AUTOMATIC PLANT MONITORING SYSTEM BASED ON IOT

An UndergraduateCAPSTONE Project
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Summer Semester 2021-2022
January, 2023

Faculty of Engineering
American International University - Bangladesh

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A CAPSTONE Project submitted to the Faculty of Engineering, American International University - Bangladesh (AIUB) in partial fulfillment of the requirements for the degree of Bachelor of Science in theirmentioned respective programs.

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DECLARATION

This is to certify that this project is our original work. No part of this work has been submitted elsewhere partially or fully for the award of any other degree or diploma. Any material reproduced in this project has been properly acknowledged.

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Students' names & Signatures

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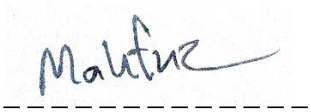

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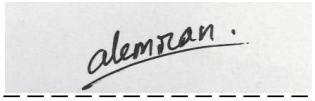
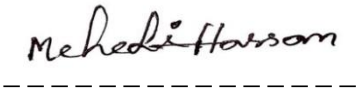


Mehedi Hassan



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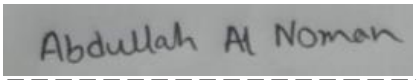

APPROVAL

The CAPSTONE Project titled **Automatic Plant Monitoring System Based on IoT** has been submitted to the following respected members of the Board of Examiners of the Faculty of Engineering in partial fulfillment of the requirements for the degree of Bachelor of Science in the respective programs mentioned below on **January 2023** by the following students and has been accepted as satisfactory.

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With the assistance of the All-Powerful Allah, we have made progress thus far on the project and anticipated success. The people who helped us finish our capstone project, Automatic Plant Monitoring System Based on IoT, deserve our sincere gratitude. Our sincere appreciation and admiration are expressed in particular to Mr. Raja Rashidul Hasan, Assistant Professor, Faculty of Engineering, American International University-Bangladesh, whose encouragement, motivation, and drive motivated us to complete this capstone project. His guidance and guidance on simulation and expertise provided us with all the assistance we required to do this capstone assignment. He spent all of his time and effort helping us and guiding us in the right route. We are also grateful to Mr. Mehedi Hasan, an engineering department assistant professor who acts as our external supervisor. His thoughtful comments supported us in moving our project forward. We would like to express our sincere thanks to all of the academic members at the American International University-Bangladesh (AIUB) Electrical and Electronics Engineering Department, without whom this project could not have been accomplished. Since none of these activities would be possible without our parents, we also want to express our gratitude to them. We would like to express our gratitude to everyone who has contributed various materials and diligent labor to this problem since without their experimental expertise, we would not be able to finish the project. We appreciate our university's commitment to excellence as well.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

Automatic plant monitoring system farming has revolutionized the agricultural industry. In this type of farming, where the farm is enclosed with polycarbonate, environmental parameters must be regulated in order to increase cultivation and provide appropriate care for the crops. This technique is widely employed in a few industries, including nursery farms and agriculture. In this system, a method is built to determine the moisture content of the soil using a soil moisture sensor, and the water is managed based on the condition of the sensor. The purpose is to develop and build a rover capable of operating on farmland and caring for the field and crops. At the same time, it would be able to collect vital data about the farm area's climate and environment. The current researches related to the farming rovers are specifically designed to do particular jobs, but this rover provides us with a multifunctional option to do many things with the same rover using different technology at the same time. The purpose of the rover was to reduce the amount of human work required to maintain the cultivated area and care for the crops. The rover's main concept has been declared and is being developed. The prototyped version has been flawlessly functioning and in line with the rover simulation. The rover may be seen functioning normally, and it is prepared to take over the area if its owner directs it to. The rover clearly utilized the components to achieve the required results.

Chapter 1

INTRODUCTION

1.1.Overture

Rovers can be useful in many ways, and an agriculture rover is not any different. Combining artificial intelligence with robotics is not new and it has proved to produce overwhelming results. Rovers can gather data, use it to predict certain dependent variables, and look after the properties. The farming industry needs more technological power to keep up with the current demand of the growing population. And nothing is more useful than IoT (Internet of Things) in solving the technological shortage in this industry. The project's main goal is to collect necessary data from a particular agricultural field and use and process it to predict certain aspects of the data.

The goal is to predict the fitness of flora on the farm and use positive variables to analyze the surroundings and predict the plant exceptional appropriate for the environment. Plants rely on environmental variables like humidity, temperature, soil moisture, pH of the soil, rainfall, air quality, and air pressure. Moreover, the rover will take a look at the plant's health, soil health, and weeding. The protection phase comes with a range of obligations for the rover as it would maintain song of weeding and keeping overgrowth of grass and needless flora and fungi, watering the flowers would be one of the most vital jobs the rover would do daily, harvesting the plant life and spraying pesticides would be a sturdy characteristic for the rover.

1.2.Engineering Problem Statement

The world is developing and in a developing world with a much faster increasing population, it is necessary for a civilization to take advantage of technology to keep up with the problems that come with overpopulation and industrialization. One of the most needed areas of research in agriculture. The farmers need the technology to grow crops and take care of the crops easily and Agriculture Rover can help achieve the goal of helping the farmers directly grow and manage the crops. Arduino and node MCU has been used as a microcontroller programmed by the C and C++ programming language. This part can be considered the main software part to control the movement of the rover. However, the data collecting and machine learning part have been done using the Python programming language.

The Project fulfills the requirements of Complex Engineering Problem in the following format:

Table 1.1 Requirements of Complex Engineering Problem

Indicator	Title	Description
CP1	Depth of knowledge required	This project needs deep knowledge of computer programming, microcontroller, Robotics, Circuit design, Raspberry Pi, Transformers, Sensors
CP2	Range of conflicting requirements	The project must combine knowledge of mechanical, electrical, computer, data science, and robotics to achieve the needed efficiency and result.
CP3	Depth of analysis required	The data collection and operation of the rover need be thoroughly analyzed
CP4	Familiarity of issues	Some of the data collection methods and rover operating methods need researches which were lacking in the previous existing rovers.
CP5	The extent of applicable codes	Are outside problems encompassed by standards and codes of practice for professional engineering Example: Codes for MATLAB, Raspberry pi, ESP32 Cam, Arduino Uno and ESP8266
CP6	The extent of stakeholder involvement and conflicting requirements	The diverse groups of stakeholders (individual farms, government agonistic, etc.) of the project has been considered with varying needs.
CP7	Interdependence	The research work will require many component parts or sub-problems like

		electrical components, robotics components etc.

1.3.Related Research Works

1.3.1. Earlier Research

(Development of IoT Controlled Agri-Rover for Automatic, 2017)

Some rover's technologies available have done some remarkable job making Agri-rovers. Seeding can be done by rovers which operate on exceptionally low energy and hardware demand. The use of Servomotors provides a precise and accurate seeding that shines overall. Flap-servomotor mechanisms can produce extensive output working with existing mechanisms.

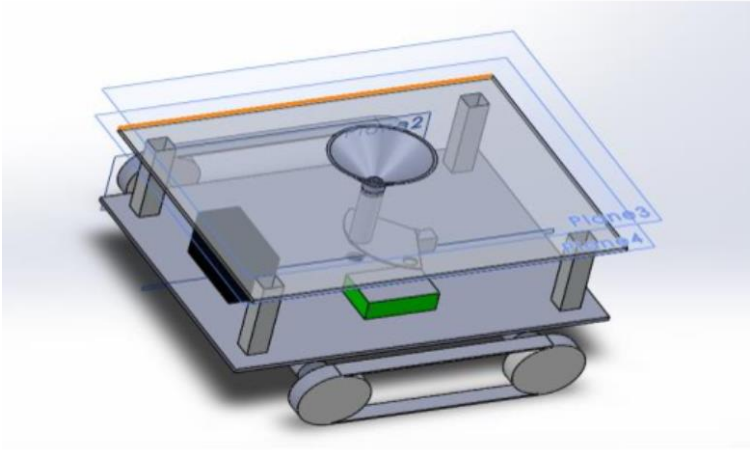


Figure 1.1 CAD Model of Proposed System [2]

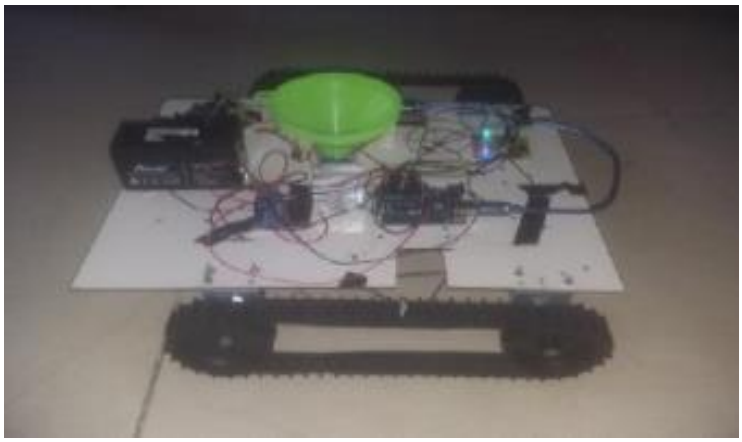


Figure 1.2 Prototype of Agri-Rover [2]

(Design and Fabrication of Grass Cutting and Water Spraying, 16–18 August 2018)

Grass Cutting and Water Spraying Rover is one of the recent additions to the irrigation and grass cutting rover research. These kinds of rovers are highly efficient in watering plants and taking care of the weeding problem in the farming area. The two different important and extraordinary feature of a farming rover which is watering the plants and taking care of the unwanted grasses has been combined to build a multidimensional rover that can operate in farming conditions with minimum effort and cost. But the scope of improving the efficiency of the rover is still possible by increasing speed and using a high-performance battery. This rover can be as useful as it suggests to be by making some technical and technological improvements.

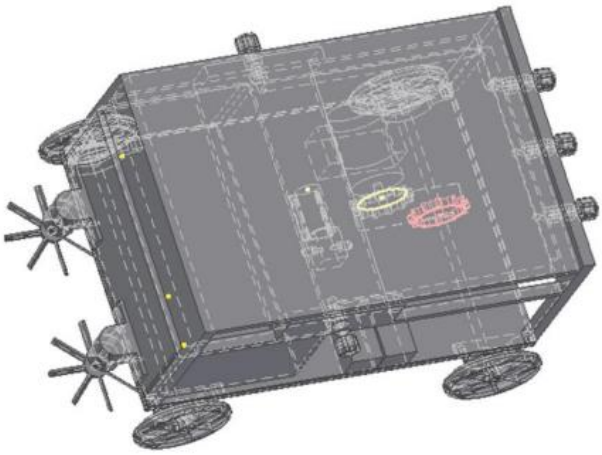


Figure 1.3 3-D CAD Model of the Rover [5]

Figure 1.4 Assembled View of Rover [5]

1.3.2. Recent Research

(Low-cost environmental monitoring mini rover based on IoT technology, 2021)

Building a rover that can identify and determine the temperature, humidity, and air quality can be done by using IoT-based sensors such as DS18B20 temperature sensors, DHT11 humidity sensors, and MQ-135 air, and detecting obstacles around the rover can be done by 4 HC-SR04 ultrasonic sensors.

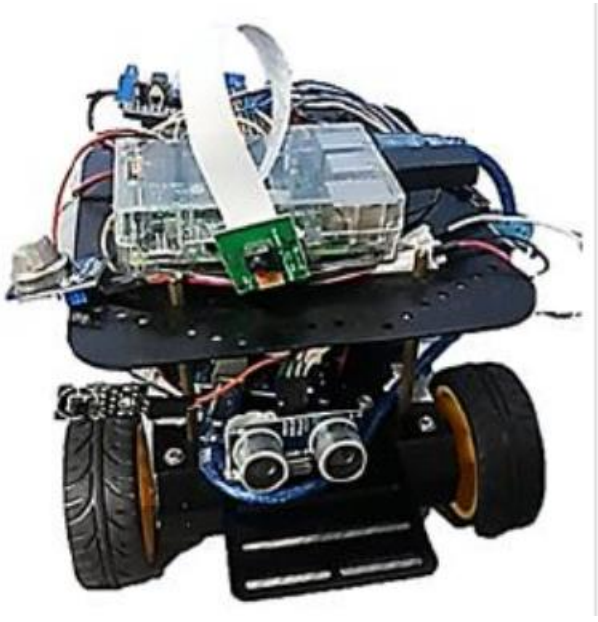


Figure 1.5 Prototype of the environmental monitoring rover [3]

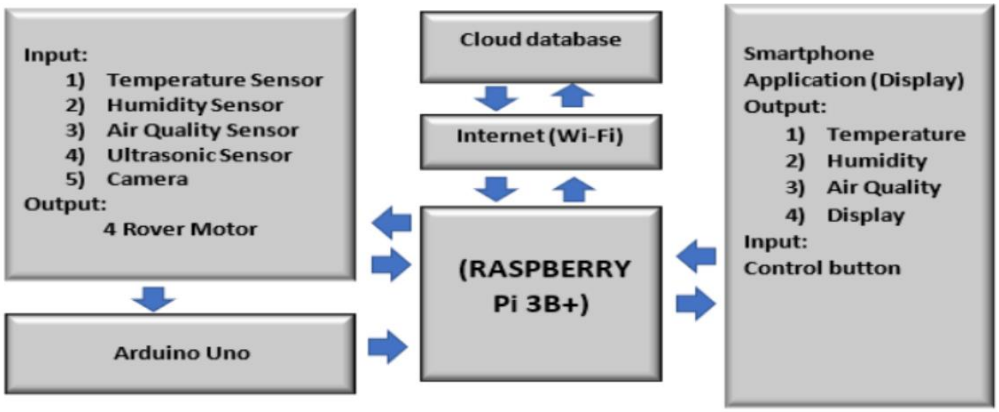


Figure 1.6 Block diagram of the overall system architecture of the IoT-based environmental monitoring rover [3]

(IoT BASED MULTIPOINT PESTICIDE SPRAYING MACHINE, April 2022)

The Indian sub-continental farmlands are as unique as they are. These pesticides have become a necessity for farming nowadays and with the benefits of these pesticides, come to the damages that are done to nature and the human population. Controlling and decreasing the use of pesticides have become a necessity. To be able to do these IoT-based machines are amazingly effective. A rover/machine can reduce the use of pesticides. It must use a navigation system, driving control, and system construction to function properly. All it must do is spray the chemicals accordingly and quantitatively. With a spraying mechanism, the machine can produce a significant impact on farming and save human health and nature.

Figure 1.7 IoT-based multipoint Pesticide Spraying Machine[4]

(Smart Agriculture Implementation using IoT and Leaf Disease Detection using Logistic Regression, 2021)

Image detection can be used to detect and identify the health of plants and leaves very easily. Logistic regression can be done to detect whether the leaves of the plants are healthy or not. This is a very logical and cunning use of artificial intelligence.

1.4. Critical Engineering Specialist Knowledge

We have selected some sensors that would be providing the best result ensuring accurate data gathering and storing. The sensors would be dedicated to their job of gathering the data. We have produced the idea of using computer vision running on the raspberry pi to identify the health of the plants and using some machine learning models we can train the collected data to produce a better prediction.

1.5. Stakeholders

The project we are attempting to complete has both benefits and drawbacks. The following are the benefits and drawbacks. The addition of a camera to conduct computer vision will be one of the benefits. The plants would be photographed and flagged as safe or unsafe. The detection algorithm would produce the result on the spot and flag the plant. The rover is a multifunctional machine that reduces the physical effort required for laborism by fusing many features into a single gadget. Use of this rover in fields of crops, in gardens, etc. would revolutionize the farming industry as it can water the plant, take care of the field, cut grass, and collect data to achieve better cultivation results throughout the year.

1.6. Objectives

The following goals are intended to be achieved by conducting the related work:

1.6.1. Primary Objectives

The goal is to design and build a rover capable of operating on farming land and taking care of the field and crops. At the same time, it would be able to collect important data regarding the climate and the environment of the farm/garden/cultivation area. The rover will collect humidity, temperature, air quality, and air pressure data from the air using dedicated sensors. However, the data-collecting job does not end there. The rover would be collecting data like soil moisture and pH measurement from the soil using dedicated sensors. Collecting data from the rainfall and measuring

the average rainfall would be a rover task. These data will be saved and later use to further experiments and predictions using a machine learning algorithm.

1.6.2. Secondary Objectives

This rover would be capable of conducting tests and showing results regarding the health of plants. This would be done using machine learning algorithms. This multitasking rover would be a new addition to the advanced rovers capable of both collecting data as a primary job and then using the data to produce a trustworthy and precise prediction to get the best result soon regarding the cultivation of crops and plants in that farming field. This would be done using a machine learning algorithm using the data collected from the field through the primary process of the rover.

1.7. Organization of Book Chapters

Chapter 1: In Chapter 1, we have tried to provide a brief overview of our project.
Chapter 2: In this chapter, we have tried to conduct a literature study as well as a thorough inquiry.
Chapter 3: In this chapter, we have explored many types of project analysis as well as our project's management system.
Chapter 4: This chapter has been divided into two sections: methodology and modeling.
Chapter 5: The results analysis and circuit review are displayed. This section briefly discusses the entire project. This section has identified how our job is done. We have tried to figure out what the project's output is and show it to you.
In Chapter 6: This is the final section or the conclusion section. This section summarizes everything about our project.

Chapter 2

PROJECT MANAGEMENT

2.1.Introduction

This project is about making a rover capable of maintaining a crop field. Taking care of the plants and getting the scientific data along with implementing them to improve the quality of the plants and reduce human labor. To get a better understanding of the progress and maintenance of the project we must have project management. Here it would be shown how it is to manage the resources, and budget and identify the problems that come along with it.

2.2.S.W.O.T. Analysis

The acronym of S.W.O.T is Strengths, Weaknesses, opportunities, and Threat. Here we would be talking about the strengths and opportunities along with the opportunities and threats we have faced during the project's creation. By this, anyone would be able to understand what is needed to create and manage this kind of technology. Technology and workforce along with other things that are resources can both be strengths and weaknesses at the same costs depending on the resource. Only with relevant and useful resources, the project can be done with maximum output. Without analyzing the threats and opportunities to face the threat it always becomes harder to make and maintain a rover like this.

Strengths:

- No Human required
- Able to collect data from the field
- Cost-effective
- Eliminate human error
- Automatic watering system
- Automatic PH value send
- Field data stored on online database
- Field data auto-analyze using MATLAB

- Automatic spray pesticides on the field
- Control moving of rover with front camera view
- Controller of rover control by Web Server (192.168.4.1)
- Offline storage of video footage
- Field data store online and offline(CSV) both
- Collecting scientific data from the field

Weaknesses:

- Training and predicting with the collected data
- Moving of robot is linear
- This rover can detect the unhealthy crops

Opportunities:

- This rover can be used on any kinds of land regardless of the kind
- Can be modified easily
- Obstacle detection
- We can improve the response time
- The modern world in awaiting for technology like that

Threat:

- Rover moving is control by Web Server. Sometime webserver got crashed.
- For combine power supply some sensors may defect due to over current.

2.3.Schedule Management

Table 2.1 Gantt Chart

Task\ Date	16 Apr	17 Apr to 9 May May-	10 May to 30 May	15 May to 30 May	10 May to 20 Jun	21 Jun to 20 Jul	21 Jul to 11 Aug	8 Sep	9 Sep to 22 Sep	23 Sep to 23 Oct	24 Oct to 20 Nov	21 Nov to 27 Nov	28 Nov to 6 Dec	7 Dec to 13 Dec	5 Jan
Orientation															

Topic selection & proposal submission															
Literature Review															
Simulation & Control Algorithm															
Hardware & Research (25-40%)															
Preparing Progress Report & chapter 1&2															
Progress Defense															
Online Chapter 1&2 and Progress Reflection Report Submission															
Hardware Assembly															
Analysis & Optimization															
Submission to External															
Submission of Project Book															
Final Defense															

2.4. Cost Analysis

We tried to stay the price as low as attainable as one in every essential project goal. A minimum study of actual expenditure was epitome instead of the intensive check for the enforced project. The cost analysis of the planned model shows the subsequent table.

Table 2.1 Cost Analysis

Equipment	**Price**
Raspberry Pi 2 Model B	9,910 /-
12V GEAR MOTOR HIGH TORQUE (4pcs)	6,000/-
80mm (about 3.15 in) Mecanum Wheel Omni-directional (4pcs)	4,400 /-
Wire	600/-
Arduino Uno R3	950/-
Motor Driver L293n	150/-
Capacitive Soil Moisture Sensor	299/-
NodeMCU ESP8266	420/-
Pm2.5 Air Quality Sensor	2,990/-
Rain Sensor 2Pcs	180/-
Water Level Sensor	90/-
Breadboard Power Supply Module	150/-
Mb102 Breadboard (Large) 4pcs	420/-
Analog Ph Sensor	2,600/-
Esp32 Cam	840/-
Rtd Pt-100 Temperature Sensor	799/-
BME280 3.3V Temperature And Humidity Sensor	696/-
Battery	2,700/-
Robot Body	4,000/-
Water Pump 3Pcs	720/-
Relay Module 5V 1CH	100/-
Relay Module 5V 2CH	150/-
Wifi Adapter	800/-
Transportation	500/-
Total	**40,464/-**

The total cost spends by our team members equally. After calculating all cost, we divided it among our members. We spend around 10,200 Taka each member.

2.5.P.E.S.T. Analysis

Political analysis:

This project does not require any government permission to create and execute. It is possible to design, create and execute.

Economic analysis:

Countries like Bangladesh, India, Pakistan, and Vietnam need technologies like this as this rover is cost-efficient and needs exceptionally minimal maintenance costs. It also reduces the cost of labor for the end-level farmer which leads to more profit.

Social analysis:

This project would be incredibly useful for people of diverse backgrounds such as gardeners, farmers, and large farming companies. However, poor farmers would be more benefited and would tend to use this technology more than anyone else.

2.6.Professional Responsibilities

Any project may end up in positive outcomes if the cooperation is effectively managed, to realize the desired ends up in a team, every member should perceive their share of responsibility. Our project team consists of 4 members, every of whom provided leadership for a definite part of our project, as we needed to travel through varied segments to form the project stand out. To form the project, stand out, we needed to begin with smart designing, like finding project ideas, meeting to debate them, hardware structure style, plants watching, book writing, book researching, investigation needed book template's points, properly structuring the book, plagiarism checking, and correcting errors. Individual Accountabilities of every member of our team is currently listed below, beside their leadership and equal performance areas:

2.6.1. Norms of Engineering Practice

The fundamental goal of this effort was to form engineering additional accessible. For us, this was a very troublesome circumstance. We created a circuit board and added sensors to it. As a result, It

was created by Proteus software. After that, it is written. This work took an extended time and a great deal of thought to end. We usually scrub the board carefully using a hand tool. A hand tool might be a fastening tool that's also held in the hand. It generates enough heat to soften the solder and let it flow into the affiliation between two workstations. the proper water price was then established exploitation the pH and Common Market sensors. We analyze code part to use the sensor properly with microcontroller.

2.6.2. Individual Responsibilities and Function as Effective Team Member

Ringku ,Md Mahfuzur Akter: My responsibility was to produce project concepts from the beginning, and that i took on leadership roles within the hardware and software implementation sectors. My 1st and most vital responsibilities were to make an inventory of essential instrumentation, purchase it, and set it up to hardware connections.

Parag, Al-Emran: My task was to ascertain the outcomes of our planned project's outputs. In researching the papers and testing the project procedure regions with simulation, I took the lead. And I worked on chapters 5 & 6. I used to be conjointly within the management of my project team and their work deadlines, additionally as contributory to the book's authoring.

Hassan, Mehedi: My task was to research the hardware connections. In areas related to pre-crural methods, I worked on chapters 3 & 4. and plant observation. I did jointly take care of the teamwork, as well as composition conferences over our project and highlighting the interconnected tasks as my responsibility. I used to take joint public commitments to action on our project.

Noman, Abdullah Al: My task was to investigate the needs of our project. I demonstrate my leadership by researching books and guiding our foreseen outcome areas. I divided our work equally among every member, authored the book, and organized the contents and references for the right edition. I worked on chapter 1 & 2.

2.7.Management Principles and Economic Models

The shortage of cheap labor and the need of crops to have proper care have become a modern problem of farming. There needs to be a solution to this problem. And a rover that does the job for you with much less cost and more efficiency can be the solution to this problem.

