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TITLE: PLANT GROWTH MONITORING USING IMAGE PROCESSING WITH AUTOMATIC IRRIGATION SYSTEM

Contents

FIGURES

CHAPTER 1: ABOUT PROJECT

1.1 Introduction

As global food demands rise, advanced agricultural technologies are needed to improve plant growth and resource utilization. This project presents an intelligent plant growth monitoring and automated irrigation system that makes use of image processing and smart control mechanisms. The core objective is to remotely monitor plant growth while enhancing crop yields and reducing labour/resource demands associated with traditional farming. The system combines a computer vision-based image processing module and an automated irrigation mechanism to create a closed-loop solution. The image processing module analyses plant images to extract visual indicators of health, while the irrigation system uses soil moisture sensors and smart irrigation valves to deliver optimal water levels. By integrating these components, the system aims to improve plant health, increase yields, reduce water consumption, and enable more sustainable agriculture. This comprehensive solution can be deployed in both small and large-scale farming operations.

1.2 Background

The growing global population has placed increasing demands on food production, necessitating the development of more efficient and sustainable agricultural practices. Traditional farming methods often rely on manual monitoring and watering, which can be labour-intensive and resource-inefficient. Advancements in computer vision, sensor technology, and control systems have enabled the creation of smart agricultural solutions to address these challenges.

Image processing techniques can be leveraged to analyse plant health indicators, such as leaf colour, size, and texture, providing real-time insights into growth status. Coupling this with automated irrigation system that respond to soil moisture levels allows for precise, adaptive irrigation management. By integrating these capabilities, a comprehensive plant growth monitoring and watering system can be developed to optimize resource utilization, enhance crop yields, and reduce labour requirements.

1.3 Problem statement

Manual plant growth monitoring and watering can be inefficient, time-consuming, and inconsistent, leading to poor plant health and productivity.

1.4 Aim

To develop a plant growth monitoring system using image processing techniques with an automatic irrigation system, to improve plant growth and water usage.

1.5 Objectives

<u>To design a system that is able to:</u>

-measure plant height using ultrasonic sensors in order to avoid stunted growth

-to measure leaf spread to the left and right or plant width using infrared sensors

-determine leaf colour, size and density using image processing

-provide real time growth monitoring of the plant

-accurately measure the soil moisture using a moisture sensor

-automatically switch on the pump to irrigate the plants when the soil moisture is below 40%

1.6 Justification

<u>Automation and Efficiency</u>-Traditional methods of plant growth monitoring involve manual measurements, which are time-consuming, labour-intensive, and prone to human errors. Implementing an automated image processing system, the monitoring process can be streamlined, reducing the need for manual intervention and increasing efficiency.

<u>Optimizing Water Usage</u>: The automated irrigation system, driven by real-time soil moisture data and plant growth analysis, can precisely deliver the optimal amount of water to each plant. This targeted approach helps minimize water waste and ensures efficient resource utilization, making the system well-suited for regions with limited water availability or facing drought conditions. By automating the irrigation process, the system can adapt to changing environmental conditions and plant needs, leading to significant water savings compared to traditional manual watering methods.

<u>Enhancing Crop Yields</u>: The image processing-based plant growth monitoring capabilities can provide valuable insights into the health and development of the plants. By analysing visual indicators such as leaf colour, size, and texture, the system can detect early signs of stress or disease, allowing for timely intervention and corrective actions. This proactive approach can help mitigate crop losses, improve plant health and ultimately lead to higher yields, contributing to increased food production and security.

Real-time Monitoring and Analysis-The ability to monitor plant growth in real-time is crucial for timely decision-making in agriculture and horticulture. Image processing systems can continuously capture plant images, allowing for immediate analysis of growth patterns.

CHAPTER 2: THEORATICAL BACKGROUND

2.1 Introduction

This chapter describes the related work of other hardware developers. It also discusses on how the system will be done from scratch in a theoretical way. All the related systems will be carefully analysed stating their advantages and disadvantages.

2.2 Published works by others

In 2017, Professor Bhavana Patil, Mr. Hemant Panchal and Mr. Shubham Yadav3 of A C Patil college India, designed an image processing plant monitoring system for detecting diseased plants. The system could detect if a plant was infected through leaf discolouration. If a plant is infected with pests sometimes the leaves will have some segments which will be brown and the rest will be green. By using image processing one could segment the leaf and check if it is infected. The system in the review used two controller/processors.[1] One of the controller was the Arduino uno which was used to interface with temperature sensor (dh11) and a gas sensor. These sensors were there to increase the accuracy of detecting that a plant is infected. The other controller was the raspberry pi which was used mainly as a server for the plant database. It was also connected to a camera which was used to take pictures for image processing. The system was very advanced and could successfully distinguish between a healthy leaf and an infected one. One of the draw backs of the system was scaling cameras to cover the whole farm. The author suggested using an arm controller which has more processing power and could accommodate these many cameras.

