation issues, and implementation challenges and description of the methods used to validate the system and validation results.

4.2 Description of the implementation

This section will provide some information about the hardware and software implementations done through our project.

4.2.1 Software implementation

a. Arduino Software (Arduino IDE):

The code of all hardware components and sensors and their interfaces are written through it.

The use of many functions and libraries. We needed to download esp32 library and Servo library for servo motor, Ultrasonic sensor library.

b. MATLAB

They need download MATLAB to run Dijkstra algorithm, it received data from ESP32.

c. WampServer

platform on Windows that allows you to create dynamic Web applications, need it to develop web Applications.

4.2.2 Hardware implementation

Starting with ESP32, we successively connect the other system components as follows:

- we connect ESR32 with one **IR sensor** to detect if a new trash put on or not, the system starting with a signal from **IR sensor.** It uses digital pin on microcontroller (ESP32), we placed it in the cover of trash can.
    - **Result**: **IR sensor** enable the system to starting work and avoid overloading system work.

- We connect ESP32 with **Moisture sensor** to check if the trash wet or dry. It uses analog pin on ESP32, we placed it on the surface of trash can.
    - **Result**: **Moisture sensor** enable us to know the amount of water in trash and then help to separate wet and dry trash.

- We connect ESP32 with **Servo motor** use it to rotate the surface of trash can either right or left depending on the reading of moisture sensor. We placed in the out of trash can connected with one edge of surface.
    - **Result: Servo motor** enable the separate of trash by rotating the surface either right or left.

- We connect ESP32with **motor driver L298,** order to control motors speed and direction. We connected the input pins in motor driver using digital pins in microcontroller, then we connected the output pins with **Servo motor**.
    - **Result**: The motor driver enables the surface to move right and left.

- We connect ESP32 with two **Ultrasonic sensors**, computes the level of trash in each trash can containers. It uses analog pins on microcontroller (ESP32), we placed it in the top of each trach containers.
    - **Result**: **Ultrasonic sensor** enables us to know the level of trash and know which it full or not.

4.3 Implementation Issues and challenges

4.3.1 Hardware Issues and challenges

During the project implementation, we faced many obstacles and had to take several issues to reach to the most suitable design of the system and reach the best properties related to the project's aims. We summarize these issues and results as follows:

1. We faced trouble while testing the system and System crashes avoidance because the servo motor was not working when it detects an object. At first, we thought that there was a problem with the servo motor, but when we change it, we faced the same problem. When testing the circuit power supply, we found there is not enough power to reach the servo.

The solution:

We connect the servo motor to enough power supply by using a L298D motor driver to convert the 12V to 5V and connects it directly to the servo.

2. When we start our work, we face problem with choosing the best microcontroller In the beginning, we did not find a suitable piece to support projects, Wi-Fi, capable of withstanding climatic conditions and high working hours, with high efficiency.

The solution:

If esp-wroom-32 was used because it is a modern piece and suitable for the parts and tasks that we have, and through it the number of pieces was provided where they were use microcontroller and WI-FI module

3. We encountered a problem when we uploaded the code to our sensors that it was not working properly

The solution:

We calibrated the sensor to show the correct output.

4.3.2 Software Issues and challenges

Many issues were faced during system implementation, such as:

- move the Surface to Left or Right 90-degree problem: At first, we were not able to make the surface turn Left or Right approximately 90 degree. We've tried many solutions, but at the end.
    - **The solution:** we made a difference between the degree of first rotation angle of and return angle

- A servo rotation and sudden stop would cause the servo to fall off a trash can and may crash.
    - **The solution:** Increase the delay time in code.

- The ESP-wroom-32 required special library to run the servo motor, ultrasonic sensor.
    - **The solution:** Downloading the required library on Arduino IDE to run the sensors.

- We faced difficulty running the Dijkstra algorithm on web site.
    - **The solution:** We run the Dijkstra algorithm on MATLAB and display the result on web Application.

- When we started designing a mobile application, we found that it may be ineffective and may cause workers difficulty in downloading or interacting.
    - **The solution:** We design a simple web page to show the shortest path and it contain a button to agree or not agree.