In making this rover, the engineering team has come across many problems and must solve those using the economic and management model on which the project is made. For example, to make the rover cost effective, it had two ways to go for. It either could use cheaper technology or it could have multi-functionalities. And it has right a multifunctional rover that can be much more effective according to the economic model followed be the engineering team. This not only makes the rover a complete package, nonetheless also a cheap alternative to all the manual work of a costly labor.

2.8.Summary

A farming rover has come as the savior for all the farmers that need cheap labor to save their business and livelihood. In the making of the project, there have been many problems, and the engineering team has found solutions. The cost and schedule analysis has been up to mark to assure a better result.

Chapter 3

METHODOLOGY AND MODELING

3.1.Introduction

The project has used some engineering techniques to create the project as it is. The idea behind the modeling and how the project works are pre-designed by the engineers. There has a working methodology followed to achieve the engineering breakthroughs seen in the project. The project was modeled and designed first then it was made following the pre-determined instructions.

3.2.Block Diagram and Working Principle

The block diagram shows how to rover analyze and control. It also shows how all sensors can access and send data.

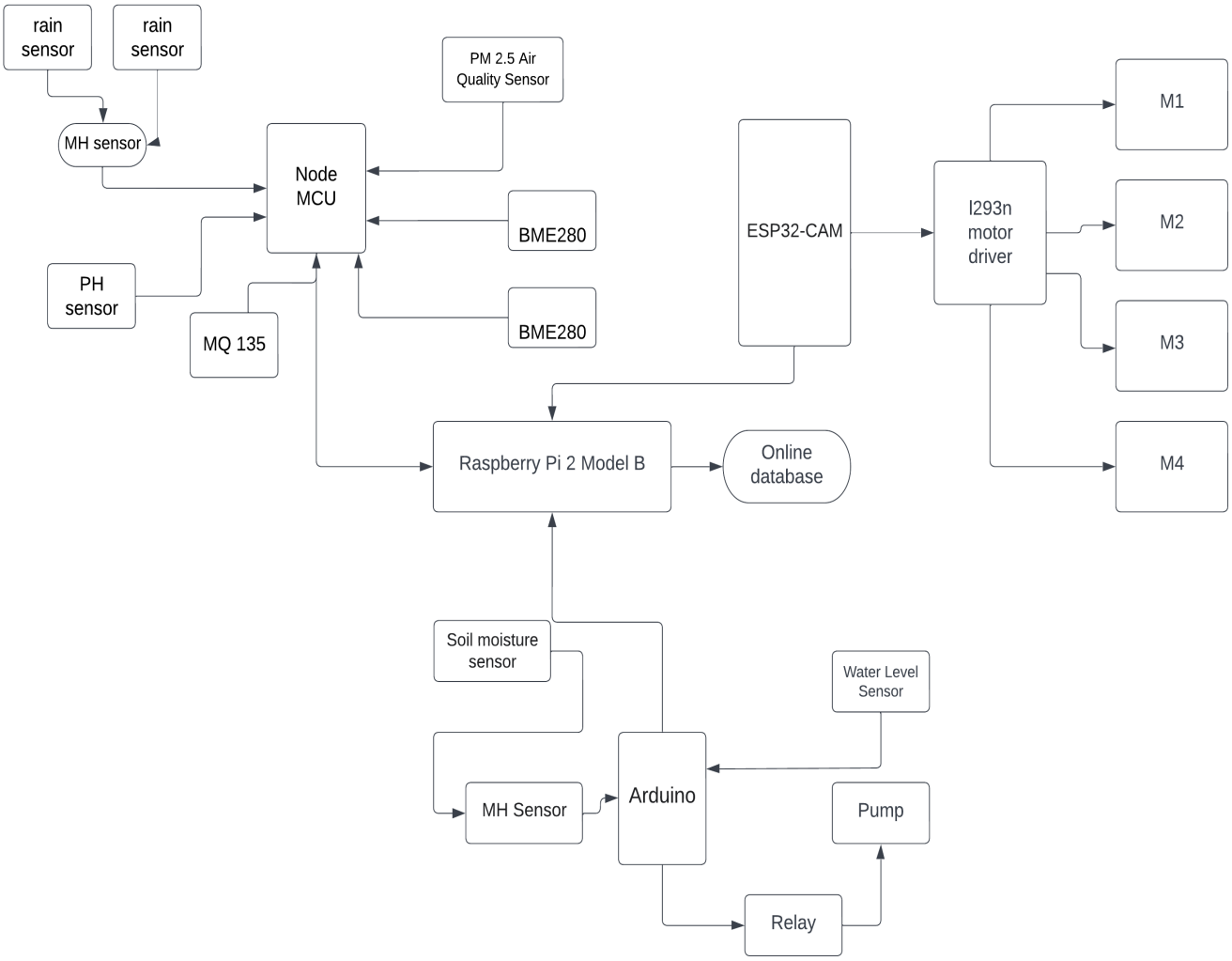


Figure 3.1 Block Diagram (entire process)

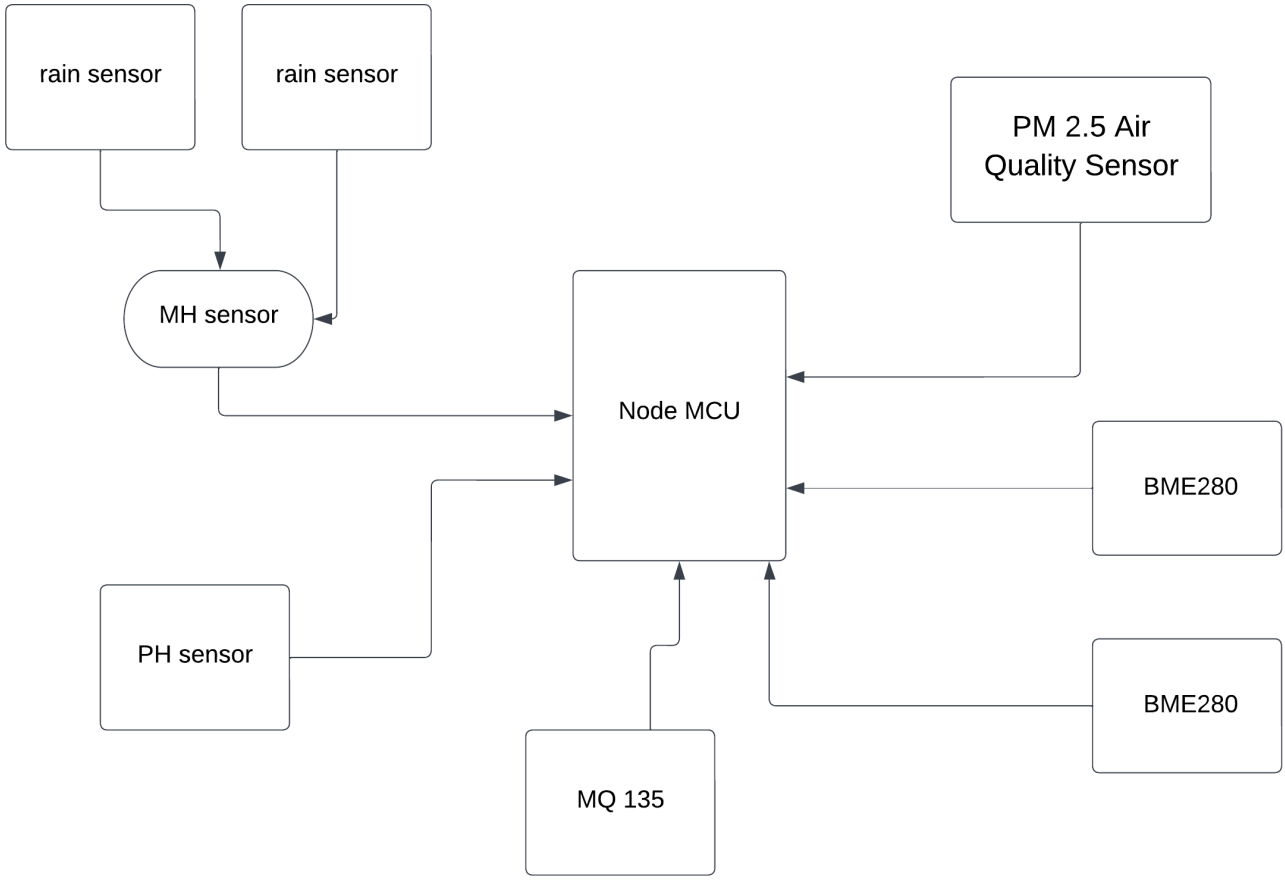


Figure 3.2 Block Diagram of Sending Field Data

By this diagram we show that we analyze some field data. Which helps us to detail study for an agriculture field. We use Node MCU ESP8266 for our microcontroller. We collect PM2.5, PM10 data for analyze air quality. By using BME280 we collect humidity, temperature, and air pressure of field. By using rain sensor, we monitor the rain level. Ph. sensor used for collect the pH level of the field soil. All the data are stored in online database as a graphical and CSV format.

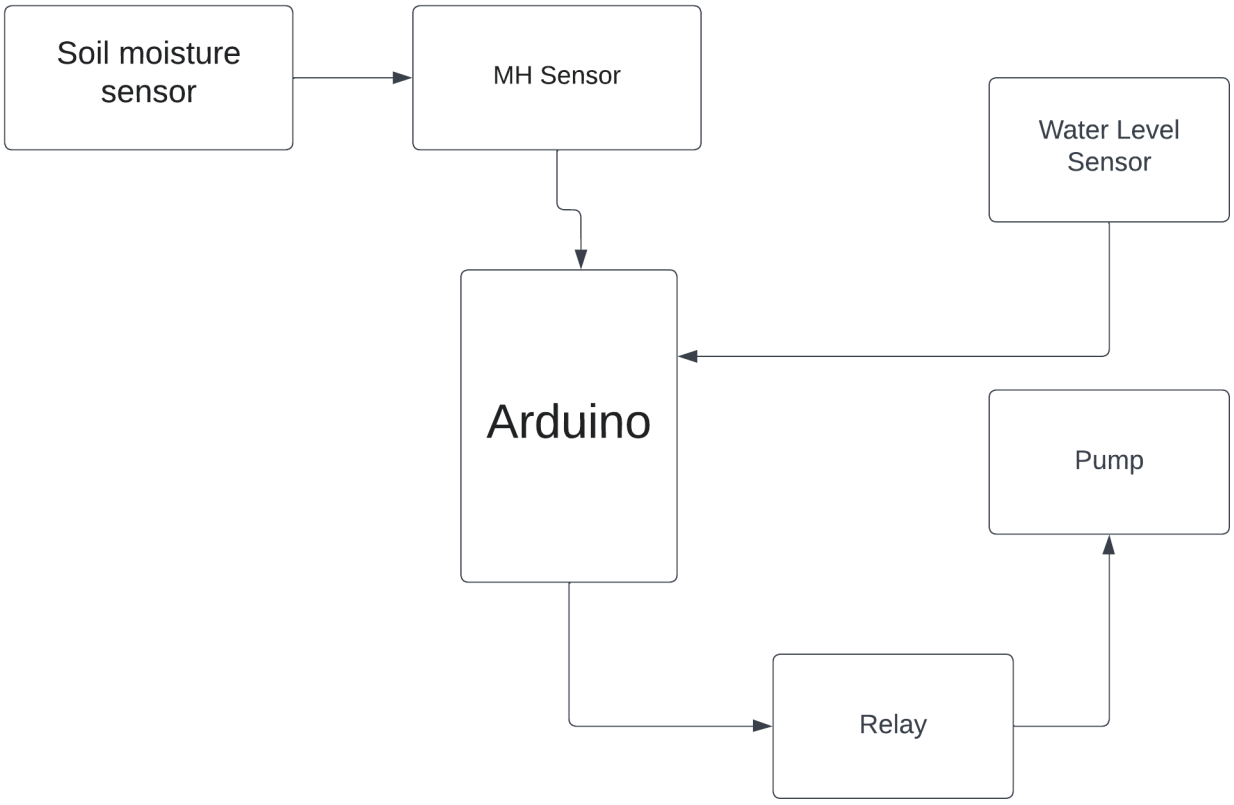


Figure 3.3 Block Diagram of Automatic Water Pumping System

We demonstrate the automated water pumping process with this figure. Our microcontroller is an Arduino Uno. To determine the soil's moisture value, we employ a unique soil moisture sensor mounted on a robot wheel. We automated the water pump based on a threshold after assessing the soil moisture value. Using water level sensor, we keep track of the water level as well.

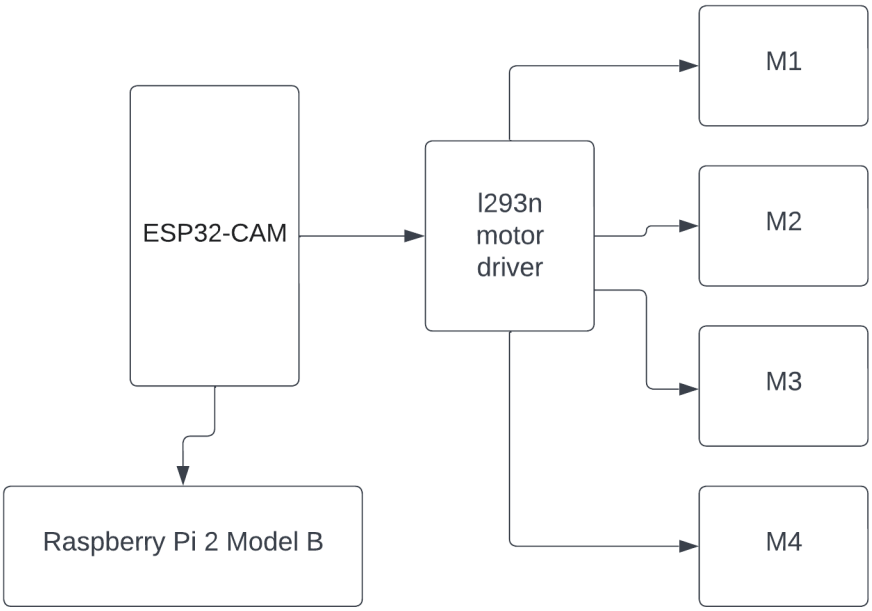


Figure 3.4 Block Diagram of Rover moving

By this diagram we show moving of rover. Here we use Raspberry PI 2 Model B as a microcontroller. Raspberry Pi connect with ESP32-Cam for video output. We use 12V 300RPM motor and mechanic wheel for smooth moving. We control the rover with live video stream and this video also store on raspberry pi.

3.3.Modeling

Here, the sketch was used to design the robot. After that, 3D art software Tinker Cad has been used to give a Proper 3D look.

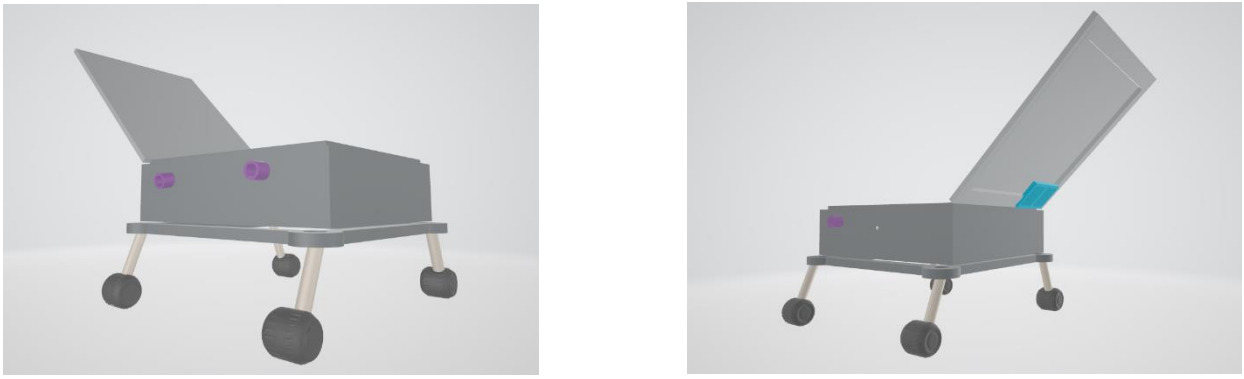


Figure 3.5 3D model of robot

The rover has a rectangle body that allows the rover to move in diverse ways without being subject to any interference from the surrounding. The body of the rover must be strong enough to endure the harsh environments and light enough to move as easily as possible.

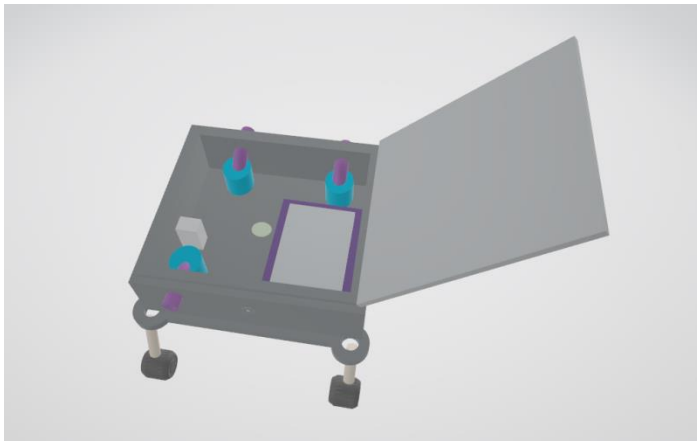


Figure 3.6 Upper part of Robot

The inside of the rover is well designed and it is a combination of different compartments and designated places for holding different components.

3.4.Summary

In this project an Automatic Plant monitoring system is being made by us which will be used in farming. Servo motor, frame and wheel are being used to make Rocker-bogie wheel for movement and solar system for generating power. Some sensor like humidity sensor, air quality sensor, PIR sensor, LDR, PH sensor, Moisture sensor, Temperature sensor are added in this system. Checking Plants health, soil health, weeding, giving pesticide spray, watering the plants and also harvesting Plants will be done by this system. There will be a camera for monitoring. All sensors and camera will be connected with Arduino and Arduino will be connected with Raspberry Pi. All works will be done by the system itself which are describe above and without human touch. All of the information stored on the Raspberry Pi will be transferred to a managed web server, Farmer can see the real time data from the server **.**

Chapter 4

PROJECT IMPLEMENTATION

4.1.Introduction

This rover is no more than a unique combination of components designed to work simultaneously to achieve the engineering problem solution. The tools and components used to make this project are implemented to solve the problems mentioned in chapter 2. The quality of the sensors used in the project are not compromised the functionalities of the rover have been increased. From building of the body of the rover to creating the circuit of the rover, everything was planned and given result as excepted.

4.2.Required Tools and Components

4.2.1. Raspberry Pi 2 Model B:

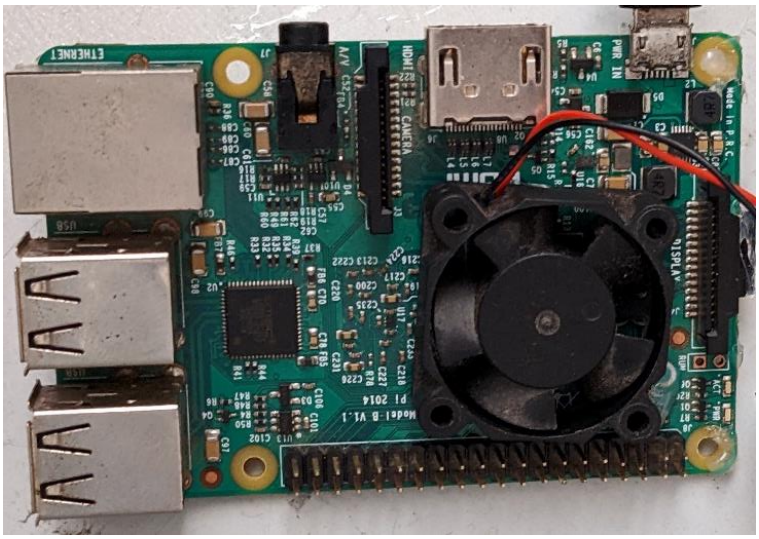


Figure 4.1 Picture of Raspberry Pi 2 Model B

The Raspberry Pi is a credit card-sized computer. The Raspberry Pi 2 Model B is the second generation Raspberry Pi. It is based on the BCM2836 system-on-chip (SoC), which includes a quad-

core ARM Cortex-A7 processor and a powerful GPU. The Raspberry Pi supports various distributions of Linux including Debian, Fedora, and Arch Linux.

4.2.2. Node MCU ESP8266:

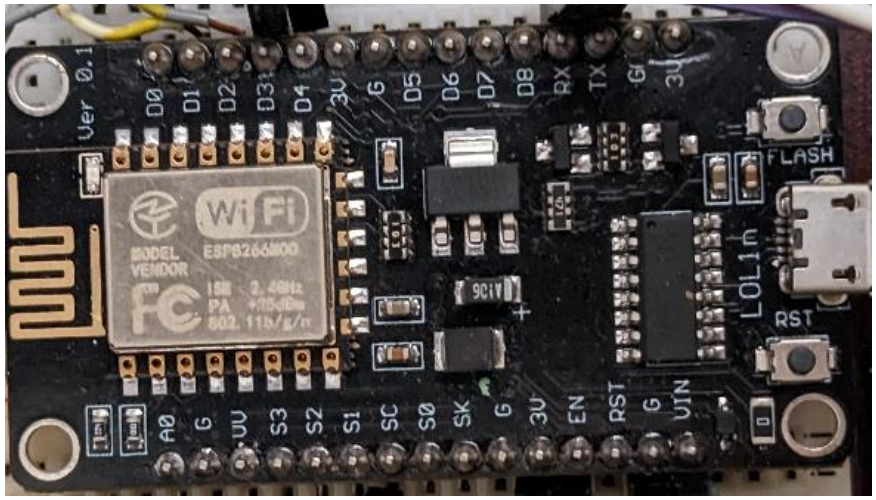


Figure 4.2 Picture of Node MCU ESP8266

Node MCU is a low-cost open source IoT platform. It first included firmware on the ESP8266 Wi-Fi SoC from Espressif Systems and hardware based on the ESP-12 module. Later, support for the ESP32 32-bit MCU was added.

4.2.3. Arduino Uno R3:

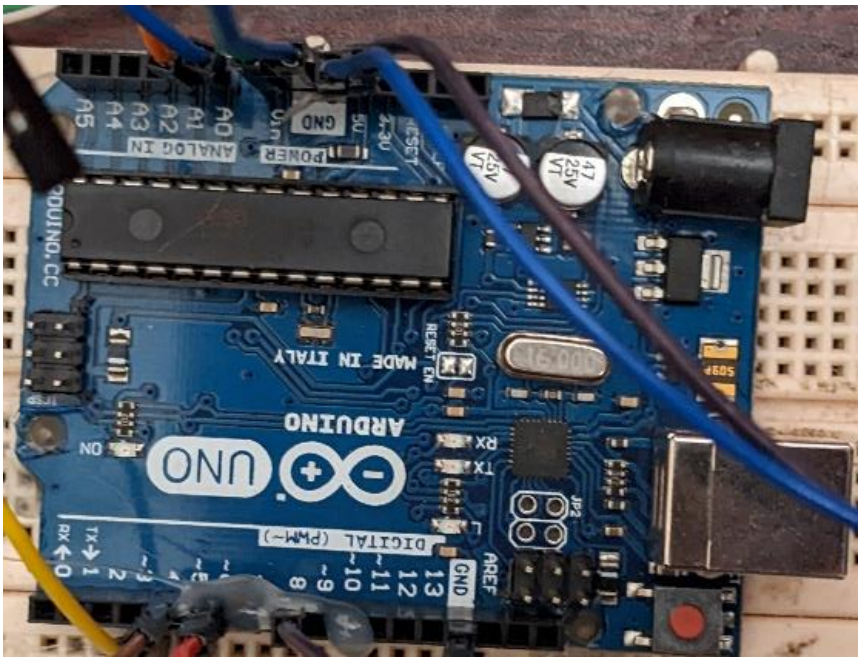


Figure 4.3 Picture of Arduino Uno R3

The Arduino Uno R3 is a microcontroller board based on a removable, dual-inline-package (DIP) ATmega328 AVR microcontroller. It has 20 digital input/output pins (of which 6 can be used as PWM outputs and 6 can be used as analog inputs). Prenames can be loaded on to it from the easy-to-use Arduino computer program.