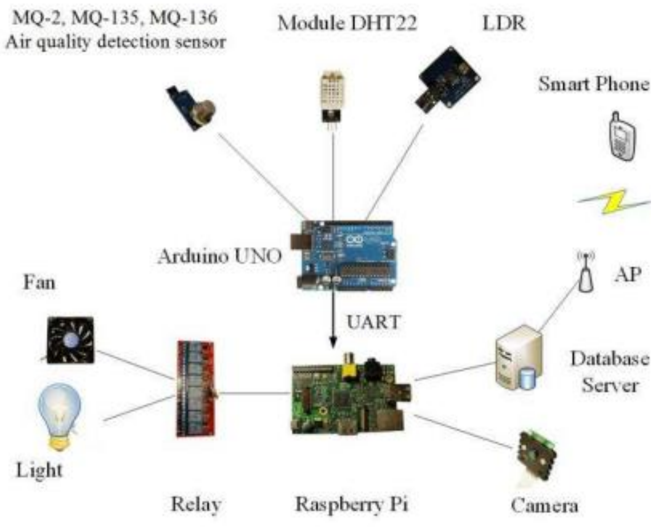

Figure 2.1: An image processing plant monitoring system for detecting diseased plants

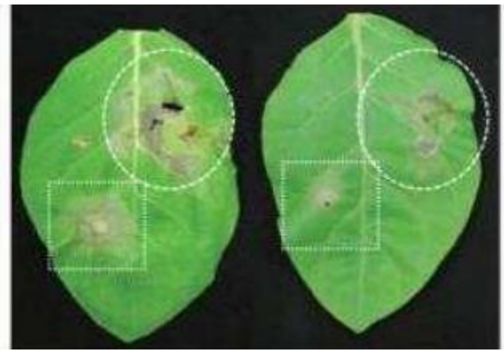

Figure 2.2: diseased leaf

In 2019 Isnan Nugraha Marcheriz and Endah Fitriani designed a tomato based plant monitoring system. The system frequently measured soil moisture content, ph of soil.[3] The system used an Arduino uno to read all the sensor. For tomato growth the system also used an esp 32 cam. Pictures were taken in an interval and send together with sensor data remotely. If the plant had less water, a pump turned on watering the plant. The system could also correct the ph of the surrounding soil such that the tomato plant had the best conditions for fast growth. The system worked perfect but there was no colour detection to determine if the tomatoes were ripening. From the diagrams below there is clear information being send to the owner for monitoring of the plant. The other diagram shows how the sensors were connected to the main controller.

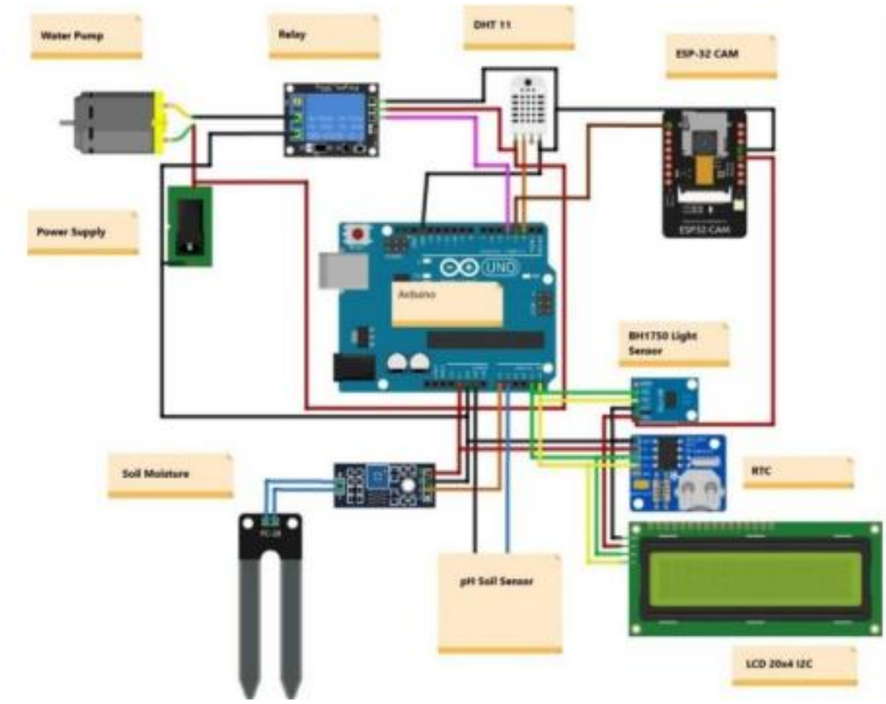

Figure 2.3: A tomatoe based plant monitoring system

Figure 2.4: A screenshot of the readings of the system

In 2022 Md Mahfuzur Akter Ringku , Md. Al-Emran and Mehedi Hassan of American internation university Bngladesh designed a rover to monitor small plant fields. The rover would take all the necessary soil parameters and send them wirelessly to the cloud, the system consisted of sensors like the ph sensor, moisture sensor and also actuators like dc pumps.the system used Arduino uno controller and then took pictures with esp32 camera module.[4] The rover had small tanks to spray pesticides. The system was solar powered so it would have little to no downtime. The system will be less effective when the season was rainy season since it would be difficult to charger the rover battery when there is little sunlight. the picture below shows how the rover was structured.