4.4 System Validation and Testing

4.4.1 Hardware testing

A. Motors test:

Firstly, we tested the motors with L298D motor driver and connect it directly with ESP-WROOM-32 as shown in figure 4.1, to make the Surface move first rotation angle of and return angle

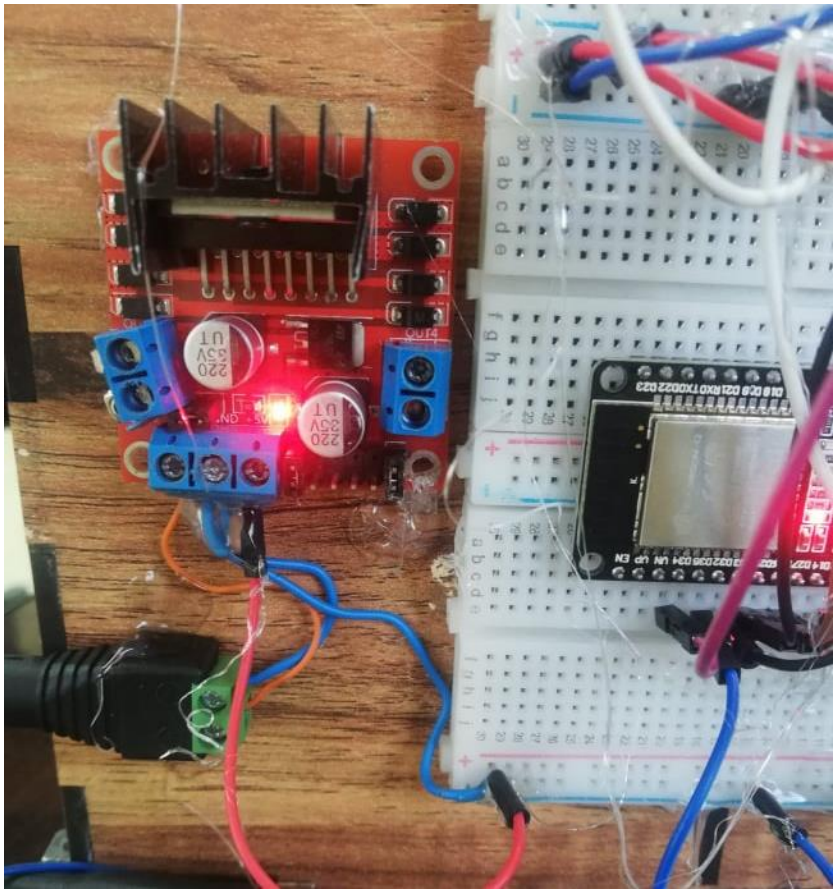


Figure 4. 1 Servo Motor Test

B. IR sensor:

To test IR sensor response speed, we connected it with esp-wroom-32 in figure4.2 and show the results on the in figure 4.3 If there is new trash or not.