4.2.4. ESP32-Cam:

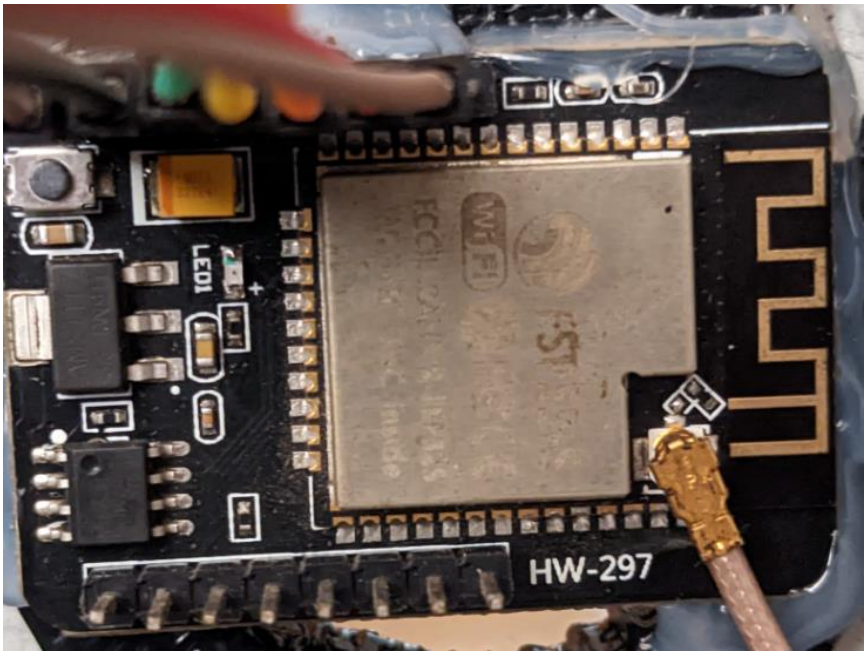


Figure 4.4 Picture of ESP32-Cam

The ESP32-CAM is a small size, low power consumption camera module based on ESP32. It comes with an OV2640 camera and provides onboard TF card slot. The ESP32-CAM can be widely used in intelligent IoT applications such as wireless video monitoring, WiFi image upload, QR identification, and so on.

4.2.5. Analog pH Sensor:

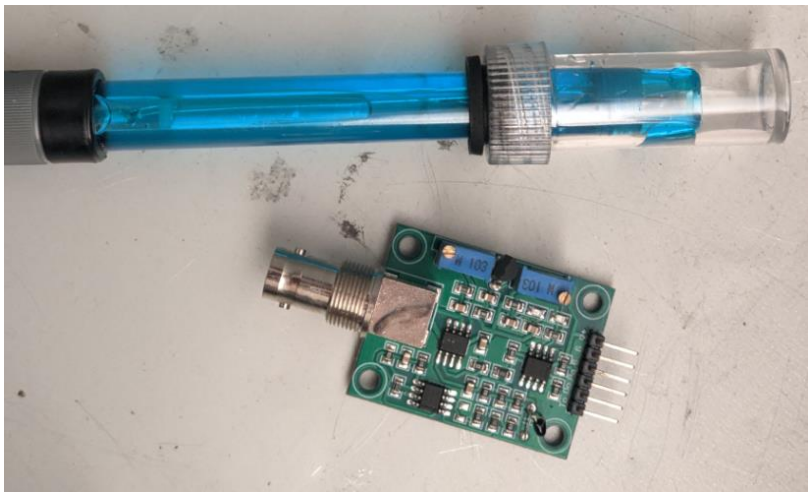


Figure 4.5 Picture of Analog pH Sensor

Professional pH Sensor Meter Kit with industrial electrode. It has built-in simple, convenient, practical connection and long life (up to 1 year), which makes it very suitable for long term online monitoring. It has an LED which works as the Power Indicator, a BNC connector and PH2.0 sensor interface. To use it, just connect the pH sensor with BND connector, then plug the PH2.0 interface into the analog input port of any Arduino controller. If programmed, you will get the pH value easily.

4.2.6. PM2.5 Air Quality Sensor:

Figure 4.6 Picture of PM2.5 Air Quality Sensor

This sensor uses laser scattering to radiate suspending particles in the air, then collects scattering light to obtain the curve of scattering light change with time. The microprocessor calculates equivalent particle diameter and the number of particles with different diameter per unit volume.

4.2.7. Rain Sensor:

Figure 4.7 Picture of Rain Sensor

It sends out a beam of infrared light that, when water droplets are on the windshield, is reflected at different angles. This tells the system to activate the wipers, as well as adjust wiper speed and frequency based on the intensity of the precipitation combined with the vehicle's speed.

4.2.8. Soil Moisture Sensor:

Figure 4.8 Picture of Soil Moisture Sensor

Soil moisture sensors measure the water content in the soil and can be used to estimate the amount of stored water in the soil horizon. Soil moisture sensors do not measure water in the soil directly. Instead, they measure changes in some other soil property that is related to water content in a predictable way.

4.2.9. MQ-135 Gas Sensor:

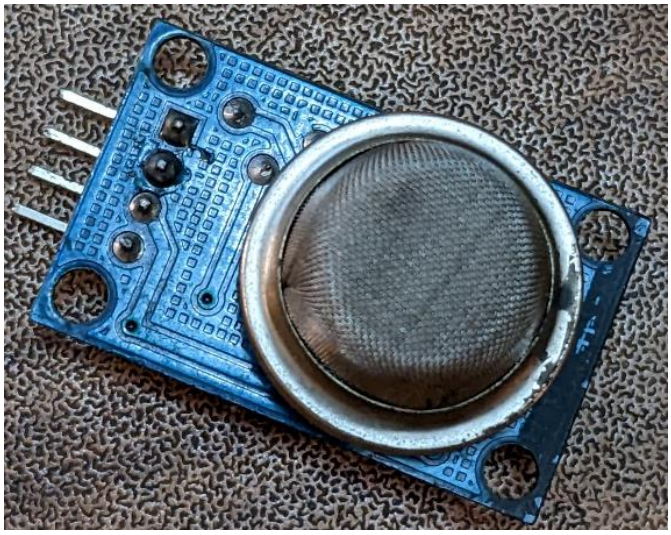


Figure 4.9 Picture of MQ-135 Gas Sensor

The MQ-135 Gas sensor can detect gases like Ammonia (NH3), sulfur (S), Benzene (C6H6), CO2, and other harmful gases and smoke. Like other MQ series gas sensors, this sensor also has a digital and analog output pin. When the level of these gases go beyond a threshold limit in the air the digital pin goes high.

4.2.10. BME280 Sensor:

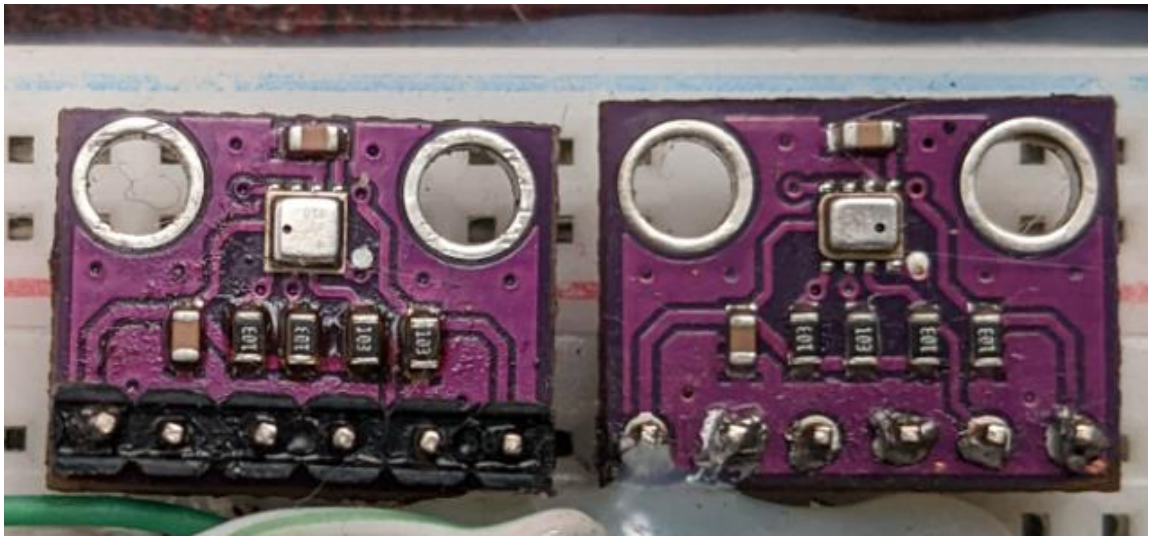


Figure 4.10 Picture of BME280 Sensor

The BME280 is a humidity sensor especially developed for mobile applications and wearables where size and low power consumption are key design parameters. The unit combines high

linearity and high accuracy sensors and is perfectly feasible for low current consumption, long-term stability, and high EMC robustness.

4.2.11. L298N Motor Driver:

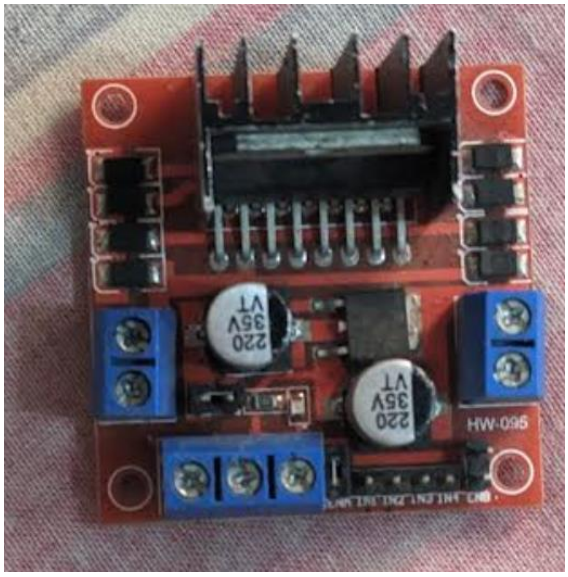


Figure 4.11 Picture of L298N Motor Driver

L298N module is a high voltage, high current dual full-bridge motor driver module for controlling DC motor and stepper motor. It can control both the speed and rotation direction of two DC motors. This module consists of an L298 dual-channel H-Bridge motor driver IC.

4.2.12. 5V Relay Module:

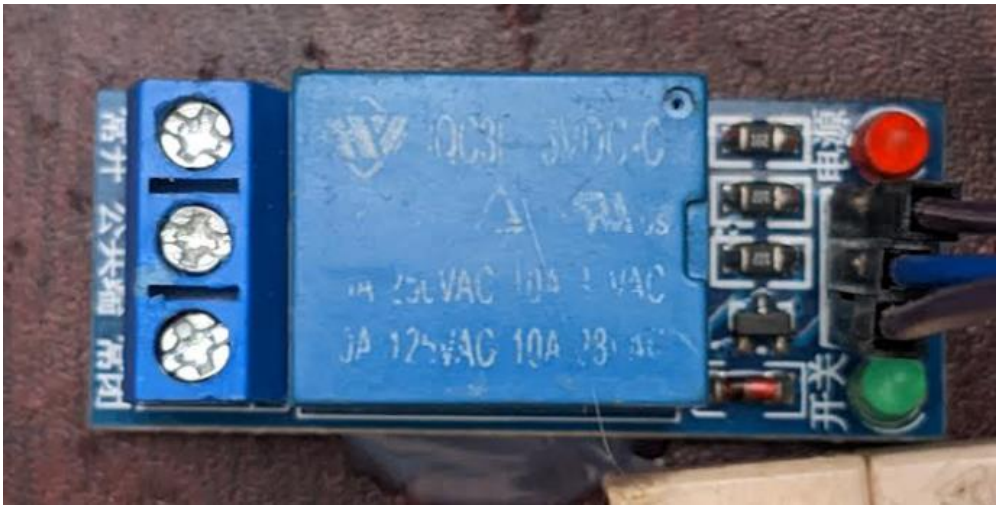


Figure 4.12 Picture of 5V Relay Module

The 5V relay module can be used to control a load such as a lighting system, motor, or solenoid. It can also be used to switch AC or DC voltages. The maximum voltage and current that the 5V relay module can control depends on the relay specifications.

4.2.13. Breadboard Power Supply Module:

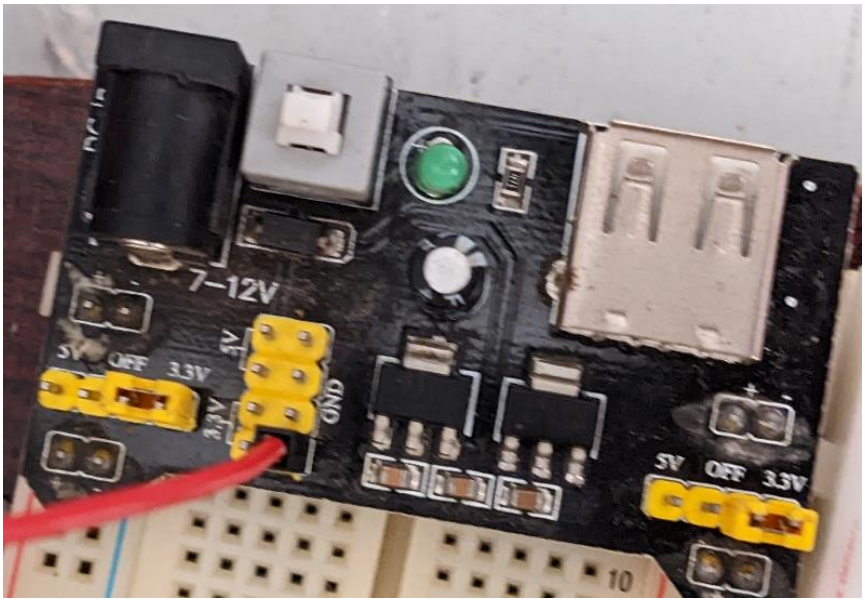


Figure 4.13 Picture of Breadboard Power Supply Module

A Breadboard Power Supply Module accepts an input through a barrel jack from a battery, a 12V adapter or any other source, and provides to our circuit a 5V or 3.3V tension, depending on our needs.

4.3.Implemented Models

The circuit of this robot has been implemented in a two-step. A circuit diagram has been designed first, and then all the components have been set physically on the insulating glass.

4.3.1. Simulation Model

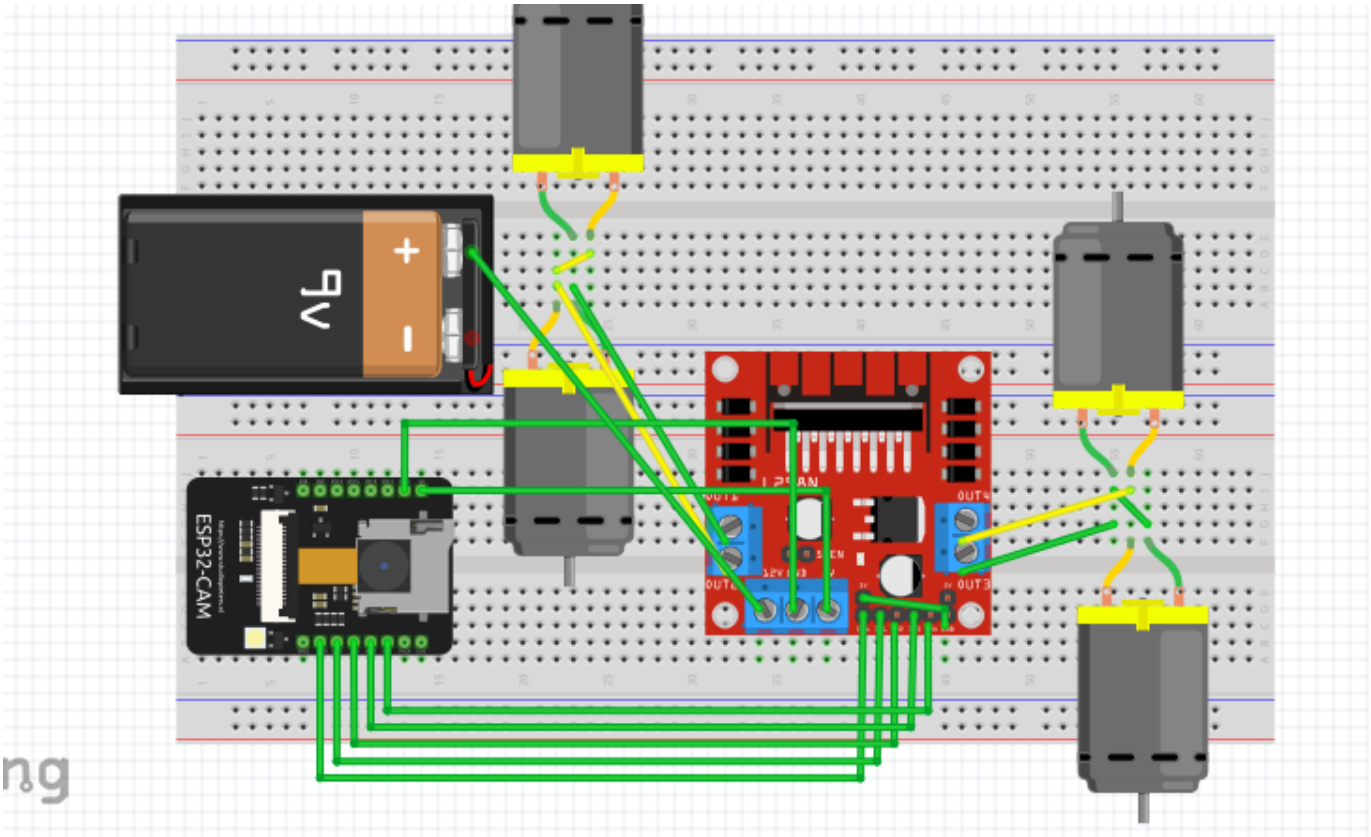


Figure 4.14 Simulation model of actuator

This diagram shows the pinout of rover moving part. We use ESP32 microcontroller for control the robot. For actuator we use 12V 300RPM high torque DC motor. For direction view part we use external camera module with esp32. We need 24V power to L293N motor driver which control the direction and speed of robot.

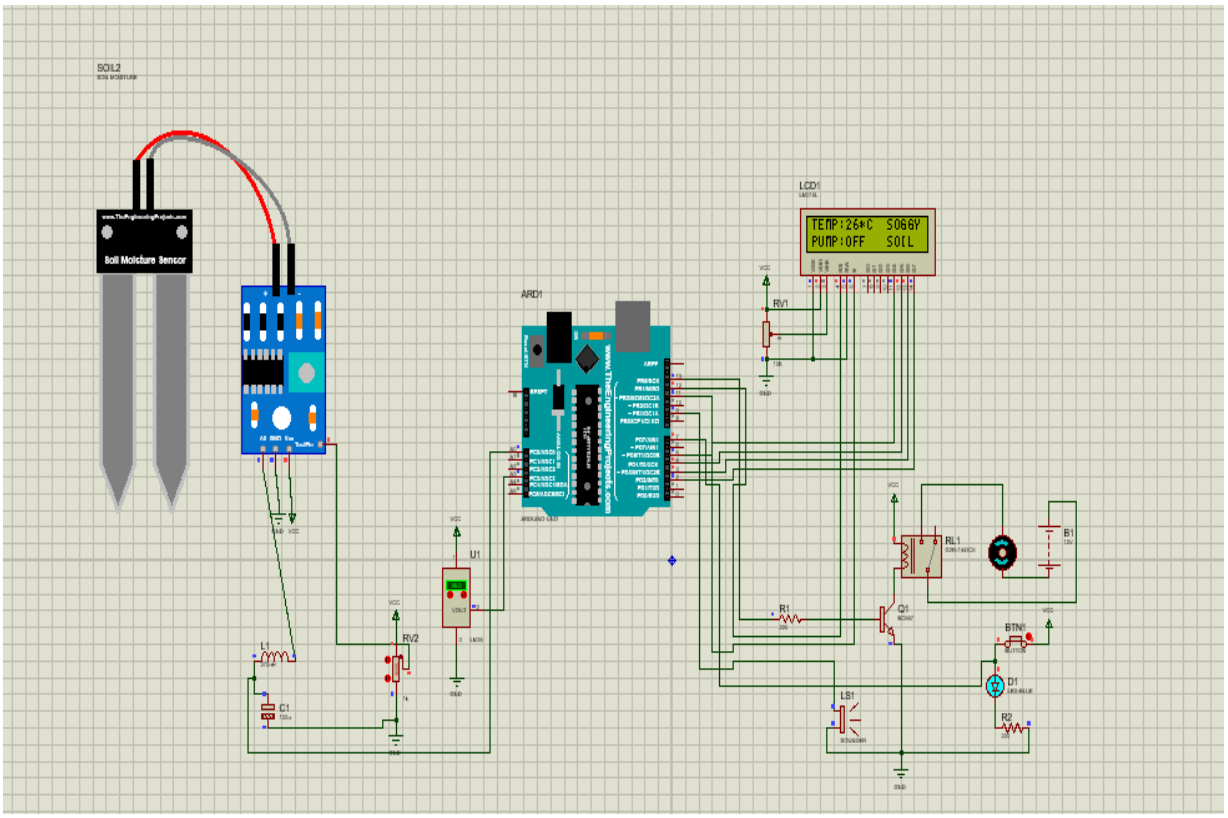


Figure 4.15 Simulation of Soil moisture and Water level sensor

In this diagram, we simulated the automatic water-pumping system. The process is controlled by Arduino Uno R3 with soil moisture and water level sensor. We use a water tank with a 5V DC water pump to pumped water.

4.3.2. Hardware Model

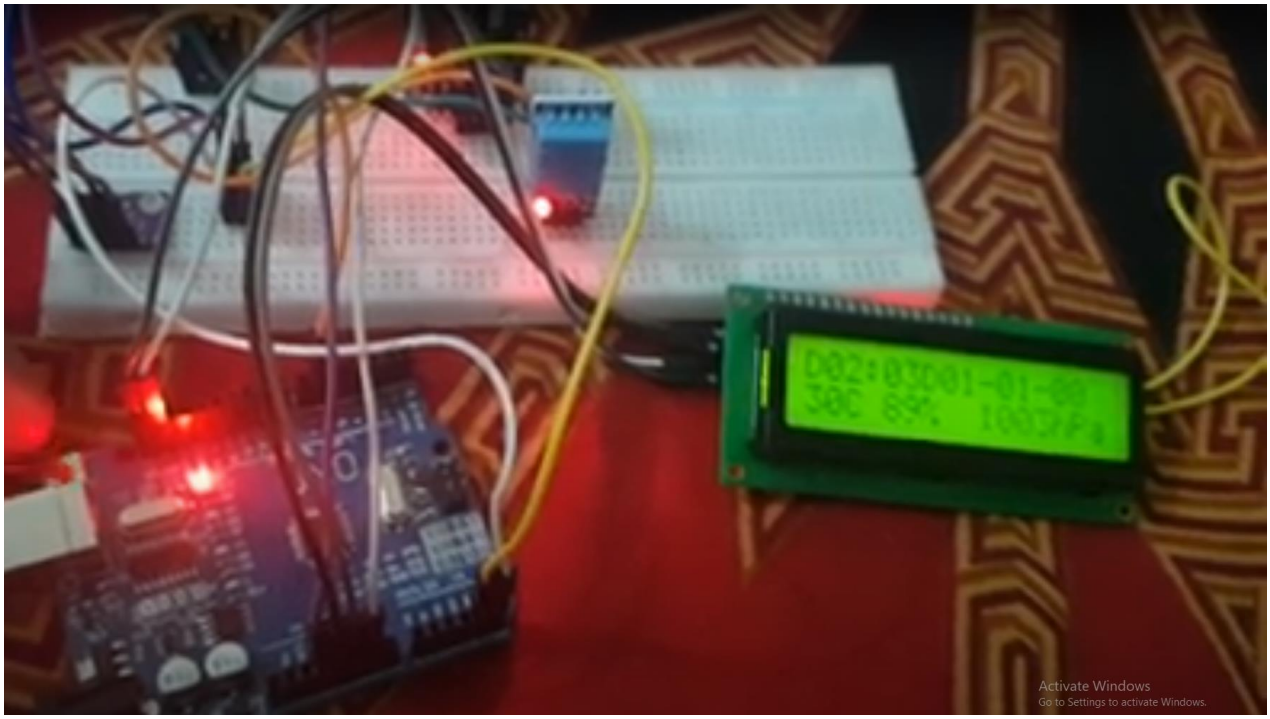


Figure 4.16 Individual collect data from the sensor

We check our sensors individually and create a manual value for it. For accuracy we use multiple sensors. We check BME280, Rain, Soil Moisture, pH, PM2.5 Air quality. We collect those data as a display output.