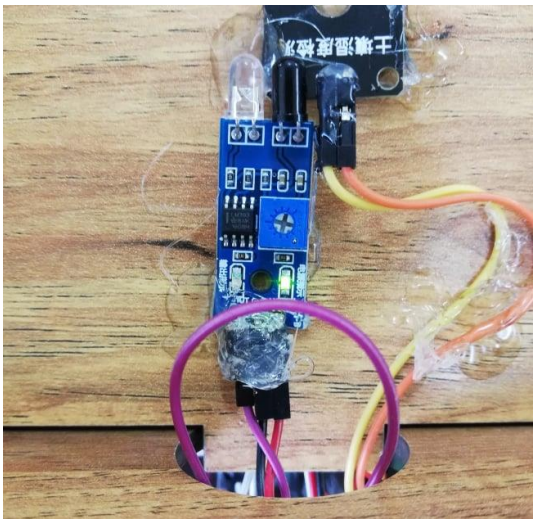


Figure 4. 2 IR Sensor Test

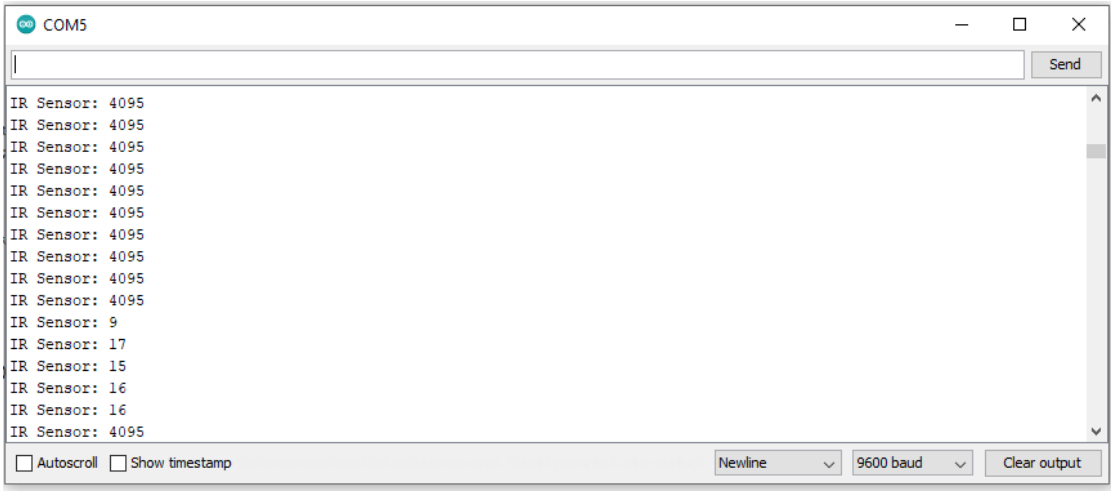


Figure 4. 3 IR Sensor Test Result

C. Moisture sensor:

To test Moisture sensor, determine wet or dry trash, we connected it with esp-wroom-32 in figure4.2, and show the results on the in figure 4.3 If the trash wet or dry.

Figure 4. 4 Moisture Sensor Test

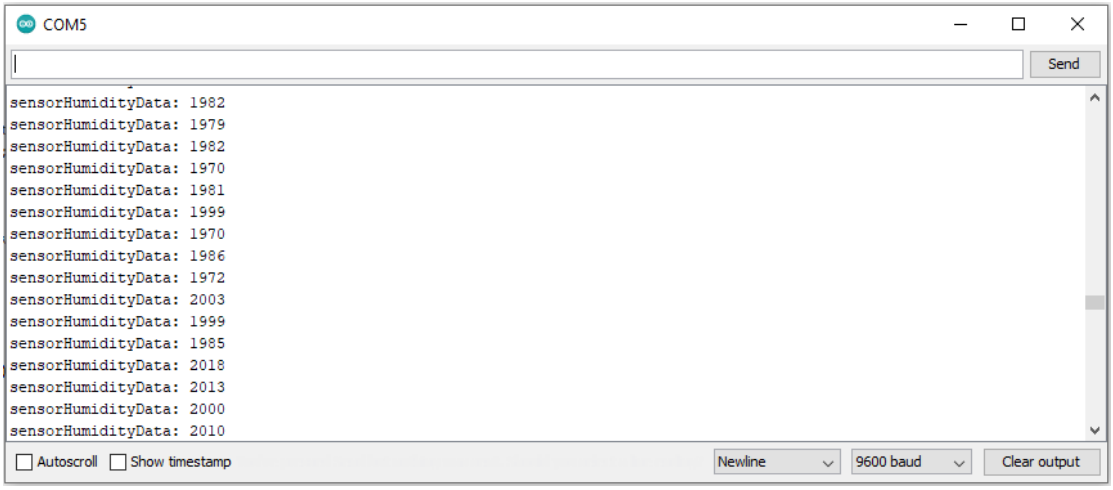


Figure 4. 5 Moisture Sensor Test Result

D. Servo motor:

To test servo motor, rotate the surface of trash can to right or left, we connected it with esp-wroom-32 in figure4.6.

Figure 4. 6 Servo Motor Test

E. Ultrasonic sensor:

To test Ultrasonic sensor, determine the level of trash in trash can, we connected it with esp-wroom-32 in figure4.7, and show the results on the in figure 4.8 and figure 4.9, show which are full or not.

Figure 4. 7 Ultrasonic Sensor Test

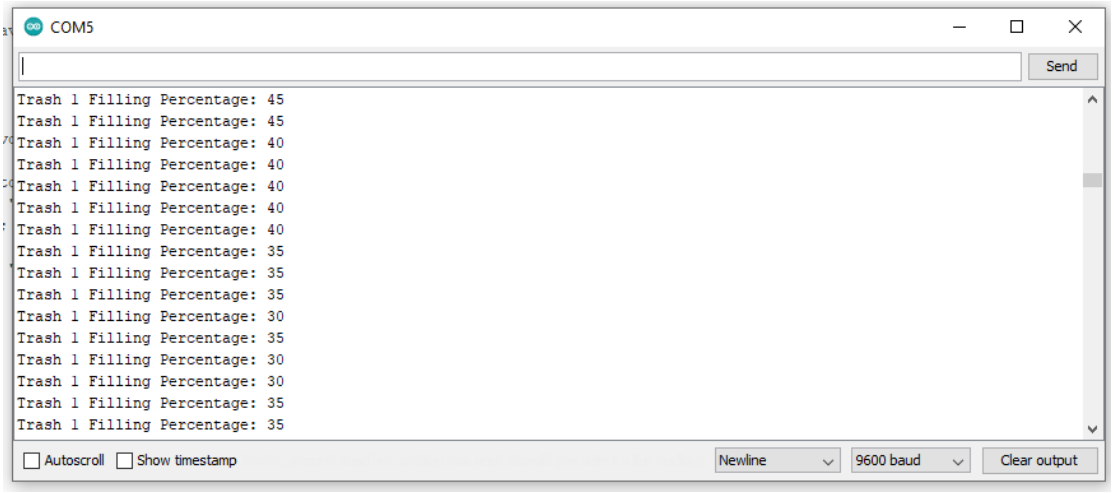


Figure 4. 8 Ultrasonic Sensor Test Result (a)

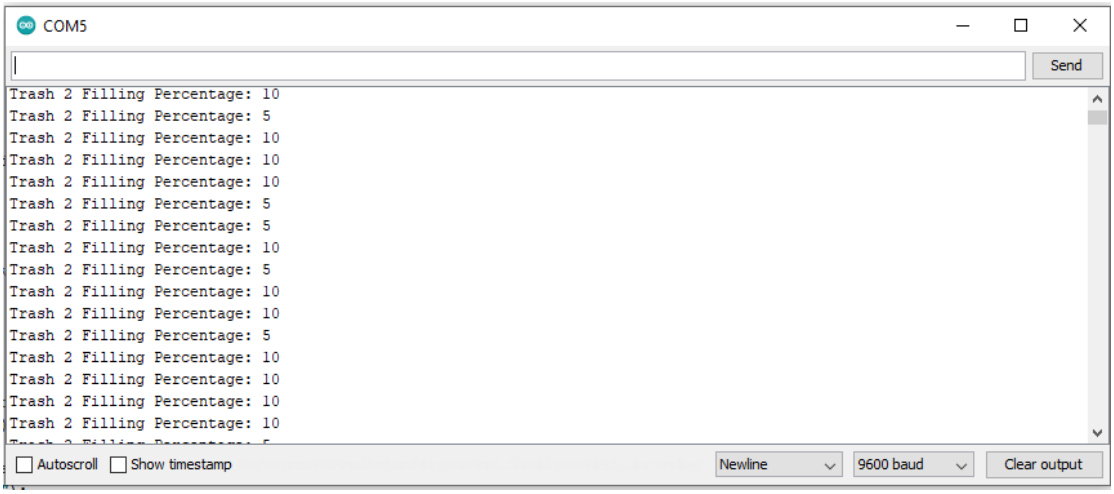


Figure 4. 9 Ultrasonic Sensor Test Result (b)

F. Wi-Fi Module:

To test ESP-Wroom-32, connect all tools on it as shown in figure 4.10, The result it shows figure 4.11