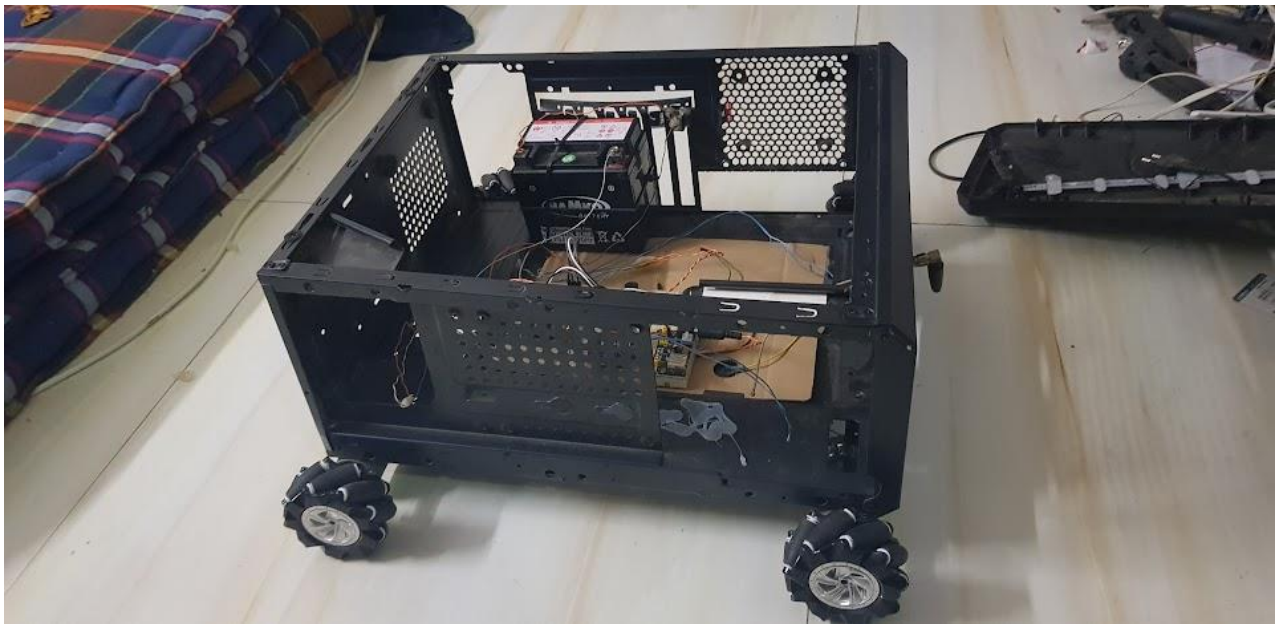


Figure 4.17 Picture of Demo Robot Body

Then we installed all the sensors in a demo body for testing purposes. We test our demo robot in a field where we got some directional value for demonstration.

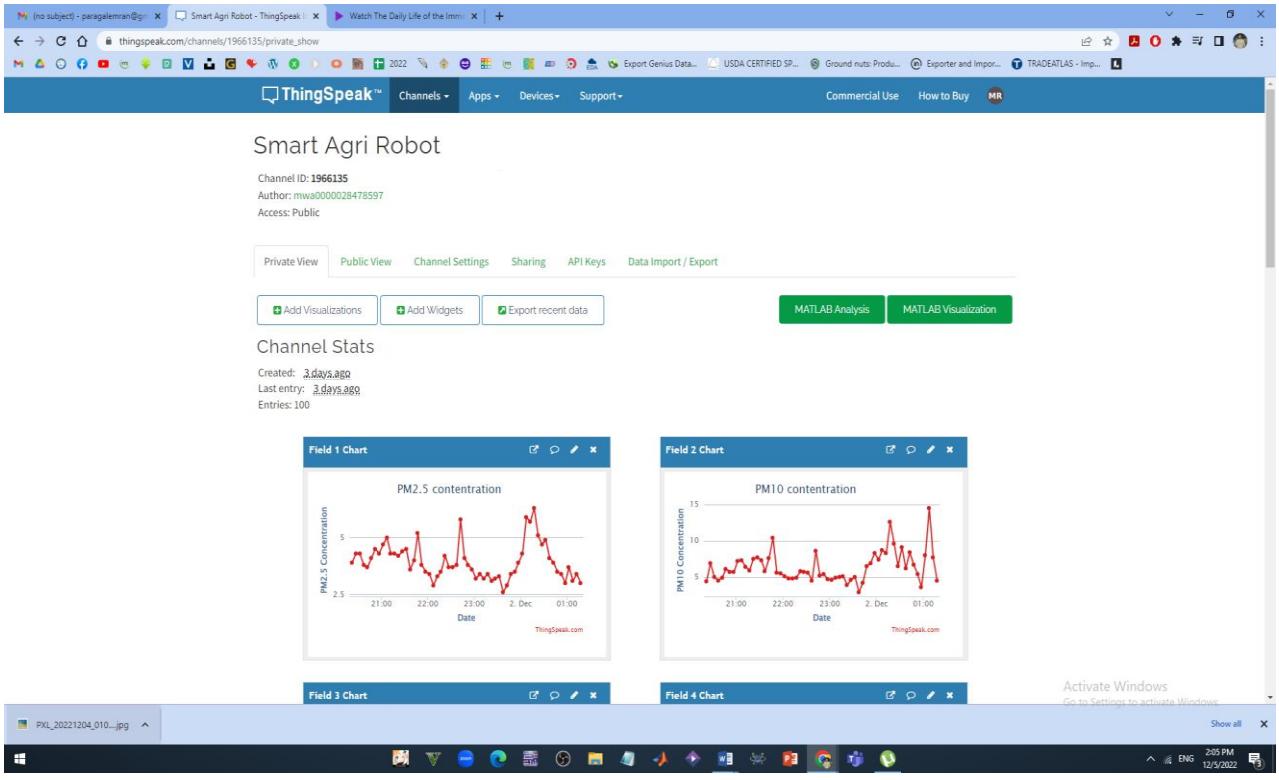


Figure 4.18 Collected Data from ThingSpeak [8]

Here we import those data in the ThingSpeak database. We make individual module for individual data. Then send it in a graph visualization.

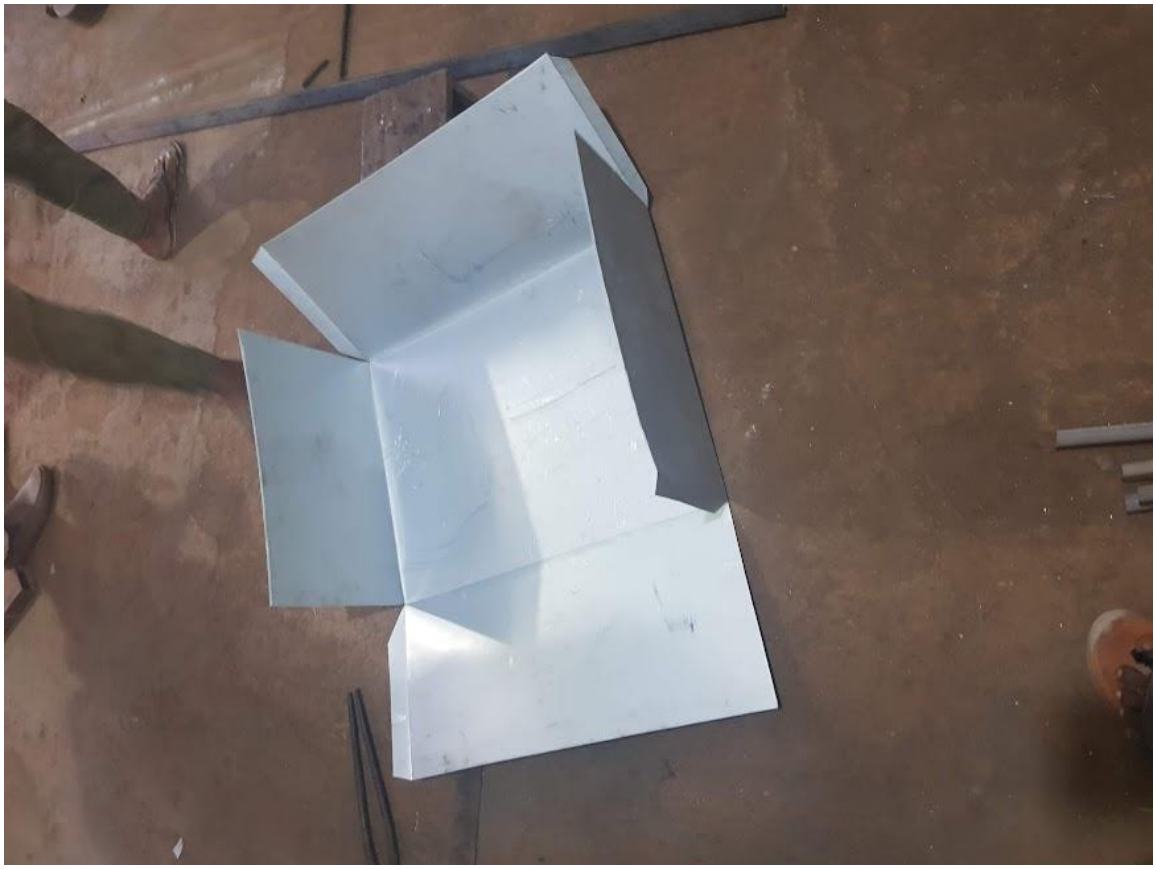


Figure 4.19 Initial Stage of making a Robot Body

After that design create our main body in a manufacturer shop. We use steel for ensure the durability of body. The frame of the robot made by iron.

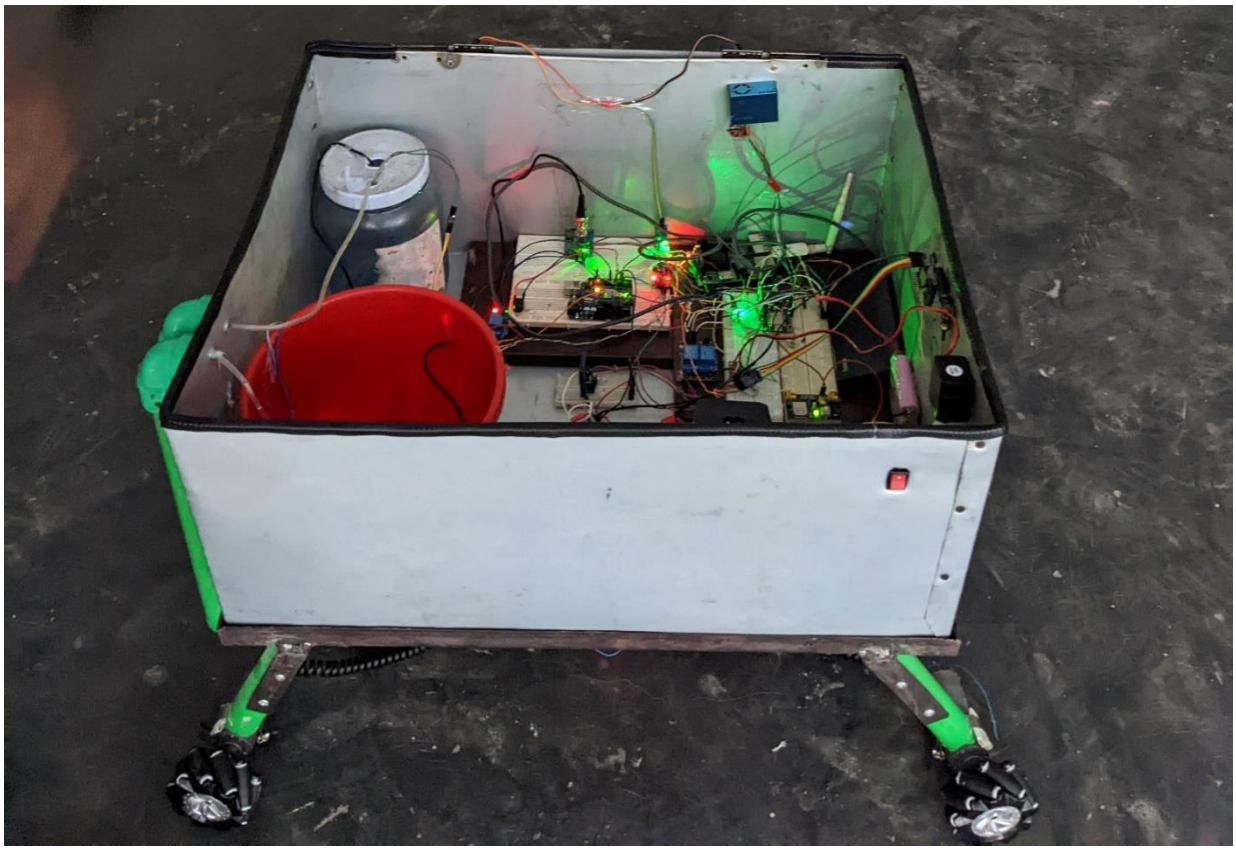


Figure 4.20 Final Stage of complete outlook

Here is our robot complete outlook. We use pvc 1” pipe for our motor grip. This is a 4WD robot. We use mechanome wheel for smooth moving. The size of the wheel is 80mm (about 3.15 in). In the box we setup all the equipment’s like sensors, boards, storage, battery, etc.

4.4. Engineering Solution in accordance with professional practices

The project's main goal was to provide solution to prohibitive cost of labor and the need for crops to have constant taking care and farmers undergoing critical problems regarding the issues. Everyone must feel secure using the rover. For this project, the influence of engineering is self-evident. All the safety measures have been taken in the making of the rover. The economic, social, cultural, and environmental effect of this rover this positive toward the farmers who will use this in their daily life.

The idea of having a helping hand with much less cost would made farmers have a better economic position. The agricultural culture of manual workload is going to be reduced because of the rover. Moreover, it is sustainable for the environment.

4.5. Summary

The prototyped model has been a success. The model works as it was intended. It has all the functionalities that was targeted. The simulated model and the prototype has a similar response and work rate. The rover works perfectly with an understanding of its work and it does not have any technical problem that the engineers faced earlier. The prototype model has proven to work in a perfect manner. All the components use in the rover supports the workload and the sensors are providing the accurate result. The results are analyzable and the rover's movements has been recorded to be working as intended.

Chapter 5

RESULTS ANALYSIS & CRITICAL DESIGN REVIEW

5.1.Introduction

Briefly discuss how the results were obtained and map the parameters required to measure to verify the proposed model successfully provides the required solution.

5.2.Results Analysis

We have presented the simulated and genuine hardware results of the project. On the simulation program proteus, we independently test each of our sensors. We install it in our device after successfully simulating all the sensors and microcontrollers. Finding the major accuracy for simulating particular value of equipment. After successfully simulating all the equipment we install all in the devices. After testing we got some results which is the main output of this project. All the graphical values are received from thingspeak cloud-beaded database [8].

5.2.1. Simulated Results

We test our sensors individually on simulation software proteus. After successfully simulating all the sensors and microcontrollers we install it in our device. The main reason of simulating individual equipment's is finding the main accuracy.

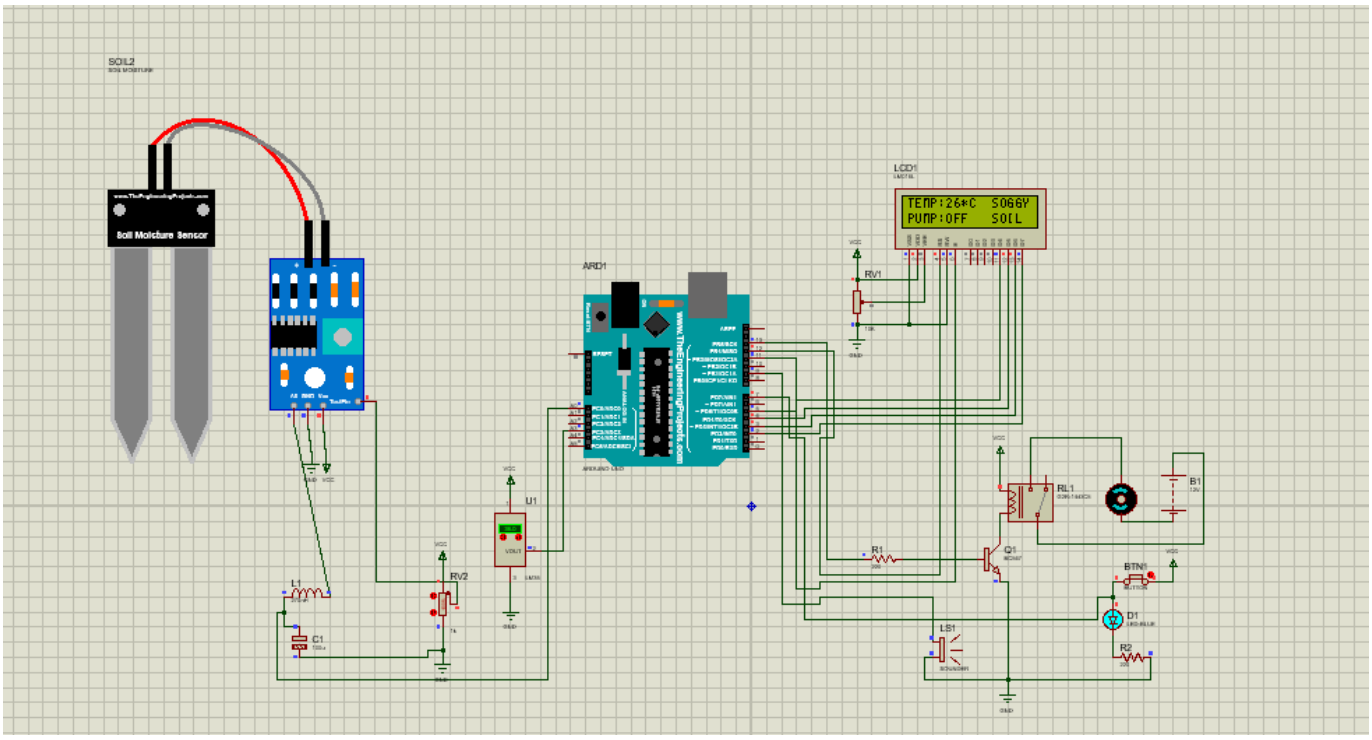


Figure 5.1 Simulation Result of moisture and water level sensor

Here we simulate the moisture and water level sensor part. Which shows us the value in LCD display as output. Here we measure the moisture level of soil and find an average value of the soil moisture.

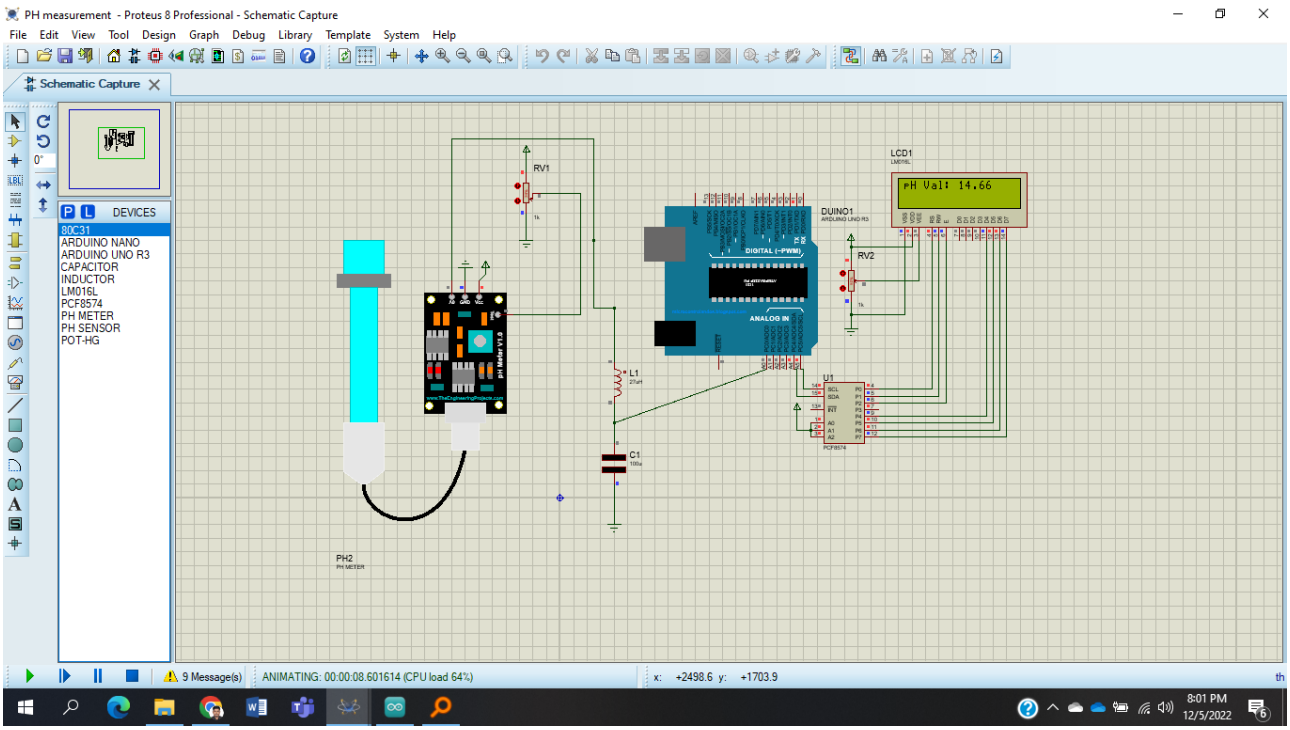


Figure 5.2 Simulation Result of ph. value of soil

After that we measure the ph. value of soil and optimizing the code. We also use LCD display to find the output value. As the accuracy of ph. sensor is exceptionally low we use another algorithm and made a maximum accuracy output.

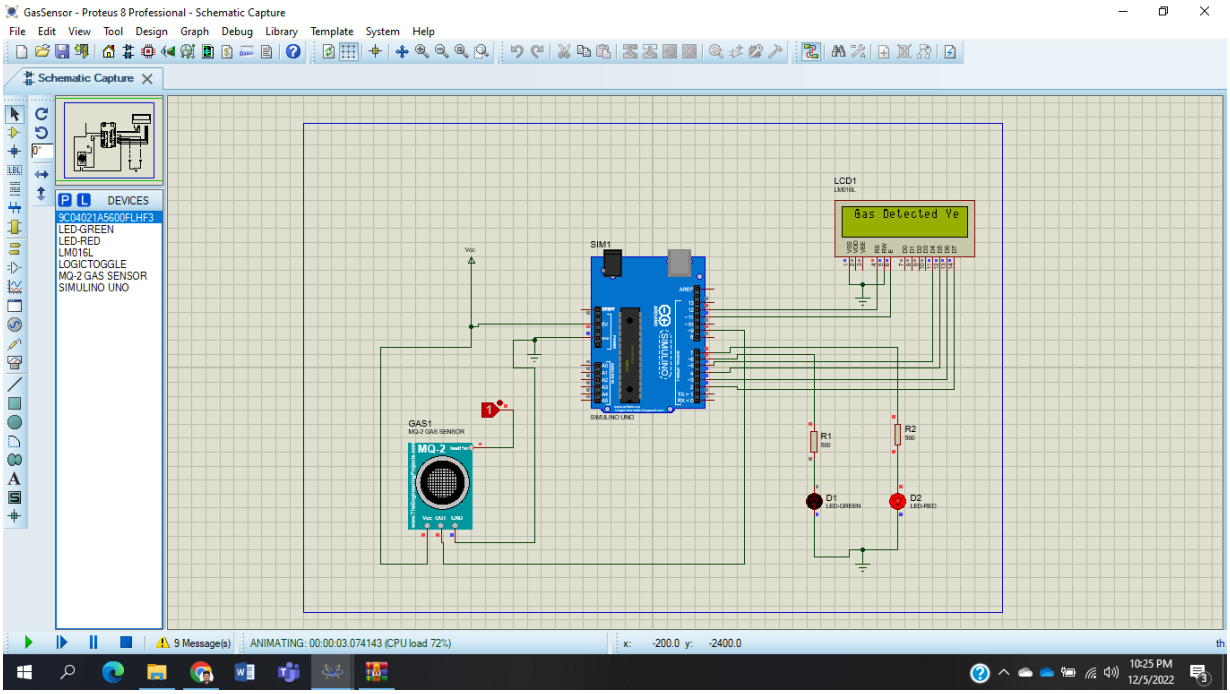


Figure 5.3 Simulation Result of GAS sensor

After that we simulate the GAS sensor MQ-135 for analyzing the field air CO2 value. For maximum accuracy output we optimize the code.