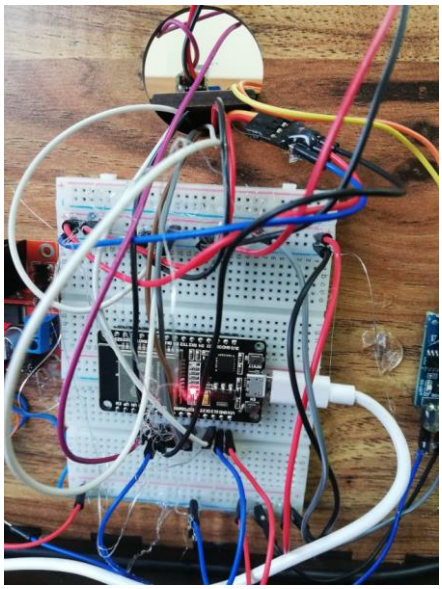


Figure 4. 10 Wi-Fi Module Test

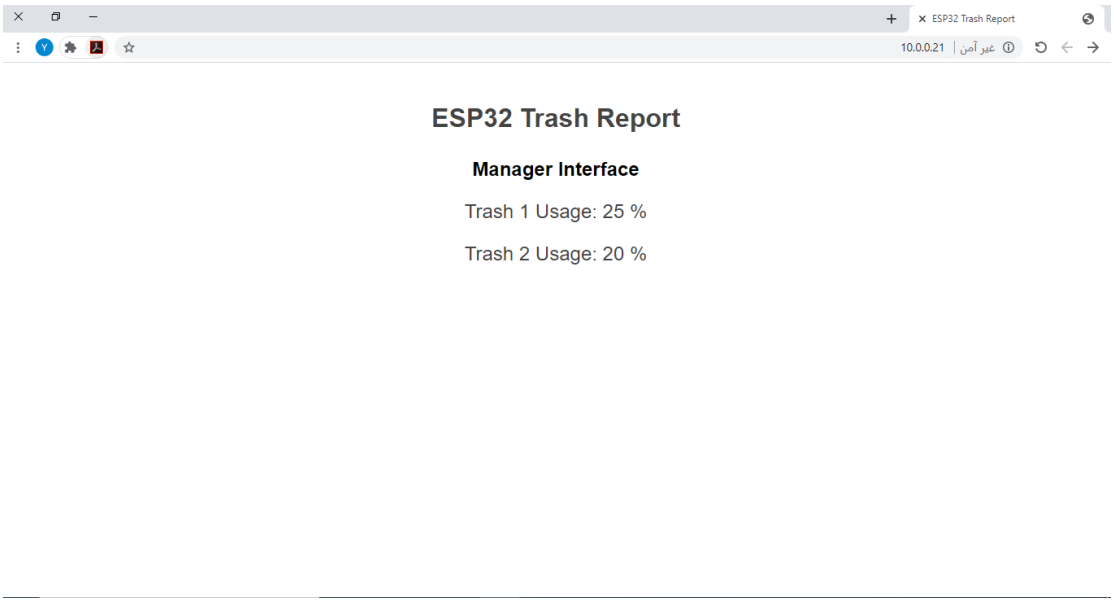


Figure 4. 11 Wi-Fi Module Test Result

4.4.2 Software testing

1.web Application:

a. First one for controller to display the read of ultrasonic sensor and show the level of trash in each trach can.

Figure 4. 12 First Web Application

b. Second one for display result of MATLAB (shortest path), this page for truck driver but can open it on controller.

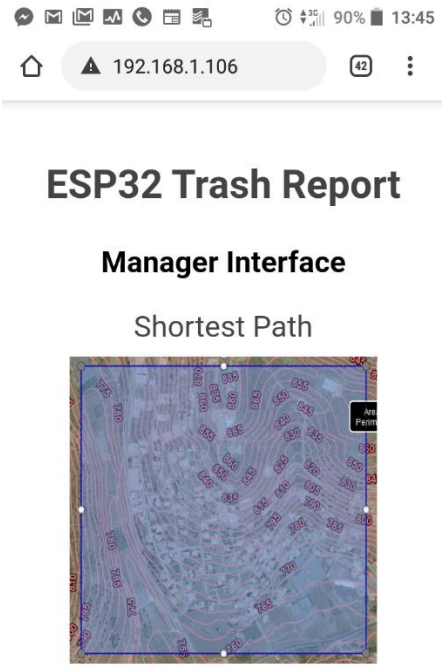


Figure 4. 13 Second Web Application on Mobile

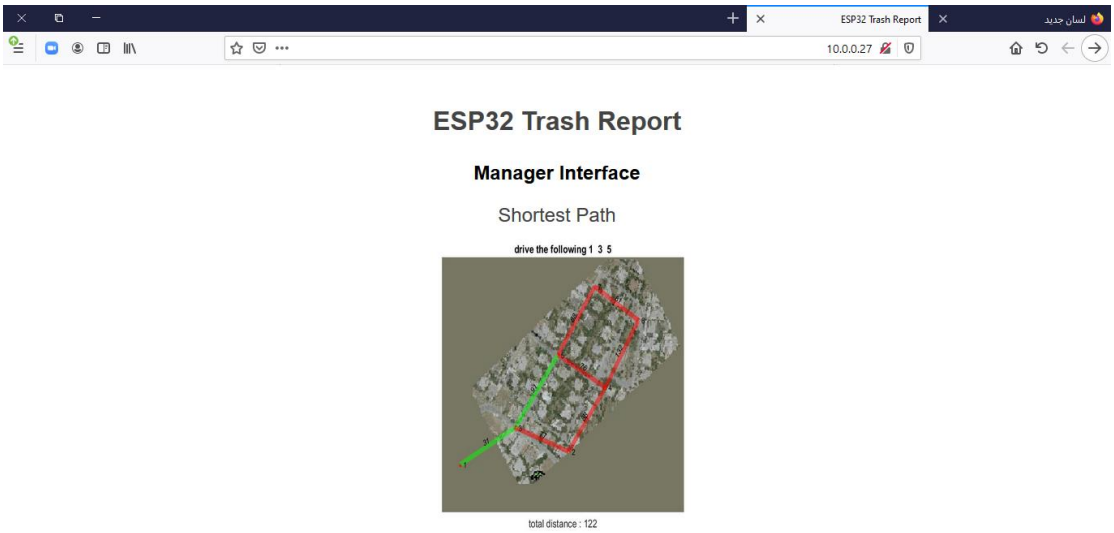


Figure 4. 14 Second Web Application on PC

Each trash can put as a node on map, in this example filed up trach can is 1,3,5 and the shortest path to reach it is shown as a green line on map picture.

4.4.3System Testing

A. Obstacle avoidance Test:
The first job was to design an intelligent trash management system and convert the regular trash can to a smart trash can that separate wet and dry trash.
And can send the level of trash to the controller on municipality, which in turn receives who are the full trash can and runs the Dijkstra algorithm to finding the shortest path to reach the full trash can.
Then send the shortest path to the truck driver via the web Application.

- If the IR sensor the If there is trash, this means that the complete system is working and then all the sensors are in operation

- If the IR sensor the If there is trash, this means that the complete system is not working and then all the sensors are in operation

- If the humidity reading of front Moisture sensor is higher than 3000, the send read esp-wroom-32 control the servo motors the move trash wet.

- If the humidity reading of front Moisture sensor is lower than 3000, the send read esp-wroom-32 control the servo motors the move trash dry

- If the measured distance value of front ultrasonic sensor is smaller than 20 cm, the send read the controller municipality will start to controller municipality in run (Dijkstra algorithm) Calculate the shortest path and send the shortest path to truck driver via web page

- If the measured distance value of right or left ultrasound sensor is smaller than 20 cm, the will start to send controller municipality for not full.

- And after that, if a truck driver visits a web page and knows the baskets are full and how to reach them in the shortest way and the least time and effort, as there is a page on the rice page, either agree or not

4.5 Implementation Results

By the end of the implementation process, we combined all the components with each other to get the final Smart Garbage Collection Management System. We mounted the AC/DC Adaptor move servo motors and ir sensor on the trash can above shelf, and we connected the moisture sensors to surface trash can surface in esp-wroom-32, and Ultrasonic, L298D motor Driver and the servo on the beside trash can. The final connection of the system is shown in figure 4.11

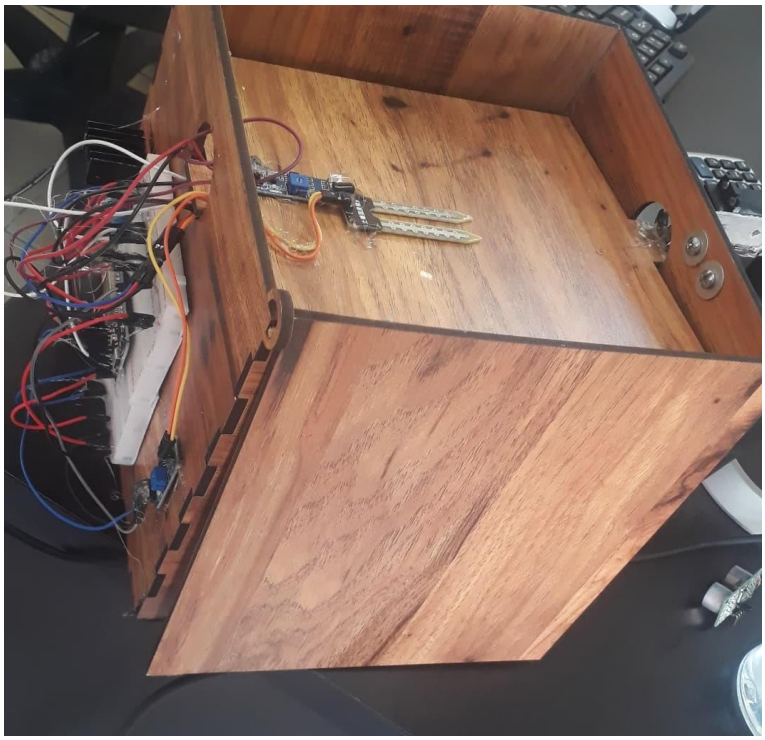


Figure 4. 15 Final connection

Chapter 5
System analysis and Discussion

5.1 Overview

This chapter introduces analysis, discussion about the results, Test of the system and system fault.