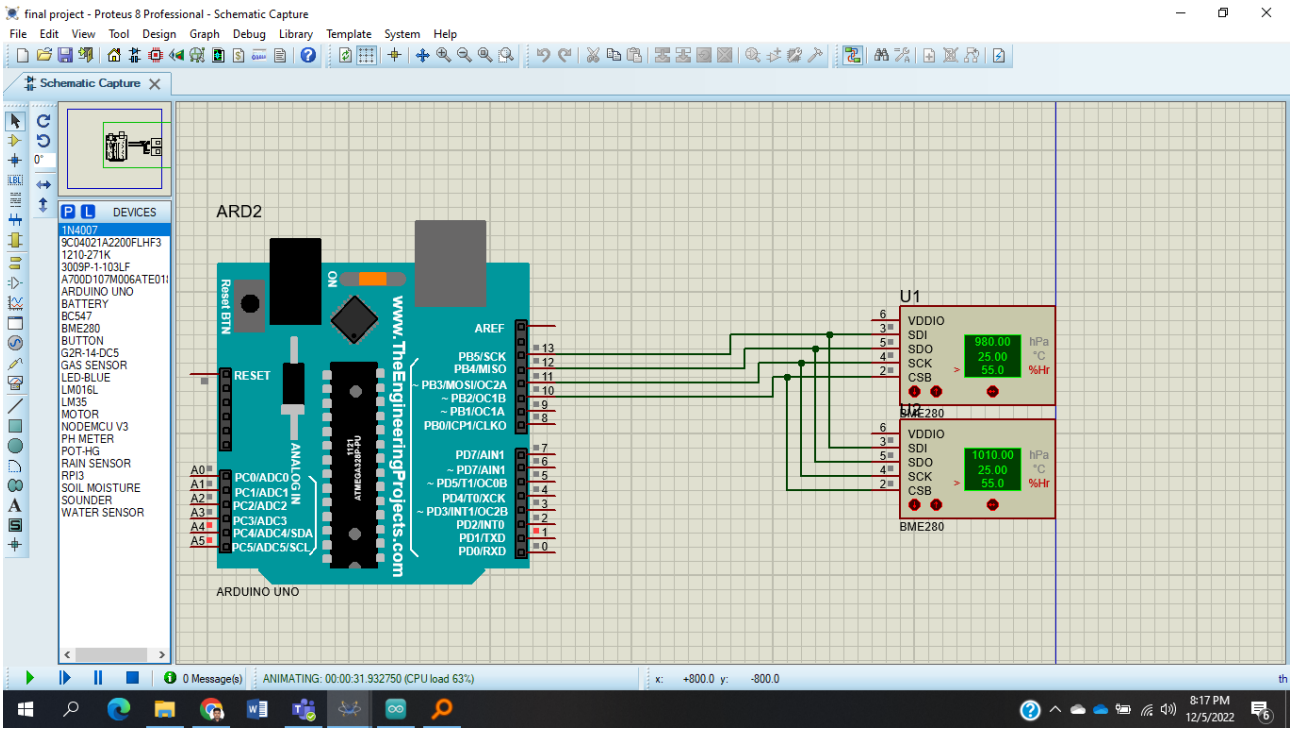


Figure 5.4 Simulation Result of BME280 sensor

Here we analyze the code of BME280 sensor. The maximum output value is collected from BME280 sensor. We analyze field temperature, humidity, PM2.5, air pressure, PM10 concentration air quality value.

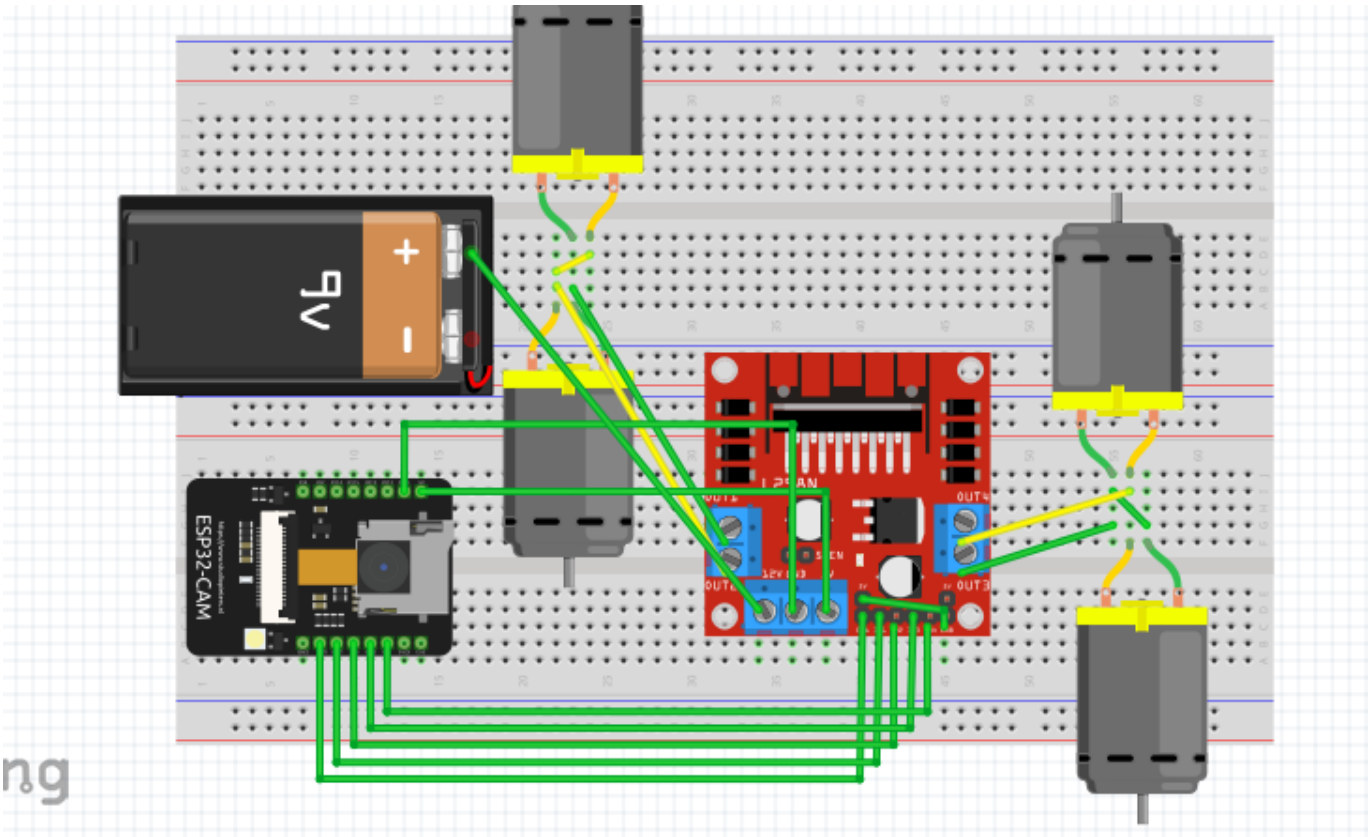


Figure 5.5 Fritzing Simulation model for actuator [9]

Here is our actuator part which we simulate by fritzing software. Before installation all the motor we select our driver and controller by simulate there. We use 4WD robot. For that we need to use 12V 300 RPM gear motor and 80mm (about 3.15 in) Mechanum wheel. For control the speed we use a PWm motor driver. The driver is L293N. We can easily use this driver for controlling 4WD robot. The maximum input voltage of this driver is 35V and output is 48V.

5.2.2. Hardware Results

After successfully simulating all the equipment we install all the devices. After testing we got some results which is the main output of this project. All the graphical values are received from thingspeak cloud-beaded database.

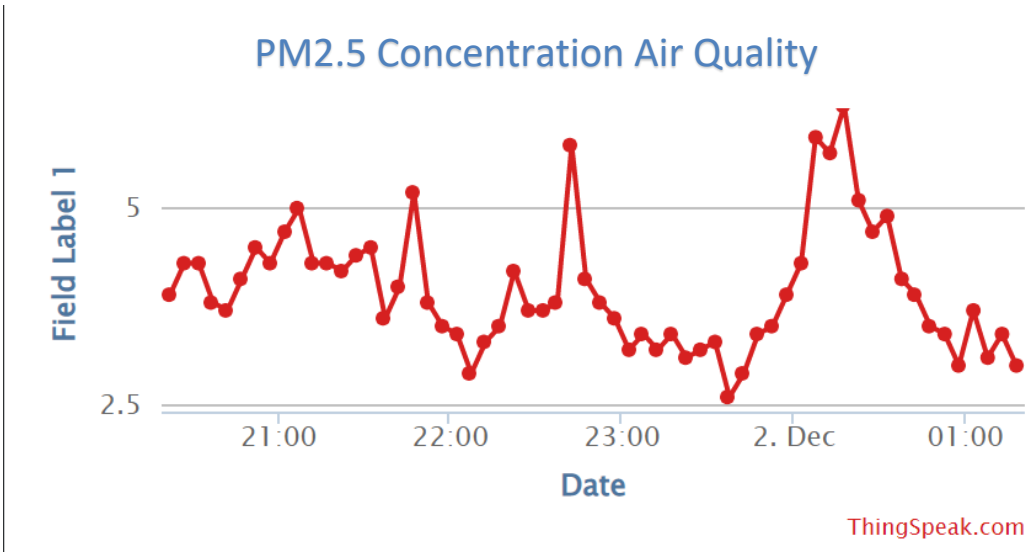


Figure 5.6 PM2.5concentration value from Air quality sensor [8]

Here we got the PM2.5 concentration value from Air quality sensor. PM2.5 means Fine Particular Matter. Fine particulate matter (PM2.5) is an air pollutant that is a concern for people's health when levels in air are high. PM2.5 are tiny particles in the air that reduce visibility and cause the air to appear hazy when levels are elevated.

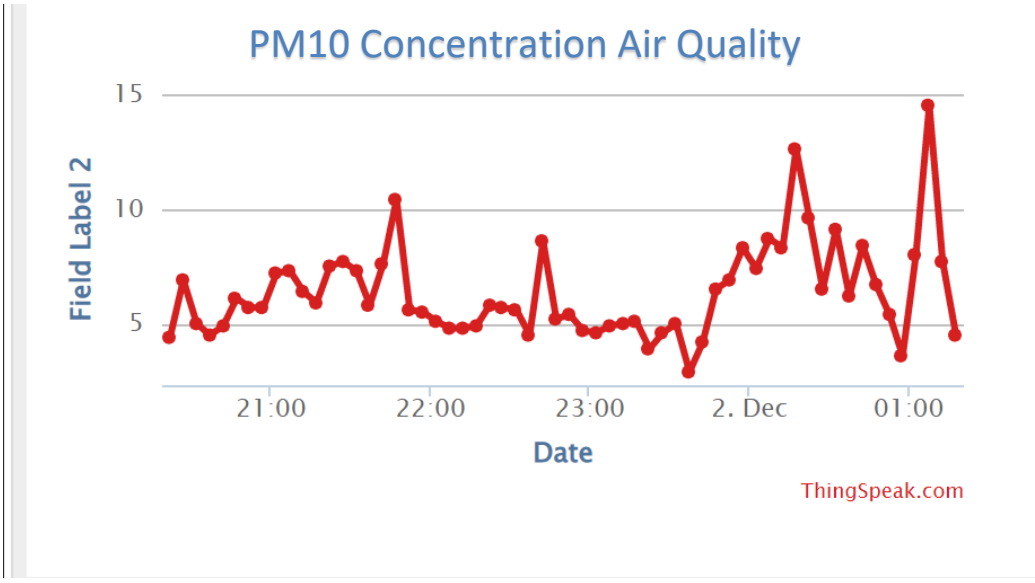


Figure 5.7 PM10 concentration value from Air quality sensor [8]

Here we got the PM10 concentration value from Air quality sensor. PM10 means Particulate Matter. Particulate matter (PM) includes microscopic matter suspended in air or water. Airborne particles are called aerosols. PM10 includes particles less than 10 μm in diameter.

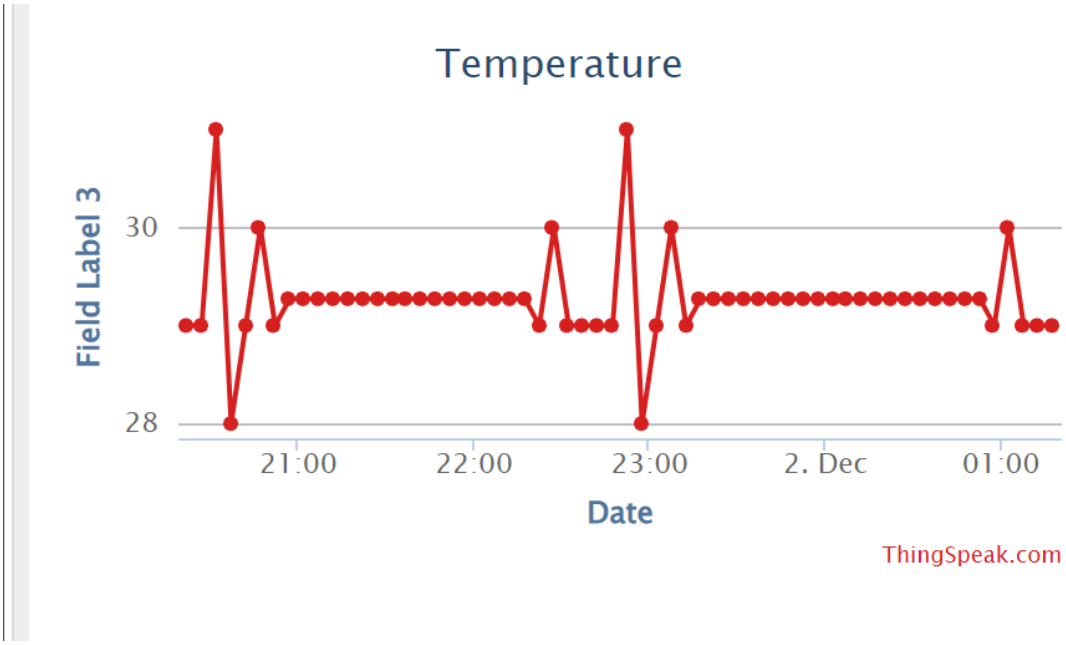


Figure 5.8 temperature of field value from BME280 sensor [8]

Here we got the temperature of field value from BME280 sensor. Temperature is a primary factor affecting the rate of plant development. Warmer temperatures expected with climate change and the potential for more extreme temperature events will impact plant productivity.

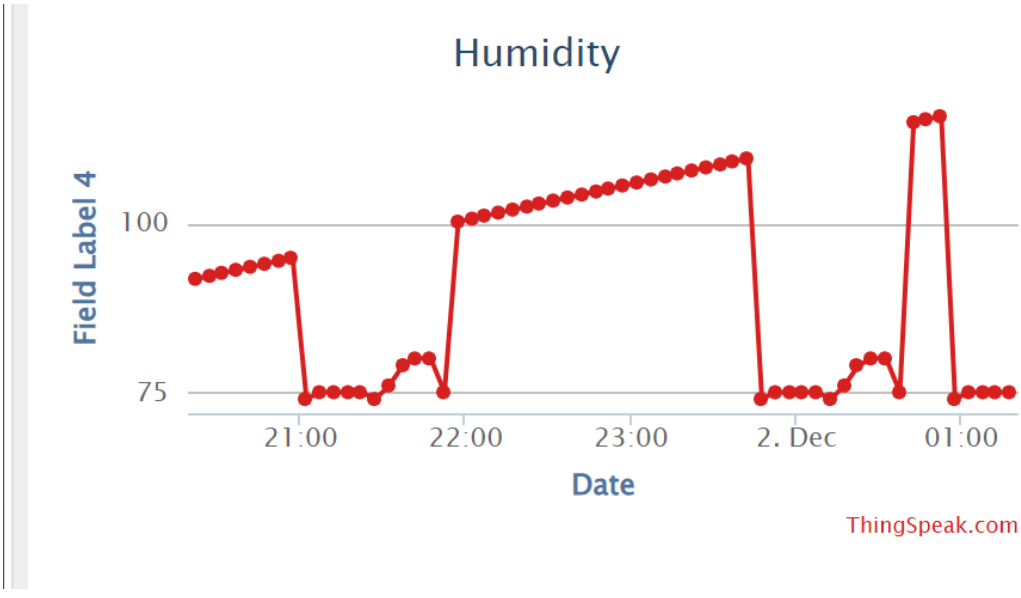


Figure 5.9 humidity value of field from BME280 sensor [8]

Here we got the humidity value of field from BME280 sensor. Relative humidity (RH) directly influences the water relations of plant and indirectly affects leaf growth, photosynthesis, pollination, occurrence of diseases and finally economic yield.

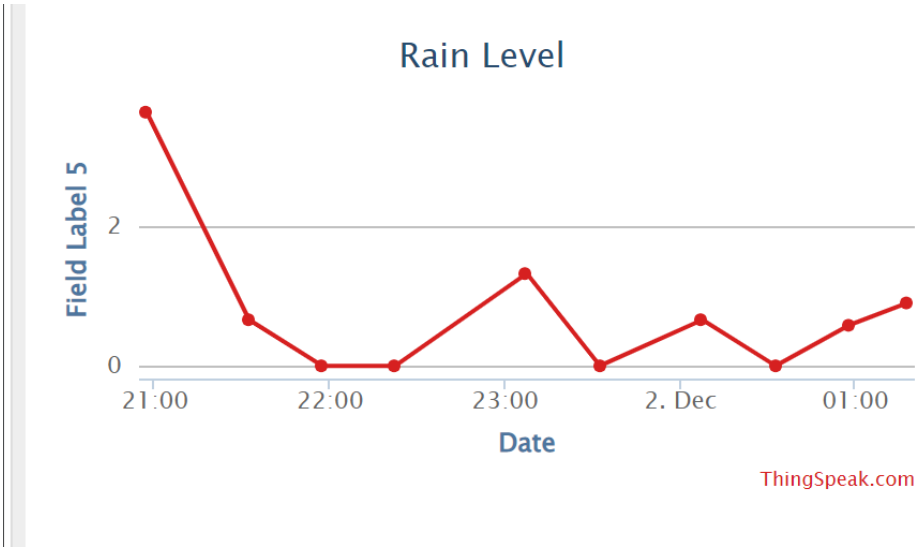


Figure 5.10 rainfall of field value from Rain sensor [8]

Here we got the rainfall of field value from Rain sensor. Rain is usually seen as a benefit to crops and fields, but there is an “ideal” amount of rainfall in any given growing season for most crops. If the average rainfall is much lower or higher than the ideal, it can lead to significant problems, from drowned crops to lower yields.

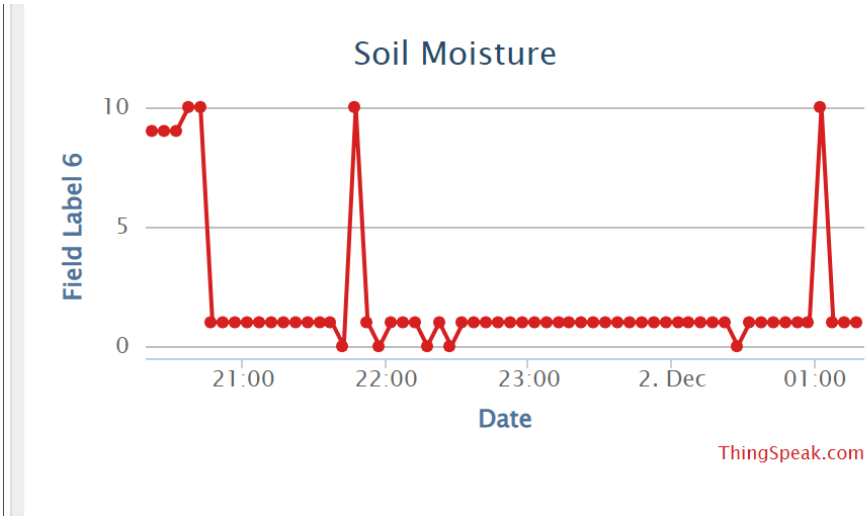


Figure 5.11 soil moisture of field value from Soil Moisture sensor [8]

Here we got the soil moisture of field value from Soil Moisture sensor. Soil moisture conditions can have a significant effect on penetration resistance. For example, in dry soil conditions soil penetration resistance is much higher than wet conditions because soil water acts as a lubricant for soil particles.

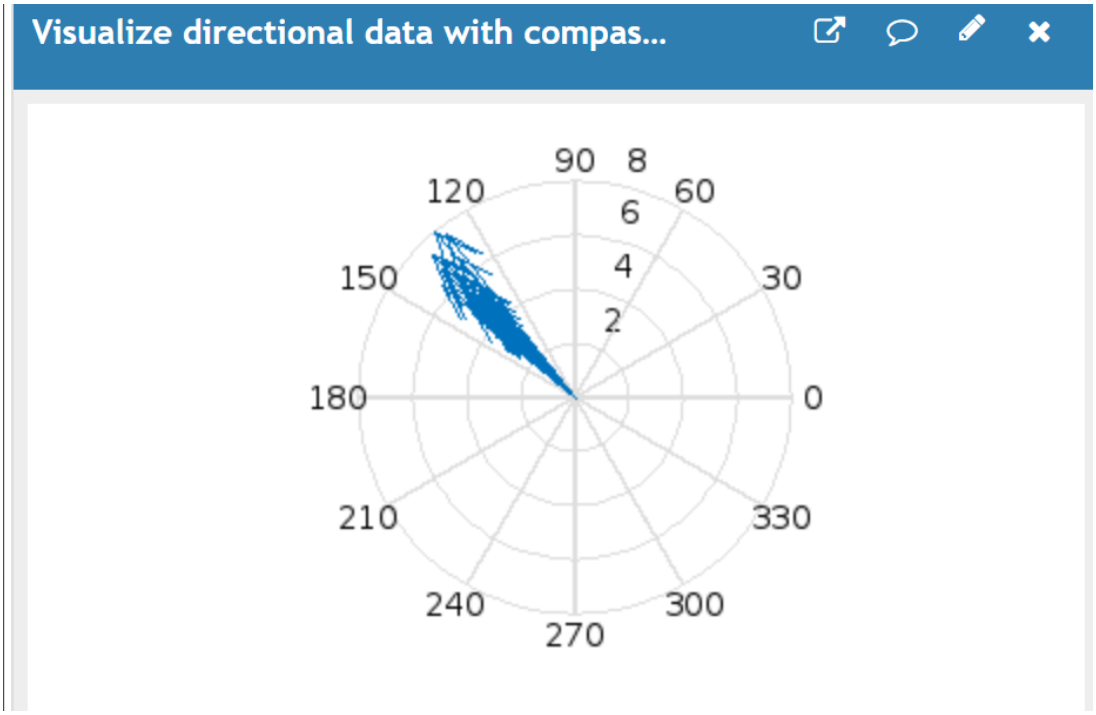


Figure 5.12 visualize directional data with compass [8]

After analyzing all the value, we use MATLAB for finding the visualize directional data with compass for wind [7]. Data visualization is a way to represent information graphically, highlighting patterns and trends in data and helping the reader to achieve quick insights. Data visualization helps to tell stories by curating data into a form easier to understand, highlighting the trends and outliers.

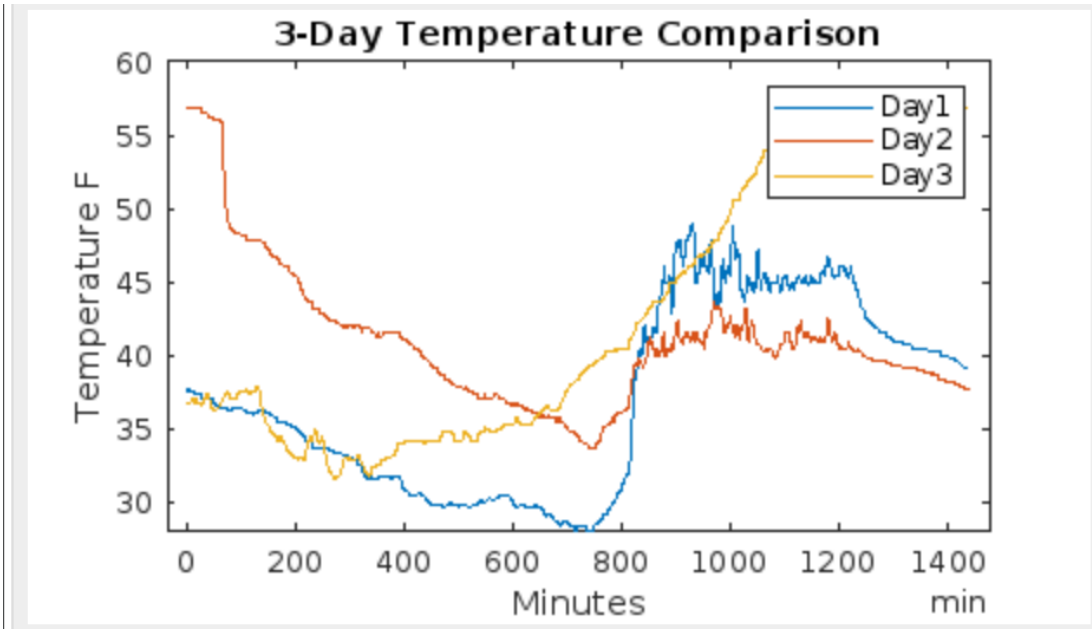


Figure 5.13 last 3-days temperature value of the field [8]

After analyzing the temperature, we use MATLAB to compare last 3-days temperature of the field [7]. Temperature changes also affect seed germination, leaf development, flowering, harvest, and fruit production. However, the effects of temperature on crop development are often implicitly presumed to be associated with air, but not soil temperature.

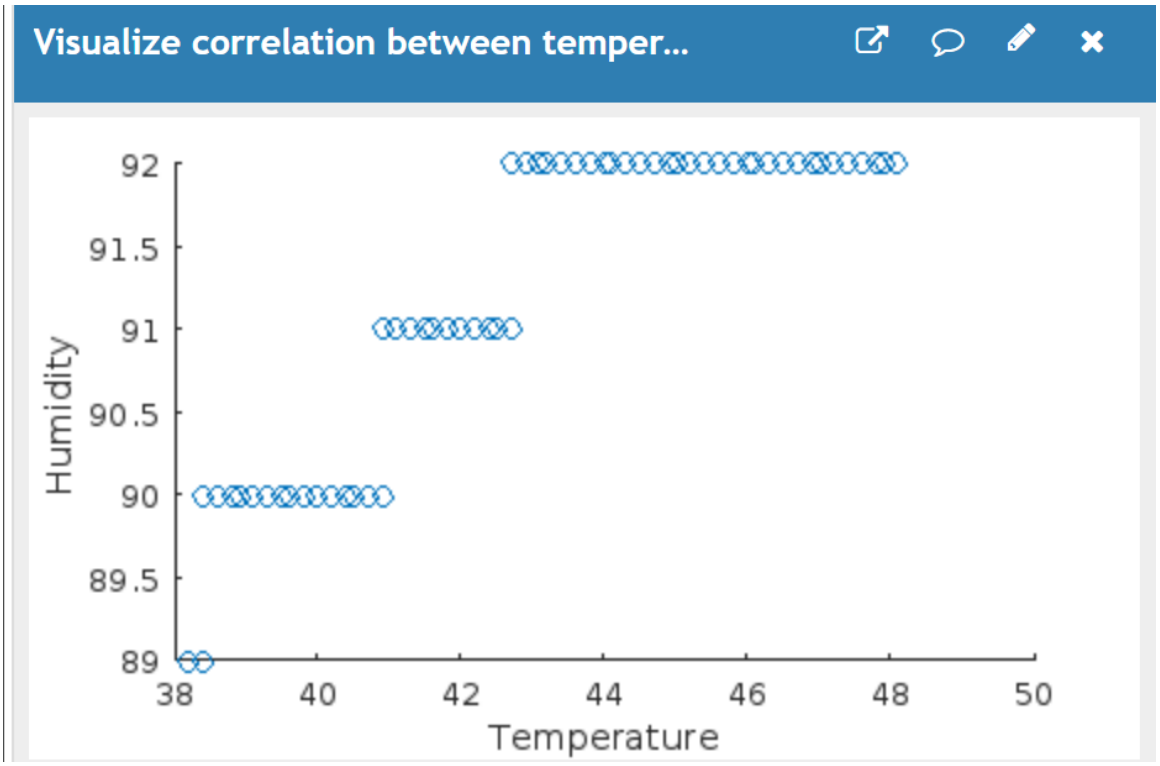


Figure 5.14 correlation between humidity and temperature [8]

We also find the correlation between humidity and temperature by using MATLAB. The relation between humidity and temperature formula simply says they are inversely proportional. If temperature increases, it will lead to a decrease in relative humidity, thus the air will become drier, whereas when temperature decreases, it becomes wet, and the relative humidity increases.

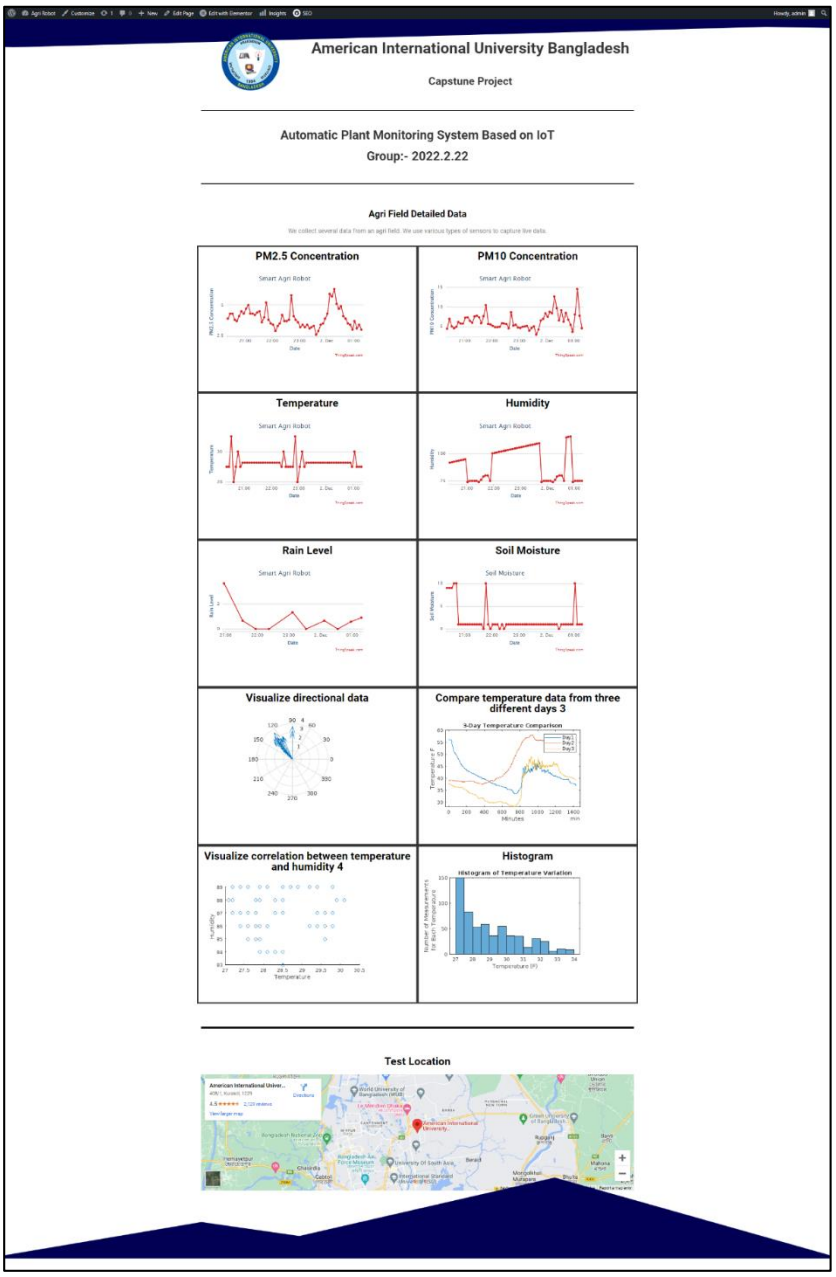


Figure 5.15 Desktop View of Website [6]

As we make the whole thing in IoT it is not possible to access the confidential data from database for security purpose. We solve this problem by using our own domain and hosted website https://hellorobo.xyz [6]. After entering the website publicly, those data are visible and updated every 15sec. The access of this website is public and accessible from anywhere. We use WordPress to develop the website.

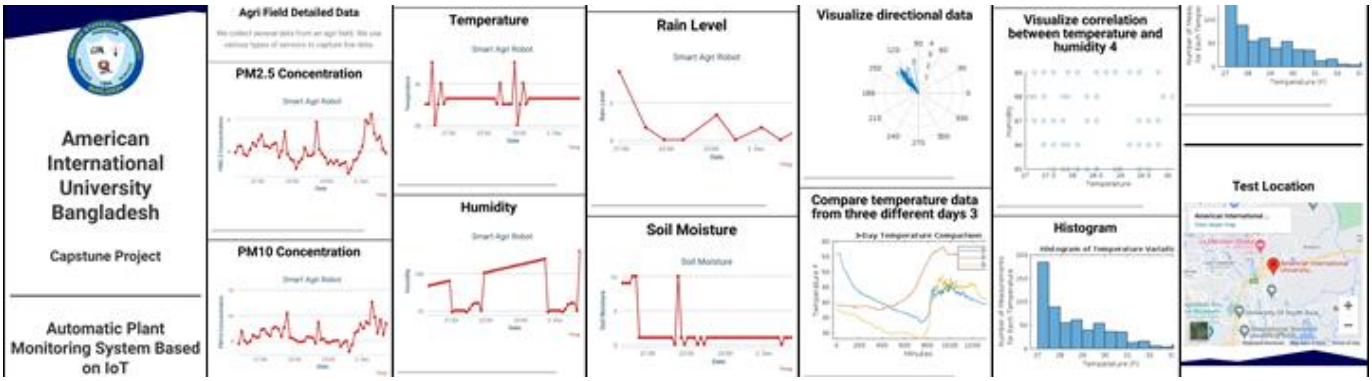
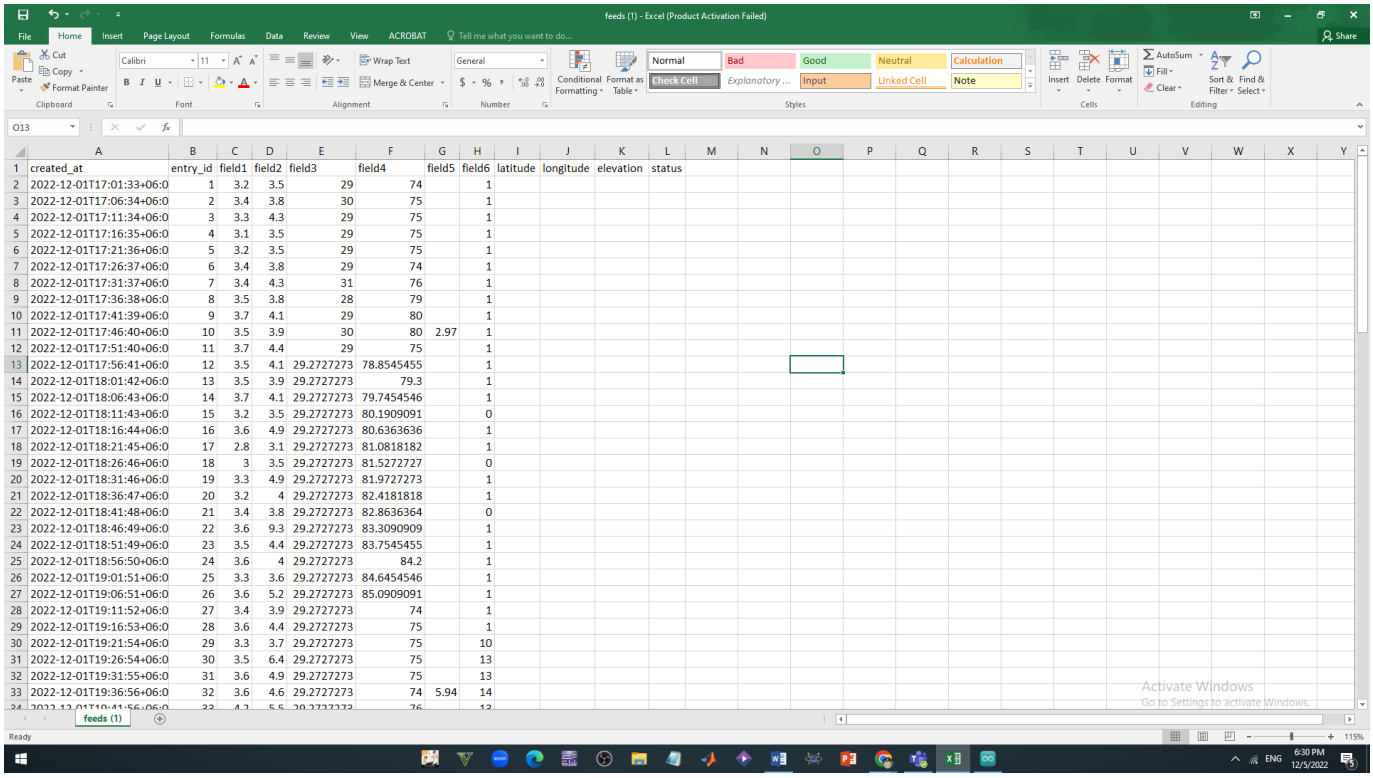


Figure 5.16 Mobile View of Website [6]

As maximum user of the country is from mobile we need to make the website mobile responsive. That is why we also added the mobile view of the website. Which show each data online with live changeable.



	A	B	C	D	E	F	G	H	I	J	K	L
1	created_at	entry_id	field1	field2	field3	field4	field5	field6	latitude	longitude	elevation	status
2	2022-12-01T17:01:33+06:0	1	3.2	3.5	29	74		1				
3	2022-12-01T17:06:34+06:0	2	3.4	3.8	30	75		1				
4	2022-12-01T17:11:34+06:0	3	3.3	4.3	29	75		1				
5	2022-12-01T17:16:35+06:0	4	3.1	3.5	29	75		1				
6	2022-12-01T17:21:36+06:0	5	3.2	3.5	29	75		1				
7	2022-12-01T17:26:37+06:0	6	3.4	3.8	29	74		1				
8	2022-12-01T17:31:37+06:0	7	3.4	4.3	31	76		1				
9	2022-12-01T17:36:38+06:0	8	3.5	3.8	28	79		1				
10	2022-12-01T17:41:39+06:0	9	3.7	4.1	29	80		1				
11	2022-12-01T17:46:40+06:0	10	3.5	3.9	30	80	2.97	1				
12	2022-12-01T17:51:40+06:0	11	3.7	4.4	29	75		1				
13	2022-12-01T17:56:41+06:0	12	3.5	4.1	29.2727273	78.8545455		1				
14	2022-12-01T18:01:42+06:0	13	3.5	3.9	29.2727273	79.3		1				
15	2022-12-01T18:06:43+06:0	14	3.7	4.1	29.2727273	79.7454546		1				
16	2022-12-01T18:11:43+06:0	15	3.2	3.5	29.2727273	80.1909091		0				
17	2022-12-01T18:16:44+06:0	16	3.6	4.9	29.2727273	80.6363636		1				
18	2022-12-01T18:21:45+06:0	17	2.8	3.1	29.2727273	81.0818182		1				
19	2022-12-01T18:26:46+06:0	18	3	3.5	29.2727273	81.5272727		0				
20	2022-12-01T18:31:46+06:0	19	3.3	4.9	29.2727273	81.9727273		1				
21	2022-12-01T18:36:47+06:0	20	3.2	4	29.2727273	82.4181818		1				
22	2022-12-01T18:41:48+06:0	21	3.4	3.8	29.2727273	82.8636364		0				
23	2022-12-01T18:46:49+06:0	22	3.6	9.3	29.2727273	83.3090909		1				
24	2022-12-01T18:51:49+06:0	23	3.5	4.4	29.2727273	83.7545455		1				
25	2022-12-01T18:56:50+06:0	24	3.6	4	29.2727273	84.2		1				
26	2022-12-01T19:01:51+06:0	25	3.3	3.6	29.2727273	84.6454546		1				
27	2022-12-01T19:06:51+06:0	26	3.6	5.2	29.2727273	85.0909091		1				
28	2022-12-01T19:11:52+06:0	27	3.4	3.9	29.2727273	74		1				
29	2022-12-01T19:16:53+06:0	28	3.6	4.4	29.2727273	75		1				
30	2022-12-01T19:21:54+06:0	29	3.3	3.7	29.2727273	75		10				
31	2022-12-01T19:26:54+06:0	30	3.5	6.4	29.2727273	75		13				
32	2022-12-01T19:31:55+06:0	31	3.6	4.9	29.2727273	75		13				
33	2022-12-01T19:36:56+06:0	32	3.6	4.6	29.2727273	74	5.94	14				

Figure 5.17 offline data storage

As our project is fully online database there was a threat the website crashing and lost the data. That is why we also added automatically offline data storage for data security. In Microsoft excel we integrated all the data with thingspeak cloud [8]. The data will be automatically saved in CSV format.

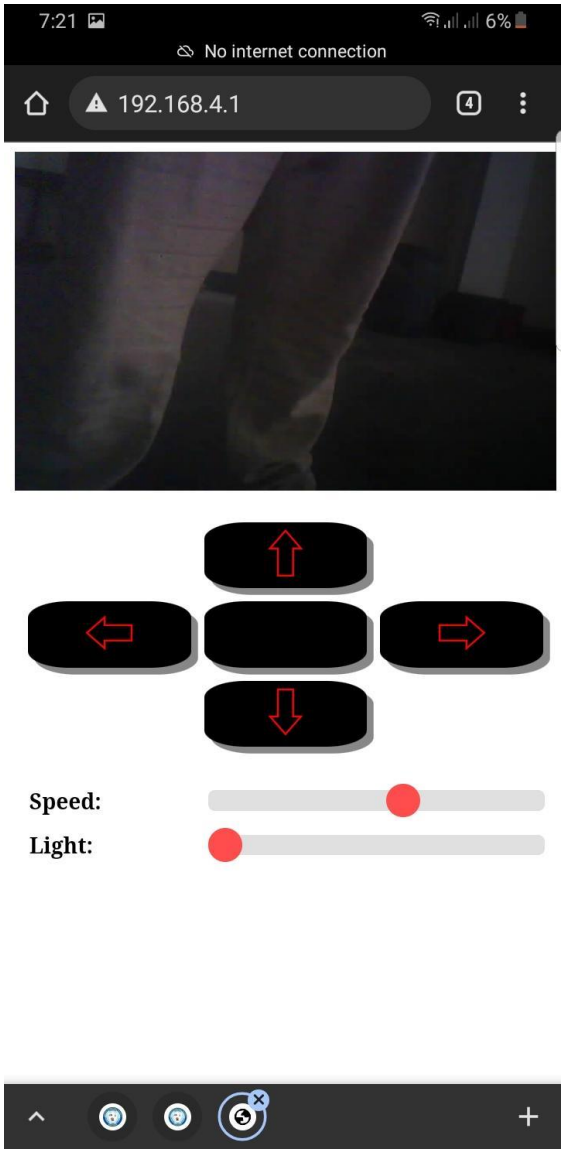


Figure 5.18 View of the controlling webserver

After completing all the analyzing process, we need to control the actuator. For controlling all actuator, we use a webserver to control the robot. 192.168.4.1 is IP address for controlling the robot. Here we also added the camera view for field surveillance by using Raspberry Pi 2 Model B. We also save the

video onRaspberry Pi. We make this private because of robot security purpose. This webserver only access some allowed devices. Here is not only the control part we also control the speed and light for night vision.

5.3. Comparison of Results

We test our sensors individually on simulation software proteus. we install the process in our device. The main reason of simulating individual equipment's is finding the main accuracy. In simulation, after that we measure the ph value of soil and optimizing the code. We also use LCD display to find the output value. As the accuracy of ph sensor is very low we use another algorithm and made a maximum accuracy output.
The testing result of our designed system is very hopeful. For the implementation of any kind of project, it is necessary to implement the circuit in any kind of simulation software. From simulation can get a proper idea about the final output of the system. For our project, we are successfully implementing all the components in proteus software. And the result is increasing after time to time and change values.
After completing the hardware design, it worked perfectly. All the sensors can read properly. sensors give feedback data to a smart device very perfectly. We get soil moisture sensor data from our smartphone and monitoring it from the smartphone. But in hardware condition it's matter of time in different day the weather condition was different that's why the value was up down in real life but in simulation it's not changed like when we implement it and apply in field.

5.4. Summary

And first we simulate our all the equipment's individually. This structure is made in an amazingly straightforward way and at an exceptionally low cost. Then the equipment position was designed, with sensors added. Output is shown some simulation software proteus and fritzing. Software we have used Arduino Uno. But we have used Raspberry Pi 2 Model B, ESP32 and ESP8266. This result section shows the data analyzing of agriculture field. We have shown the real time data in the hardware section. The same results also shown in the https://hellorobo.xyz [6]. 12V battery is used for power supply. It will have all the motor and sensor power. pH and Moisture data automatically work on device. This entire process has been monitored through mobile and desktop or any other internet-based device. Overall, all the simulation, data, and images were explained satisfactorily.

Chapter 6

CONCLUSION

6.1.Summary of Findings

The rover was made to reduce the human labor to maintain the cultivation area and taking care of the crops. The main concept of the rover has been declared and worked in. The prototyped version has been working perfectly and in an alignment to the simulation created for the rover. The rover can be seen working as intended and it is ready to take over the field upon instruction from its user. It is evident that the rover has been perfectly using the components to produce results that were intended.

6.2.Novelty of the work

The current researches related to the farming rovers are specifically designed to do jobs, but this rover provides us with a multifunctional option to do many things with the same rover using different technology at the same time. The rover is designed in a way that will give us anything we need as a farmer cultivating a firm al by ourselves. The data collection can be done by any rover, but the unique aspect of the rover is, it does not rest collecting the data it takes care of the crops and field at the same time. The weeding problems can be handled by the rover with the additional feature of watering the crops.

6.3.Cultural and Societal Factors and Impacts

The agricultural culture in the sub-continent is highly depended upon manual labor. This manual labor is much costly to the general farmers. However, taking care of the crops are necessary and it cannot be ignored. The main idea behind the rovers was to provide farmers with enough resources and help them in a much less cost, changing the whole culture of the current view on the field of agriculture. The rover can be used from the seeding process to taking care of the crops including the field. This can be considering as a success to the project. The idea of reducing the cost and manual labor of farmers will be achieved through this project soon.

The farmers belonging to the poor class of the society are going to profit the most. As they need cheaper labor more than anybody else and this rover can be a second option for them. The technology used in the rover is quite simple to use. Anyone can use the rover without needing to be a tech person. The rover is an automated technology which makes it easier for famers to maintain the quality of the farming field as there is no escape from getting take care of for the field and the crops in the present of the rover.

6.4.Limitations of the Work

The rover will be taking care of the weeding problem and it will water the plants when it is necessary. It will collect humidity, temperature, air quality, and air pressure data from the air using dedicated sensors. However, the data must be trained and used to improve the rover to get more efficient results. The movement of the rover can be improved as it does not move in a perfectly linear line. And the detection of unhealthy crops must be done to achieve a multifunctional rove that can do anything a farmer can do.