5.2 System analysis

5.2.1: Obstacle avoidance discussion results

The amendment was finalized so that the possibility of damage to the parts and their being affected by external factors such as temperature, rain and other factors were avoided. Meanwhile, the parts can be accessed easily for maintenance work.

5.2.2: Separation process discussion Result

For the Separation process test discussions, it was observed from the tests that wet and dry sensors could detect the small and big trash when the sources were in the surface of trash can.

5.2 Analysis and discussion about the end shape of trash can

A sampling method has been applied and placed on the trash can. So that the trash can was equipped with Infrared and moisture sensors. The experiment was performed. Initially a group of litter was placed on top of a basket, as shown in figures bellow.

Figure 5.1 and Figure 5.2 shows the Wet trash experiment where the direction of rotation was to the left.

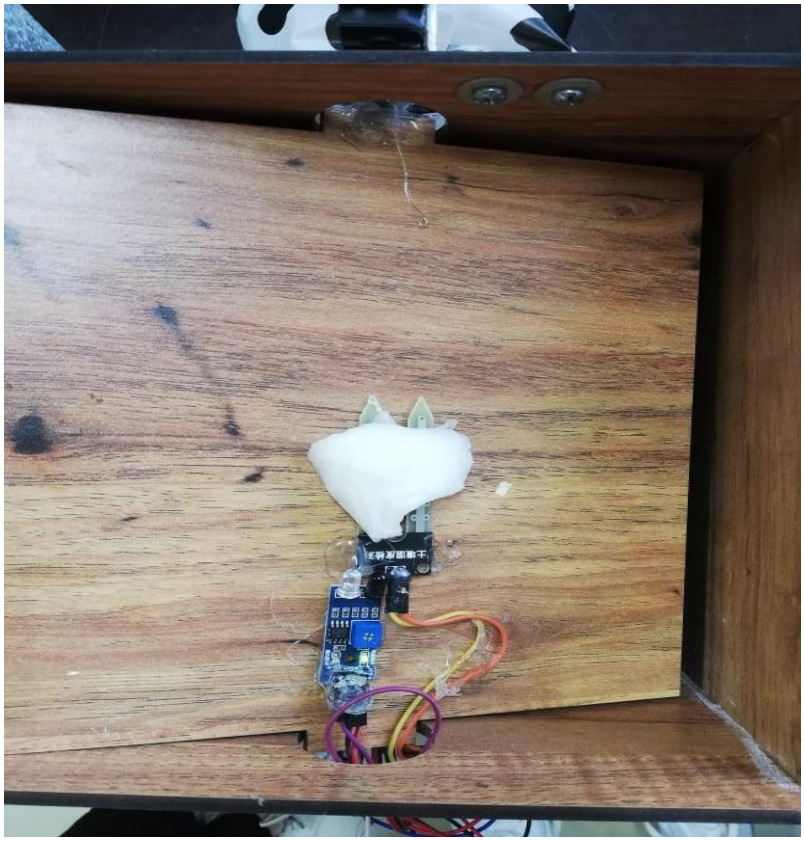


Figure 5. 1 Wet Trash Test

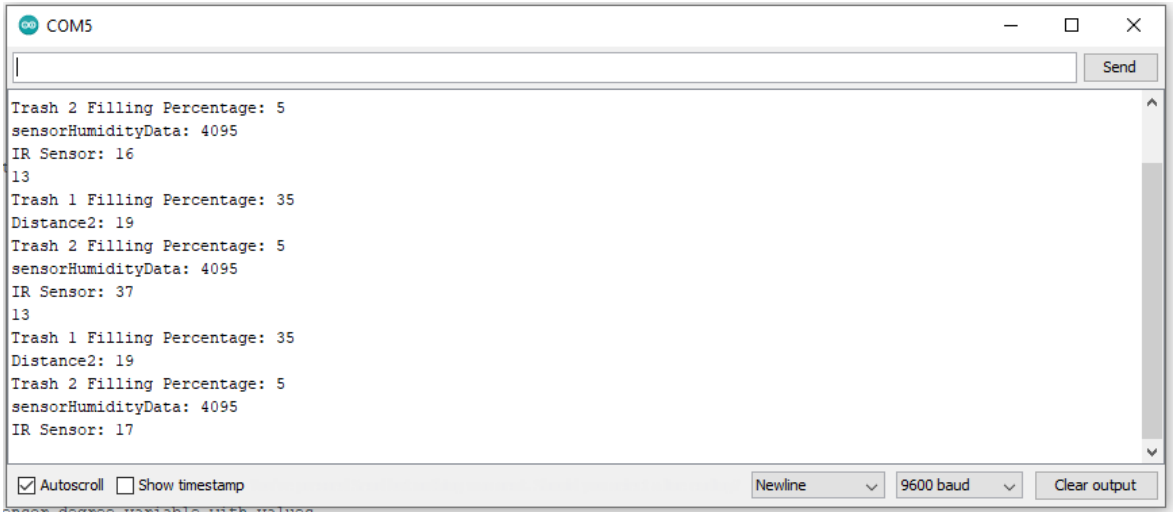


Figure 5. 2 Wet Trash Test Result

Figure 5.3 and Figure 5.4 shows the Dry trash experiment where the direction of rotation was to the right.

Figure 5. 3 Dry Trash Test

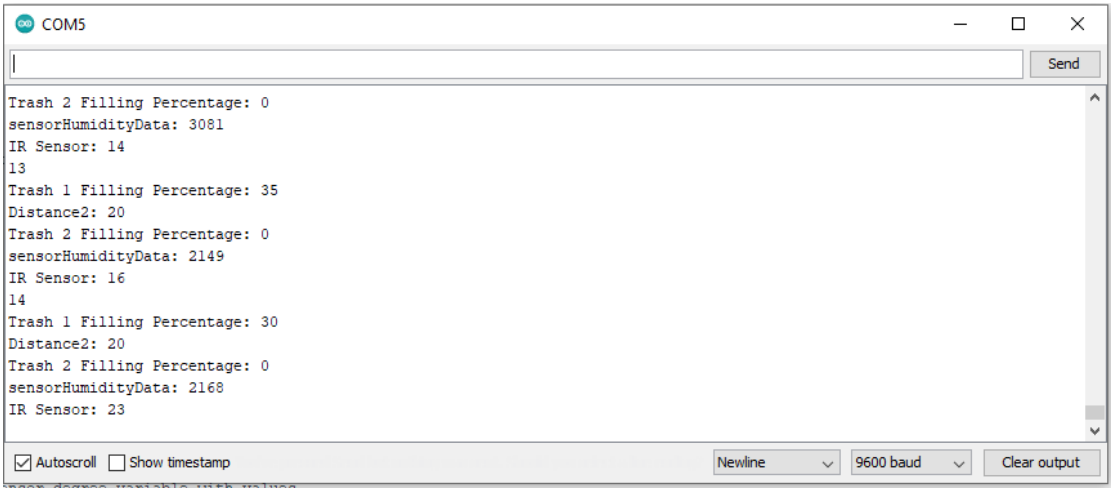


Figure 5. 4 Dry Trash Test Result

5.3Networks and internet connection Test.

		Test 1	Test 2	Test 3
Wi-Fi module		Network (A)	Network (A)	Network (A)
Controller		Network (A)	Network (B)	Network (B)
Mobile		Network (A)	Network (B)	Network (C)
Result		Success	Success	Success

Table 2 Networks and internet connection Test

5.4System failure:

The system fault when disconnecting the internet on one part of the system. Or one of the system tools or sensors become damaged.

Chapter 6
Conclusion

6.1 Summary:

This project is about to design a smart system to management trash collection in Hebron city or in any other city, At this level, hardware components, software tools and design are explained, all parts of system are tested and succeed, despite the implementation issues we create in the end a complete integrated management system, this system is based on IOT and we succeed to run it with Wi-Fi module and use it as a microcontroller.

6.2 Challenges:

The first challenge faced us was the mechanical constraints and how to build the system based on IOT, balanced, reliable, and effective. The second challenge faced was the component constraints, the quality of some components such as servo motor and ultrasonic sensor which is damaged quickly and the quality of wires was bad .The third challenge is the environments constraints, the fourth challenges is permeant internet connection.

6.3 Recommendations and future work:

By further developments and improvements:

- Develop a mobile application instead of web Application s.
- Finding the shortest path in each two hours instead of beginning of each day.
- Finding the shortest path regards to truck driver place.

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