.

6.5.Future Scopes

The rover need to be deigned in a way that allows it to move in a more linear motion. Using and training the data in a machine learning algorithm would make the proper use of the collected data. This can be achieved using various machine learning algorithm such as multiple regression, Decision tree classifier, Naïve bias and SVM etc. The image detection algorithms must be used to detect the defects in the crops and teach the rover to use pesticides according to the founded results.

6.6.Social, Economic, Cultural and Environmental Aspects

6.6.1. Sustainability

The project meets the SDG (Sustainable Development Goals).

- No poverty
- Zero hunger
- Good health and well being
- quality education

- Gender equality
- Clean water and sanitation
- Affordable and clean energy
- Decent work and economic growth, industry
- Innovation and Infrastructure
- Reduced inequality
- Sustainable cities and communities
- Responsible consumption and production
- Climate action
- Life bellow water
- Life on land
- Peace and justice
- Strong institutions
- Partnerships to achieve the goal

Most of the goals which are related to either the ability of technology for everyone or the equality of opportunity or even the socio-economical factor mentioned here can be achieved by this project. The availability of the rover to the public and the farmers across the planet will help achieve the sustainable development goal in a much easier way.

6.6.2. Economic and Cultural Factors

The rover industry is a fast growing industry. It has achieved good amount of success in this brief period. However, the technology yet to go to many sectors where there is a potential use of this rover. Agriculture sector is barely effected by the rover technology. The technology has so much things to provide to the farmers that all we have now can be described as the beginning.

The Local and International Standards and Professional Code of Ethics were followed by the engineers while working in the project and it is looked after that no violation can be occurred in the future.

6.7. Conclusion

The rover industry is a fast growing industry. It has achieved good amount of success in this brief period. However, the technology yet to go to many sectors where there is a potential use of this rover. Agriculture

sector is barely effected by the rover technology. The technology has so much things to provide to the farmers that all we have now can be described as the beginning.

The Local and International Standards and Professional Code of Ethics were followed by the engineers while working in the project and it is looked after that no violation can be occurred in the future.

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Appendix A

Arduino Program for Rover Moving:

```
#include "esp_camera.h"
#include <Arduino.h>
#include <WiFi.h>
#include <AsyncTCP.h>
#include <ESPAsyncWebServer.h>
#include <iostream>
#include <sstream>

struct MOTOR_PINS
{
  int pinEn;
  int pinIN1;
  int pinIN2;
};

std::vector<MOTOR_PINS> motorPins =
{
  {12, 13, 15},  //RIGHT_MOTOR Pins (EnA, IN1, IN2)
  {12, 14, 2},  //LEFT_MOTOR  Pins (EnB, IN3, IN4)
};
#define LIGHT_PIN 4

#define UP 1
```

```
#define DOWN 2
#define LEFT 3
#define RIGHT 4
#define STOP 0

#define RIGHT_MOTOR 0
#define LEFT_MOTOR 1

#define FORWARD 1
#define BACKWARD -1

const int PWMFreq = 1000; /* 1 KHz */
const int PWMResolution = 8;
const int PWMSpeedChannel = 2;
const int PWMLightChannel = 3;

//Camera related constants
#define PWDN_GPIO_NUM     32
#define RESET_GPIO_NUM    -1
#define XCLK_GPIO_NUM      0
#define SIOD_GPIO_NUM     26
#define SIOC_GPIO_NUM     27
#define Y9_GPIO_NUM       35
#define Y8_GPIO_NUM       34
#define Y7_GPIO_NUM       39
#define Y6_GPIO_NUM       36
```

```
#define Y5_GPIO_NUM       21
#define Y4_GPIO_NUM       19
#define Y3_GPIO_NUM       18
#define Y2_GPIO_NUM        5
#define VSYNC_GPIO_NUM    25
#define HREF_GPIO_NUM     23
#define PCLK_GPIO_NUM     22

const char* ssid     = "hiiiiiii";
const char* password = "12345678";

AsyncWebServer server(80);
AsyncWebSocket wsCamera("/Camera");
AsyncWebSocket wsCarInput("/CarInput");
uint32_t cameraClientId = 0;

const char* htmlHomePage PROGMEM = R"HTMLHOMEPAGE(
<!DOCTYPE html>
<html>
<head>
<meta name="viewport" content="width=device-width, initial-scale=1, maximum-scale=1, user-scalable=no">
<style>
    .arrows {
      font-size:40px;
      color:red;
```

```
}
td.button {
  background-color:black;
  border-radius:25%;
  box-shadow: 5px 5px #888888;
}
td.button:active {
  transform: translate(5px,5px);
  box-shadow: none;
}

.noselect {
  -webkit-touch-callout: none; /* iOS Safari */
    -webkit-user-select: none; /* Safari */
     -khtml-user-select: none; /* Konqueror HTML */
       -moz-user-select: none; /* Firefox */
        -ms-user-select: none; /* Internet Explorer/Edge */
            user-select: none; /* Non-prefixed version, currently
                                  supported by Chrome and Opera */
}

.slidecontainer {
  width: 100%;
}

.slider {
```

```
  -webkit-appearance: none;
  width: 100%;
  height: 15px;
  border-radius: 5px;
  background: #d3d3d3;
  outline: none;
  opacity: 0.7;
  -webkit-transition: .2s;
  transition: opacity .2s;
}

.slider:hover {
  opacity: 1;
}

.slider::-webkit-slider-thumb {
  -webkit-appearance: none;
  appearance: none;
  width: 25px;
  height: 25px;
  border-radius: 50%;
  background: red;
  cursor: pointer;
}

.slider::-moz-range-thumb {
```

```
    width: 25px;
    height: 25px;
    border-radius: 50%;
    background: red;
    cursor: pointer;
  }

</style>

</head>
<body class="noselect" align="center" style="background-color:white">

<!--h2 style="color: teal;text-align:center;">Wi-Fi Camera &#128663; Control</h2-->

<table id="mainTable" style="width:400px;margin:auto;table-layout:fixed" CELLSPACING=10>
<tr>
<img id="cameraImage" src="" style="width:400px;height:250px"></td>
</tr>
<tr>
<td></td>
<td class="button" ontouchstart='sendButtonInput("MoveCar","1")'
ontouchend='sendButtonInput("MoveCar","0")'><span class="arrows" >&#8679;</span></td>
<td></td>
</tr>
<tr>
<td class="button" ontouchstart='sendButtonInput("MoveCar","3")'
ontouchend='sendButtonInput("MoveCar","0")'><span class="arrows" >&#8678;</span></td>
```

```
<td class="button"></td>

<td class="button" ontouchstart='sendButtonInput("MoveCar","4")'
ontouchend='sendButtonInput("MoveCar","0")'><span class="arrows" >&#8680;</span></td>

</tr>

<tr>

<td></td>

<td class="button" ontouchstart='sendButtonInput("MoveCar","2")'
ontouchend='sendButtonInput("MoveCar","0")'><span class="arrows" >&#8681;</span></td>

<td></td>

</tr>

<tr/><tr/>

<tr>

<td style="text-align:left"><b>Speed:</b></td>

<td colspan=2>

<div class="slidecontainer">

<input type="range" min="0" max="255" value="150" class="slider" id="Speed"
oninput='sendButtonInput("Speed",value)'>

</div>

</td>

</tr>

<tr>

<td style="text-align:left"><b>Light:</b></td>

<td colspan=2>

<div class="slidecontainer">

<input type="range" min="0" max="255" value="0" class="slider" id="Light"
oninput='sendButtonInput("Light",value)'>

</div>
```

```
</td>
</tr>
</table>

<script>
    var webSocketCameraUrl = "ws:\/\/" + window.location.hostname + "/Camera";
    var webSocketCarInputUrl = "ws:\/\/" + window.location.hostname + "/CarInput";
    var websocketCamera;
    var websocketCarInput;

    function initCameraWebSocket()
    {
      websocketCamera = new WebSocket(webSocketCameraUrl);
      websocketCamera.binaryType = 'blob';
      websocketCamera.onopen    = function(event){};
      websocketCamera.onclose   = function(event){setTimeout(initCameraWebSocket, 2000);};
      websocketCamera.onmessage = function(event)
      {
        var imageId = document.getElementById("cameraImage");
        imageId.src = URL.createObjectURL(event.data);
      };
    }

    function initCarInputWebSocket()
    {
      websocketCarInput = new WebSocket(webSocketCarInputUrl);
```

```
  websocketCarInput.onopen    = function(event)
  {
    var speedButton = document.getElementById("Speed");
    sendButtonInput("Speed", speedButton.value);
    var lightButton = document.getElementById("Light");
    sendButtonInput("Light", lightButton.value);
  };
  websocketCarInput.onclose   = function(event){setTimeout(initCarInputWebSocket, 2000);};
  websocketCarInput.onmessage = function(event){};
}

function initWebSocket()
{
  initCameraWebSocket ();
  initCarInputWebSocket();
}

function sendButtonInput(key, value)
{
  var data = key + "," + value;
  websocketCarInput.send(data);
}

window.onload = initWebSocket;
document.getElementById("mainTable").addEventListener("touchend", function(event){
  event.preventDefault()
```

```
    });
</script>
</body>
</html>
)HTMLHOMEPAGE";



void rotateMotor(int motorNumber, int motorDirection)
{
  if (motorDirection == FORWARD)
  {
    digitalWrite(motorPins[motorNumber].pinIN1, HIGH);
    digitalWrite(motorPins[motorNumber].pinIN2, LOW);
  }
  else if (motorDirection == BACKWARD)
  {
    digitalWrite(motorPins[motorNumber].pinIN1, LOW);
    digitalWrite(motorPins[motorNumber].pinIN2, HIGH);
  }
  else
  {
    digitalWrite(motorPins[motorNumber].pinIN1, LOW);
    digitalWrite(motorPins[motorNumber].pinIN2, LOW);
  }
}
```

```
void moveCar(int inputValue)
{
  Serial.printf("Got value as %d\n", inputValue);
  switch(inputValue)
  {

    case UP:
      rotateMotor(RIGHT_MOTOR, FORWARD);
      rotateMotor(LEFT_MOTOR, FORWARD);
      break;

    case DOWN:
      rotateMotor(RIGHT_MOTOR, BACKWARD);
      rotateMotor(LEFT_MOTOR, BACKWARD);
      break;

    case LEFT:
      rotateMotor(RIGHT_MOTOR, FORWARD);
      rotateMotor(LEFT_MOTOR, BACKWARD);
      break;

    case RIGHT:
      rotateMotor(RIGHT_MOTOR, BACKWARD);
      rotateMotor(LEFT_MOTOR, FORWARD);
      break;
```

```
    case STOP:
      rotateMotor(RIGHT_MOTOR, STOP);
      rotateMotor(LEFT_MOTOR, STOP);
      break;

    default:
      rotateMotor(RIGHT_MOTOR, STOP);
      rotateMotor(LEFT_MOTOR, STOP);
      break;
  }
}

void handleRoot(AsyncWebServerRequest *request)
{
  request->send_P(200, "text/html", htmlHomePage);
}

void handleNotFound(AsyncWebServerRequest *request)
{
    request->send(404, "text/plain", "File Not Found");
}

void onCarInputWebSocketEvent(AsyncWebSocket *server,
                              AsyncWebSocketClient *client,
                              AwsEventType type,
                              void *arg,
```

```
                uint8_t *data,
                size_t len)
{
  switch (type)
  {
    case WS_EVT_CONNECT:
      Serial.printf("WebSocket client #%u connected from %s\n", client->id(), client->remoteIP().toString().c_str());
      break;
    case WS_EVT_DISCONNECT:
      Serial.printf("WebSocket client #%u disconnected\n", client->id());
      moveCar(0);
      ledcWrite(PWMLightChannel, 0);
      break;
    case WS_EVT_DATA:
      AwsFrameInfo *info;
      info = (AwsFrameInfo*)arg;
      if (info->final && info->index == 0 && info->len == len && info->opcode == WS_TEXT)
      {
        std::string myData = "";
        myData.assign((char *)data, len);
        std::istringstream ss(myData);
        std::string key, value;
        std::getline(ss, key, ',');
        std::getline(ss, value, ',');
        Serial.printf("Key [%s] Value[%s]\n", key.c_str(), value.c_str());
```

```
      int valueInt = atoi(value.c_str());
      if (key == "MoveCar")
      {
        moveCar(valueInt);
      }
      else if (key == "Speed")
      {
        ledcWrite(PWMSpeedChannel, valueInt);
      }
      else if (key == "Light")
      {
        ledcWrite(PWMLightChannel, valueInt);
      }
    }
    break;
  case WS_EVT_PONG:
  case WS_EVT_ERROR:
    break;
  default:
    break;
 }
}

void onCameraWebSocketEvent(AsyncWebSocket *server,
                            AsyncWebSocketClient *client,
                            AwsEventType type,
```

```
                void *arg,
                uint8_t *data,
                size_t len)
{
  switch (type)
  {
    case WS_EVT_CONNECT:
      Serial.printf("WebSocket client #%u connected from %s\n", client->id(), client->remoteIP().toString().c_str());
      cameraClientId = client->id();
      break;
    case WS_EVT_DISCONNECT:
      Serial.printf("WebSocket client #%u disconnected\n", client->id());
      cameraClientId = 0;
      break;
    case WS_EVT_DATA:
      break;
    case WS_EVT_PONG:
    case WS_EVT_ERROR:
      break;
    default:
      break;
  }
}

void setupCamera()
```

```
{
  camera_config_t config;
  config.ledc_channel = LEDC_CHANNEL_0;
  config.ledc_timer = LEDC_TIMER_0;
  config.pin_d0 = Y2_GPIO_NUM;
  config.pin_d1 = Y3_GPIO_NUM;
  config.pin_d2 = Y4_GPIO_NUM;
  config.pin_d3 = Y5_GPIO_NUM;
  config.pin_d4 = Y6_GPIO_NUM;
  config.pin_d5 = Y7_GPIO_NUM;
  config.pin_d6 = Y8_GPIO_NUM;
  config.pin_d7 = Y9_GPIO_NUM;
  config.pin_xclk = XCLK_GPIO_NUM;
  config.pin_pclk = PCLK_GPIO_NUM;
  config.pin_vsync = VSYNC_GPIO_NUM;
  config.pin_href = HREF_GPIO_NUM;
  config.pin_sscb_sda = SIOD_GPIO_NUM;
  config.pin_sscb_scl = SIOC_GPIO_NUM;
  config.pin_pwdn = PWDN_GPIO_NUM;
  config.pin_reset = RESET_GPIO_NUM;
  config.xclk_freq_hz = 20000000;
  config.pixel_format = PIXFORMAT_JPEG;

  config.frame_size = FRAMESIZE_VGA;
  config.jpeg_quality = 10;
  config.fb_count = 1;
```

```
  // camera init
  esp_err_t err = esp_camera_init(&config);
  if (err != ESP_OK)
  {
    Serial.printf("Camera init failed with error 0x%x", err);
    return;
  }

  if (psramFound())
  {
    heap_caps_malloc_extmem_enable(20000);
    Serial.printf("PSRAM initialized. malloc to take memory from psram above this size");
  }
}

void sendCameraPicture()
{
  if (cameraClientId == 0)
  {
    return;
  }
  unsigned long  startTime1 = millis();
  //capture a frame
  camera_fb_t * fb = esp_camera_fb_get();
  if (!fb)
```

```
  {
     Serial.println("Frame buffer could not be acquired");
     return;
  }

  unsigned long  startTime2 = millis();
  wsCamera.binary(cameraClientId, fb->buf, fb->len);
  esp_camera_fb_return(fb);

  //Wait for message to be delivered
  while (true)
  {
    AsyncWebSocketClient * clientPointer = wsCamera.client(cameraClientId);
    if (!clientPointer || !(clientPointer->queueIsFull()))
    {
      break;
    }
    delay(1);
  }

  unsigned long  startTime3 = millis();
  Serial.printf("Time taken Total: %d|%d|%d\n",startTime3 - startTime1, startTime2 - startTime1, startTime3-startTime2 );
}

void setUpPinModes()
```

```
{
  //Set up PWM
  ledcSetup(PWMSpeedChannel, PWMFreq, PWMResolution);
  ledcSetup(PWMLightChannel, PWMFreq, PWMResolution);

  for (int i = 0; i < motorPins.size(); i++)
  {
    pinMode(motorPins[i].pinEn, OUTPUT);
    pinMode(motorPins[i].pinIN1, OUTPUT);
    pinMode(motorPins[i].pinIN2, OUTPUT);

    /* Attach the PWM Channel to the motor enb Pin */
    ledcAttachPin(motorPins[i].pinEn, PWMSpeedChannel);
  }
  moveCar(STOP);

  pinMode(LIGHT_PIN, OUTPUT);
  ledcAttachPin(LIGHT_PIN, PWMLightChannel);
}


void setup(void)
{
  setUpPinModes();
 // Serial.begin(115200);
```

```
  WiFi.softAP(ssid, password);
  IPAddress IP = WiFi.softAPIP();
  Serial.print("AP IP address: ");
  Serial.println(IP);

  server.on("/", HTTP_GET, handleRoot);
  server.onNotFound(handleNotFound);

  wsCamera.onEvent(onCameraWebSocketEvent);
  server.addHandler(&wsCamera);

  wsCarInput.onEvent(onCarInputWebSocketEvent);
  server.addHandler(&wsCarInput);

  server.begin();
  Serial.println("HTTP server started");

  setupCamera();
}


void loop()
{
  wsCamera.cleanupClients();
  wsCarInput.cleanupClients();
  sendCameraPicture();
```

```
  Serial.printf("SPIRam Total heap %d, SPIRam Free Heap %d\n", ESP.getPsramSize(),
ESP.getFreePsram());

}
```

Arduino Code for Data Analysis:

```
#include <ESP8266WiFi.h>

#include <Wire.h>

#include <Adafruit_Sensor.h>

#include <Adafruit_BME280.h>

#include "MQ135.h"

#include <Arduino.h>

#define LENG 31   //0x42 + 31 bytes equal to 32 bytes

unsigned char buf[LENG];


int PM01Value=0;          //define PM1.0 value of the air detector module

int PM2_5Value=0;         //define PM2.5 value of the air detector module

int PM10Value=0;         //define PM10 value of the air detector module

//int moisture_percentage;

const int sensor_pin = A0;


const int potPin=A0;

float ph;

float Value=0;


float h, t, p, pin, dp;

char temperatureFString[6];
```

```
char dpString[6];
char humidityString[6];
char pressureString[7];
char pressureInchString[6];

Adafruit_BME280 bme; // I2C
String apiKey = "ODTD945PY1W2IMDT";
// replace with your routers SSID
const char* ssid = "Zero";
// replace with your routers password
const char* password = "zero5584";

const char* server = "api.thingspeak.com";
WiFiClient client;

void setup()
{
  Serial.begin(9600);
  delay(10);
  Serial.println();
  Serial.print("Connecting to ");
  Serial.println(ssid);
  WiFi.begin(ssid, password);

  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
```

```
    Serial.print(".");
  }
  Serial.println("");
  Serial.println("WiFi connected");

    // Printing the ESP IP address
  Serial.println(WiFi.localIP());

  if (!bme.begin())
  {
    Serial.println("Could not find a valid BME280 sensor, check wiring!");
    while (1);
}
}

void loop()
{


  if(Serial.find(0x42)){    //start to read when detect 0x42
    Serial.readBytes(buf,LENG);

    if(buf[0] == 0x4d){
      if(checkValue(buf,LENG)){
        PM01Value=transmitPM01(buf); //count PM1.0 value of the air detector module
        PM2_5Value=transmitPM2_5(buf);//count PM2.5 value of the air detector module
```

```
      PM10Value=transmitPM10(buf); //count PM10 value of the air detector module
    }
   }
Value= analogRead(potPin);
Serial.print(Value);
Serial.print(" | ");
float voltage=Value*(3.3/4095.0);
ph=(3.3*voltage);
Serial.println(ph);
delay(500);

 }

 static unsigned long OledTimer=millis();
  if (millis() - OledTimer >=1000)
  {
    OledTimer=millis();

    Serial.print("PM1.0: ");
    Serial.print(PM01Value);
    Serial.println("  ug/m3");

    Serial.print("PM2.5: ");
    Serial.print(PM2_5Value);
    Serial.println("  ug/m3");
```

```
Serial.print("PM10 : ");
Serial.print(PM10Value);
Serial.println("  ug/m3");
Serial.println();

MQ135 gasSensor = MQ135(A0);
float air_quality = gasSensor.getPPM();
Serial.print("Air Quality: ");
Serial.print(air_quality);
Serial.println("  PPM");
Serial.println();

h = bme.readHumidity();
t = bme.readTemperature();
t = t*1.8+32.0;
dp = t-0.36*(100.0-h);

p = bme.readPressure()/100.0F;
pin = 0.02953*p;
dtostrf(t, 5, 1, temperatureFString);
dtostrf(h, 5, 1, humidityString);
dtostrf(p, 6, 1, pressureString);
dtostrf(pin, 5, 2, pressureInchString);
dtostrf(dp, 5, 1, dpString);

Serial.print("Temperature = ");
```

```
    Serial.println(temperatureFString);
    Serial.print("Humidity = ");
    Serial.println(humidityString);
    Serial.print("Pressure = ");
    Serial.println(pressureString);
    Serial.print("Pressure Inch = ");
    Serial.println(pressureInchString);
    Serial.print("Dew Point = ");
    Serial.println(dpString);

    Serial.println(".....");
int moisture_percentage;
 moisture_percentage = ( 100.00 - ( (analogRead(sensor_pin)/1023.00) * 100.00 ) );
    if (client.connect(server,80))  // "184.106.153.149" or api.thingspeak.com
  {
      String postStr = apiKey;
      postStr +="&field1=";
      postStr += String(PM01Value);
      postStr +="&field2=";
      postStr += String(PM2_5Value);
      postStr +="&field3=";
      postStr += String(PM10Value);
      postStr +="&field4=";
      postStr += String(air_quality);
      postStr +="&field5=";
      postStr += String(temperatureFString);
```

```
    postStr +="&field6=";
    postStr += String(humidityString);
    postStr +="&field7=";
    postStr += String(pressureInchString);
    postStr += "&field8=";
    postStr += String(moisture_percentage);
    postStr += "&field9=";
    postStr += String(ph);
    postStr += "\r\n\r\n";

    client.print("POST /update HTTP/1.1\n");
    client.print("Host: api.thingspeak.com\n");
    client.print("Connection: close\n");
    client.print("X-THINGSPEAKAPIKEY: "+apiKey+"\n");
    client.print("Content-Type: application/x-www-form-urlencoded\n");
    client.print("Content-Length: ");
    client.print(postStr.length());
    client.print("\n\n");
    client.print(postStr);
  }
 client.stop();


  }

}
```

```
char checkValue(unsigned char *thebuf, char leng)
{
  char receiveflag=0;
  int receiveSum=0;

  for(int i=0; i<(leng-2); i++){
  receiveSum=receiveSum+thebuf[i];
  }
  receiveSum=receiveSum + 0x42;

  if(receiveSum == ((thebuf[leng-2]<<8)+thebuf[leng-1]))  //check the serial data
  {
    receiveSum = 0;
    receiveflag = 1;
  }
  return receiveflag;
}
int transmitPM01(unsigned char *thebuf)
{
  int PM01Val;
  PM01Val=((thebuf[3]<<8) + thebuf[4]); //count PM1.0 value of the air detector module
  return PM01Val;
}
//transmit PM Value to PC
int transmitPM2_5(unsigned char *thebuf)
{
```

```
  int PM2_5Val;
  PM2_5Val=((thebuf[5]<<8) + thebuf[6]);//count PM2.5 value of the air detector module
  return PM2_5Val;
  }
//transmit PM Value to PC
int transmitPM10(unsigned char *thebuf)
{
  int PM10Val;
  PM10Val=((thebuf[7]<<8) + thebuf[8]); //count PM10 value of the air detector module
  return PM10Val;
}
```

MATLAB Code 01:

```
readChannelID = 12397;
TemperatureFieldID = 4;
readAPIKey = '';

tempF = thingSpeakRead(readChannelID,'Fields',TemperatureFieldID,...
'NumMinutes',10*60, 'ReadKey',readAPIKey);

histogram(tempF);
xlabel('Temperature (F)');
ylabel('Number of Measurements\newline for Each Temperature');
title('Histogram of Temperature Variation');
```

MATLAB Code 02:

```
readChannelID = 12397;
TemperatureFieldID = 4;
HumidityFieldID = 3;

readAPIKey = '';

data = thingSpeakRead(readChannelID,'Fields',[TemperatureFieldID HumidityFieldID], ...
                      'NumPoints',300, ...
                      'ReadKey',readAPIKey);

temperatureData = data(:,1);

humidityData = data(:,2);
scatter(temperatureData,humidityData);
xlabel('Temperature');
ylabel('Humidity');
```

MATLAB Code 03:

```
readChannelID = 12397;
myFieldID = 4;
oneDay = [datetime('yesterday') datetime('today')];
readAPIKey = '';
```

```
temperatureDay1 = thingSpeakRead(readChannelID,'Fields',myFieldID, ...
                        'dateRange', oneDay, 'ReadKey',readAPIKey);
temperatureDay2 = thingSpeakRead(readChannelID,'Fields',myFieldID, ...
                        'dateRange',oneDay-days(1),'ReadKey',readAPIKey);
temperatureDay3 = thingSpeakRead(readChannelID,'Fields',myFieldID, ...
                       'dateRange', oneDay-days(2),'ReadKey',readAPIKey);

myTimes1 = minutes(1:length(temperatureDay1));
myTimes2 = minutes(1:length(temperatureDay2));
myTimes3 = minutes(1:length(temperatureDay3));

plot(myTimes1,temperatureDay1, myTimes2,temperatureDay2, myTimes3, temperatureDay3);
legend({'Day1','Day2','Day3'});
xlabel('Minutes');
ylabel('Temperature F');
title('3-Day Temperature Comparison');
```

MATLAB Code 04:

```
readChannelID = 12397;
WindDirFieldID = 1;
WindSpeedFieldID = 2;

readAPIKey = '';
```

```
windDir = thingSpeakRead(readChannelID,'Fields',WindDirFieldID,'NumPoints',60,...
'ReadKey',readAPIKey);
windSpeed = thingSpeakRead(readChannelID,'Fields',WindSpeedFieldID,...
'NumPoints',60,'ReadKey',readAPIKey);

rad = windDir*2*pi/360;
rad = rad+pi/2;
u = cos(rad) .* windSpeed;
v = sin(rad) .* windSpeed;

compass(u,v);
```

Datasheet of the ICs used

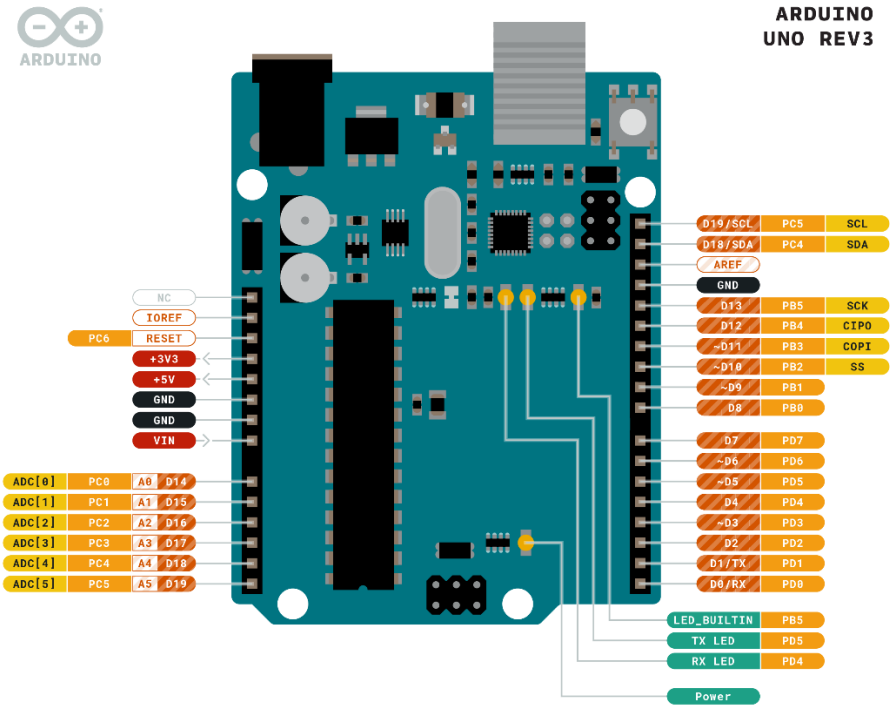

Figure 7.1 Arduino Uno R3 Datasheet

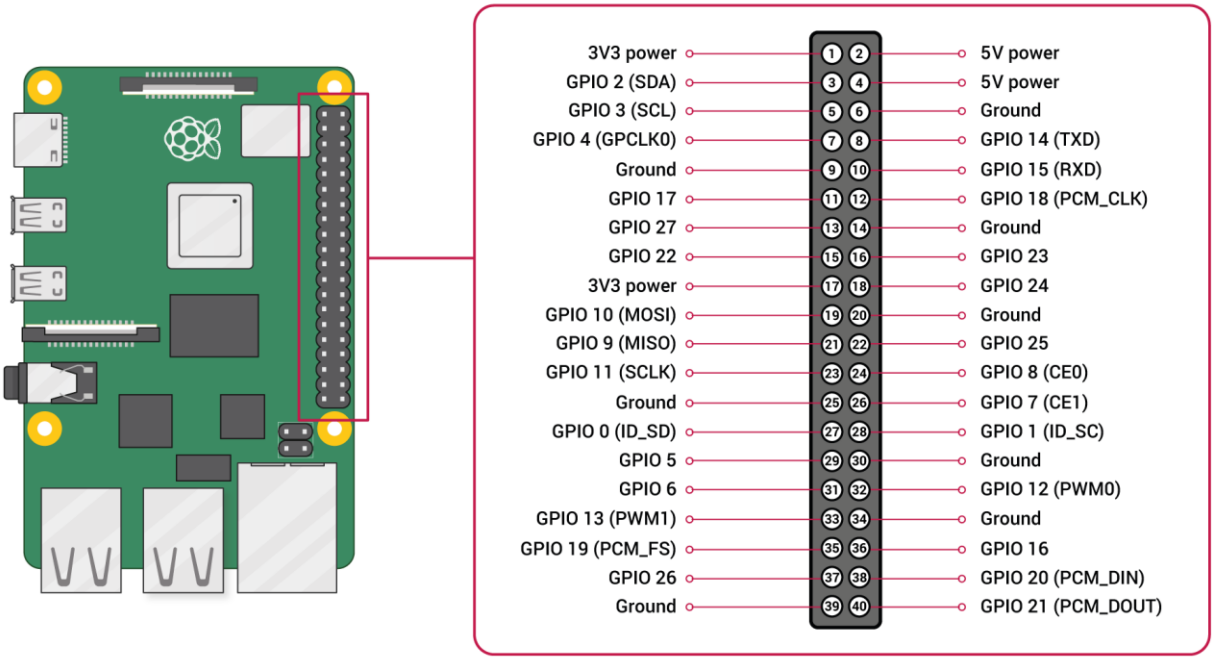

Figure 7.2 Raspberry Pi 2 Model B Datasheet

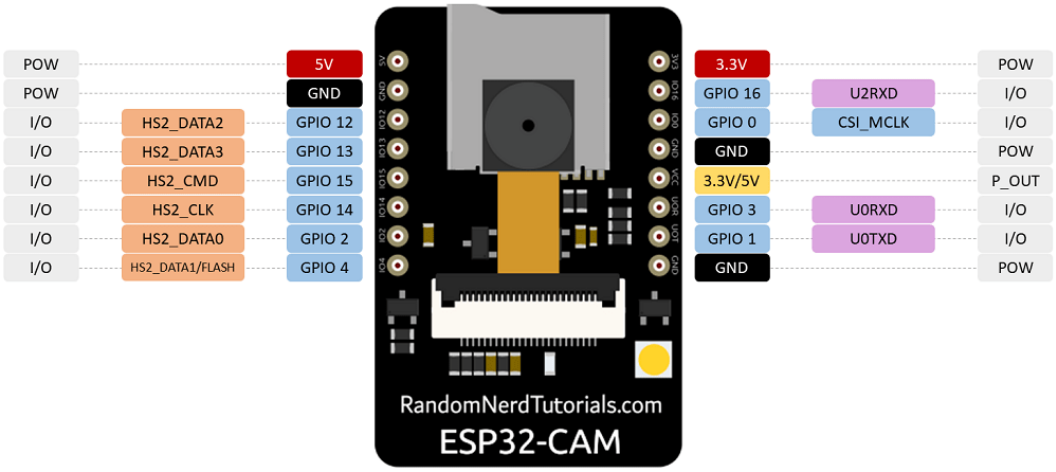

Figure 7.3 Esp32 Cam Datasheet

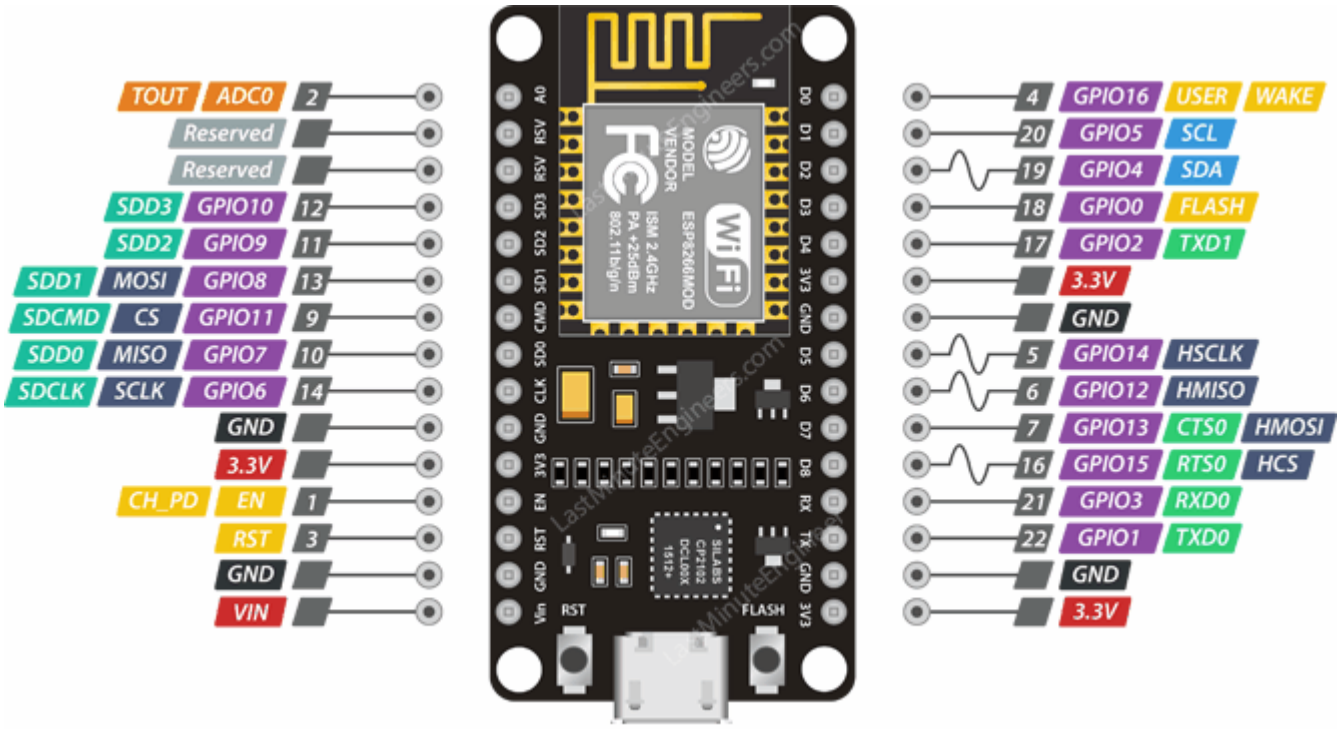

Figure 7.4 Esp8266 Datasheet

Appendix B

iThenticate Plagiarism Report

Appendix Z

DETAILED DIRECTIONS ON FORMATTING

7.1.Introduction

In this section, how the students can use the template is explained.Follow the specific sections for any specific query.

This template is made keeping in mind the needs of **students in AIUB.** The template will help you a lot of formatting work. If you follow the steps, your thesis will have some less reason to get rejected.

7.2.From Declaration to Abstract

For these sections, the work is simple and straightforward. Modify the contents there e.g. select **Fall/Spring/Summer**from the drop-down menu list, fill up different information etc. Select the **semester of your registrationalong with academic year** (**final defense semester**) for **Capstone Project. Moreover, month of final Defense should be selected in title page, cover page and approval page.**

7.3.Entering the Text

To enter your own text, just replace your text in template. For example, suppose the title of your second chapter is 'Literature Review'. Then you will have to just replace "DETAILED DIRECTIONS ON FORMATTING" (see above) with "LITERATURE REVIEW". **Do not change the font name or size there. Similarly, in the introduction section and other sections, replace your text.**

Beginning a sentence by the words 'but' and 'and' should be avoided. Passive voice should be used as far as possible.

7.3.1. Using Bold, Italic or Underline and use of Bullets

You can use BOLDor*italic* text in your writing for giving emphasis. But using them very frequently or without much thinking will make your report visually unpleasant. Use them only for giving some selected point more importance.

7.3.1.1. Text Justification

Always justify your passages so that the lines are uniformly spread along the margin. To justify select the passage and press *Ctrl + J* (or, alternatively go to Microsoft word Ribbon: Home ⇒ Paragraph Section ⇒ Justify (4^{th} option)).

7.3.2. Spacing Option

Use 1.5 of line spacing [go to Microsoft word Ribbon: Home ⇒ Paragraph Section ⇒spacing (just right to thejustify option)]

7.3.3. How to use Numbering

As you can see, give your sections number like 1.2., 1.3., 1.3.1.etc. This will also help the table of content as you will see later.

To create numbering, go to Home ⇒ Paragraph Section ⇒ Numbering. You will also see that writing (writing 1.2.+ press space) will automatically create aligned number after 1.1. You can also use "change list level" and "set numbering value" in numbering menu (Right click) to change the numbering style and starting number.

7.3.4. Using Color

You can use color to give emphasis. But try to use eye soothing colors and again do not overuse.

A general rule for formatting text is presented here. Use this table as your guideline.

Table 9.1 A summary of rules for text editing presented with example

Text Type	**Example From this chapter**	**Font Name**	**Font Size**	**Font Alignment**	**Emphasis**	**Custom Style**
Chapter number	**Chapter 9**	Times Now Roman	14	Middle (Ctrl + E)	BOLD	**AIUB_1**
Chapter name	**DETAILED DIRECTIONS ON FORMATTING**	Times Now Roman	16	Middle (Ctrl + E)	BOLD	**AIUB_2**
Subheading Level 1	**Introduction (9.1)**	Times Now Roman	14	Left (Ctrl + L)	BOLD	**AIUB_3**
Subheading Level 2	**Using Bold, Italic or Underline and use of Bullets (9.3.1)**	Times Now Roman	12	Left (Ctrl + L) along with a TAB	BOLD	**AIUB_4**
*Subheading Level 3	**Text Justification (9.3.1.1)**	Times Now Roman	12	Left (Ctrl + L) along with double TAB	BOLD	**AIUB_5**
Normal Text		Times Now Roman	12	Justify (Ctrl + J)	NORMAL	**AIUB_T**

*Do not go beyond subheading level 3.

The custom style (look last column of the table) is very important. You can found them is MS WORD ribbon ⇒ Home ⇒ Style. Select appropriate style. If you are just replacing your text in this template, you will automatically use them.

The custom style is important because it is used to automatically generate the table of content. (See next section 9.4: Table of contents)

7.4.Table of Contents

You can manually edit the table of content. But a more efficient way is used here. **The table of content will be updated automatically when you change anything. So, you don't need to edit anything manually.**

7.4.1. How to Update Table of content Automatically

7.4.1.1. Mark your text according to Table 9.1

Suppose, you have created a chapter named "How to use this template". After writing this, you have to select the text ("How to use this template") and go to Home ⇒ Styles ⇒ select AIUB_2 (table 9.1 says so).

If you are writing the caption 9.4.1 named "How to Update Table of content automatically" (This is in subheading level 2), you have to select the lines ("How to Update Table of content automatically") and select the styles named "AIUB_4" (see table 9.1).

If you are writing any normal text (inside any subsection), like this line, according to table 9.1, you have to select this passage and select style "**AIUB_T**" ('T' for text here).

7.4.1.2. Update the Table

Just right click the "Table of content" and select "**Update field**" & "**Update Entire Table**". **Only make sure, you have used specific style (see last column of the table) because 'Table of content' uses the style to pick up the titles.** If the page number or any of the titles changes, update the table and the correction will be automatic.

You will see the content will be updated according to new page number automatically.

If you see any problem in table of content, just ctrl + click on the page number (from the right side of the table of contents). This will take you to the page. Find there what you have mistaken.

9.4.2 How to update Table of Contents manually

This is quite straightforward. Edit as you like. Keep track of the page number by yourself. And, if you change any page, correct all the pages by typing again.

7.5. List of Figures

Using list of figure is same as table of contents, only difference: Select the title of the figure and select style "**AIUB_F**" (F stands for figure). Then right click "list of figures" and select "update field". The figure list will be updated according to new page number automatically.

7.6. Use of Table

Always give table no. according to chapter (see Table 9.1 – indicating that it is table from chapter 9 & 1st table). Also give a good caption that explains the purpose of the table. **Mention the table name in the text**(e.g. the result of our work is presented in Table 9.1 or something like that, etc).

"Auto fit" the table to windows –

1. Select the whole table
2. Go to : layout ⇒Autofit⇒Autofit to Windows

7.7. Use of Figures

Do not use directly copied figure from other publications. If you have to use some copyright contents, then give reference of that source like Figure.1 is taken from [1] (means this figure has been taken from reference 1).

Figure 9.1 Logo of AIUB [1]

Always give a figure name, figure caption explaining what the figure implies and mention your figure in your writings. Align the figure and its caption in the middle, e.g. see the above Figure 9.1.

It is wise to keep the aspect ratio of figure fixed; do not distort it. Do not use blurred images (see Figure 9.2).

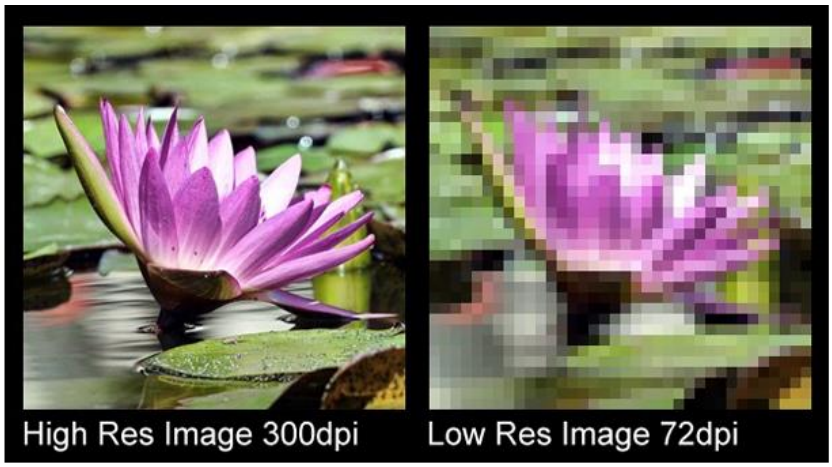

Figure 9.2 Example of an image with acceptable resolution(left one) and unacceptable resolution (right one).

Please check all figures in your paper both on screen and on a black-and-white hardcopy. When you check your paper on a black-and-white hardcopy, please ensure that:

- The colors used in each figure contrast well,
- The image used in each figure is clear,
- All text labels in each figure are legible.
- Keep the images properly sized and at the middle of the margin (Do not cross margin and do not give extra-large or extra-small images)

In case of presenting graph, you can use color. But, use color that can contrast well even in black & white print. Use symbols in your graph, label them properly with units (see figure 9.3).

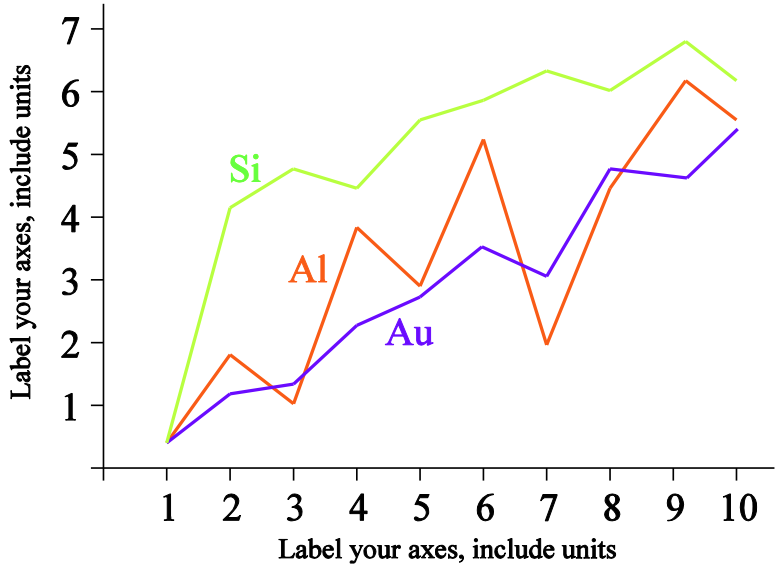

Figure 9.3 An exampleof graph that uses color which can be easily distinguished even in black and white print; the graphs are properly labeled also.

To draw the curves, it is highly recommended to use professional software "**ORIGIN 8.5**" or later version. But you can also use **MATLAB** or **Microsoft Excel** but these are not professional.

7.8. Writing Equations

UseMSword equation writer (Insert ⇒ Equation) to write the equations, e.g.

$$P_{avg} = \frac{1}{T}\int_0^T A\ sinwt\ dt \tag{9.1}$$

Also use equation number according to the chapter, e.g. equation (9.1) is the 1st equation from chapter 9.

7.9. Using Symbols

(Go to the menu Ribbon) Insert ⇒ Symbol to create symbols (ω, φ, ϕ, δ etc).

7.10. Appendices

In the appendix section, give those parts of your thesis which are not essential to understand the main idea or findings of the thesis. But if the reader wants the details or more explanation, then the appendix will help them.

Give the code you used in simulation or in project, the data sheets (only important parts, not full sheet), and necessary diagrams for details understanding in the appendix.

For example, if you have worked on mathematical modeling, do not give the details derivation in your results chapter because it will hamper the flow of reading and obscure the findings. Rather, present the main equations and results there and give the detail derivation in the appendix.

7.11. References

It will contain list of references: books, journal / periodical papers, URL sites).

- The heading of the References section must not be numbered.
- All reference items must be in 12 point font.
- Please use Regular and Italic styles to distinguish different fields as shown in the References section.
- Number the reference items consecutively in square brackets (e.g. [1]).
- When referring to a reference item, please simply use the reference number, as in **[2].**Do not use "Ref. [3]" or "Reference [3]" except at the beginning of a sentence, e.g. "Reference [3] shows …".
- Multiple references are each numbered with separate brackets (e.g. [2], [3], [4]–[6]).

Examples of reference items of different categories shown in the References section include:

- example of websites [1]
- example of a book in [2]
- example of a book in a series in [3]
- example of a journal article in [4]
- example of a conference paper in [5]
- example of a patent in [6]
- example of a website in [7]
- example of a web page in [8]
- example of a databook as a manual in [9]
- example of a datasheet in [10]
- example of a master's thesis in [11]
- example of a technical report in [12]
- example of a standard in [13]

For example, if you are using any book as reference, see [2] in 'reference section' of this template to know how to cite the book.

A more effective way is to use professional software named '**ENDNOTE**' that can automatically update the references as you change anything. If you get time, better use that software.

7.12. Error Correction

Use Microsoft word spelling checker for possible error. Want to be perfect! A more effective way to check spelling: Get a hard copy of your thesis and read from backwards of the line. This will lose your focus on content and increase attention on the spelling.

7.13. Summary

This section works as a thesis guide by demonstrating how to use this template in detail. This section also focuses on general techniques regarding 'how a dissertation should be written'.