Figure 2.5: A rover to monitor small plant fields

The systems above proved effective in motoring plant growth with some of them giving real time data on mobile applications and websites. The systems bridged the gap between Internet Of Things and agriculture. The systems above were particularly monitoring soil moisture content, quality of air and the use of camera modules to take pictures for further analysis. There were a few drop backs of some of the systems, one being lack of a sophisticated microcontroller that could be used with multiple cameras to monitor a large field like the ARM controller. Most of the systems were best suited for green house monitoring where there is a small ground to cover, visually.

2.4 System configuration

In theory, the system will be able to measure plant height, stem width and take an image for further processing to define the leaf size and leaf density. The pictures will be sent to a database remotely and will be further analysed. The system can detect colour which helps in determining that the plant is now ripe or not. For measuring height and stem width ultrasonic and infrared sensors will be used respectively. A soil moisture sensor is used to accurately measure the soil moisture percentage which then activates or deactivates the automatic irrigation system depending on the soil moisture percentage value. A liquid crystal display will be put in place to display locally how the plant will be growing. A Global System for Mobile communication module will be available on the system to send informative messages to the owner about the plant growth.

2.4.1 Liquid Crystal Display

A liquid-crystal display (LCD) is a flat-panel display or other electronically modulated optical device that uses the light-modulating properties of liquid crystals combined with polarizers. Liquid crystals do not emit light directly but instead use a backlight or reflector to produce images in colour or monochrome.

LCDs are available to display arbitrary images (as in a general-purpose computer display) or fixed images with low information content, which can be displayed or hidden: preset words, digits, and seven-segment displays (as in a digital clock) are all examples of devices with these displays. They use the same basic technology, except that arbitrary images are made from a matrix of small pixels, while other displays have larger elements.

LCDs can either be normally on (positive) or off (negative), depending on the polarizer arrangement. For example, a character positive LCD with a backlight will have black lettering on a background that is the colour of the backlight, and a character negative LCD will have a black background with the letters being of the same colour as the backlight.

LCDs are used in a wide range of applications, including LCD televisions, computer monitors, instrument panels, aircraft cockpit displays, and indoor and outdoor signage. Small LCD screens are common in LCD projectors and portable consumer devices such as digital cameras, watches, calculators, and mobile telephones, including smartphones. LCD screens have replaced heavy, bulky and less energy-efficient cathode-ray tube (CRT) displays in nearly all applications. The phosphors used in CRTs make them vulnerable to image burn-in when a static image is displayed on a screen for a long time, e.g., the table frame for an airline flight schedule on an indoor sign. LCDs do not have this weakness, but are still susceptible to image persistence.

Figure 2.6: Interface I2C LCD

Features of a 16*2 LCD module

Operating Voltage is 4.7V to 5.3V

Alphanumeric LCD display module

Current consumption is 1mA without backlight

Consists of two rows and each row can print 16 characters.

Each character is built by a 5×8 pixel box

Can work on both 8-bit and 4-bit mode

It can also display any custom generated characters

Available in Green and Blue Backlight

Pin Number	Pin Name	Description
Pin 1	Vss(Ground)	Ground pin connected to system ground.
Pin 2	Vdd(+5V)	Powers LCD with 5V (4.7V-5.3V).
Pin 3	VE(Contrast V)	Describes the contrast level of display. Grounded for maximum contrast.
Pin 4	Register Select	Connected to microcontroller to shift between command/data register.
Pin 5	Read/Write	Used to read or write data. Normally grounded to write data on LCD.
Pin 6	Enable pin	Connected to microcontroller and toggled between 1 and 0 for data acknowledgement.
Pin 7-14	Data pins D0-D7	Data pins 0-7 form an 8-bit data line and can be connected to a microcontroller to send 8-bit data. LCD can also operate on 4-bit data mode where in such cases pin 4, 5, 6 and 9 will be left out
Pin 15	LED positive	Backlight LED pin positive terminal.
Pin 16	LED negative	Backlight LED pin negative terminal.

Table 2.1: lcd pinout

2.4.2 **Global System for Mobile Communications** (Gsm) module

GSM (Global System for Mobile Communications, originally Groupe Spécial Mobile), is a standard developed by the European Telecommunications Standards Institute. It was created to describe the protocols for second-generation (2G) digital cellular networks used by mobile phones and is now the default global standard for mobile communications – with over 90% market share, operating in over 219 countries and territories.

GSM is an open and digital cellular technology used for transmitting mobile voice and data services operates at the 850MHz, 900MHz, 1800MHz and 1900MHz frequency bands. GSM system was developed as a digital system using time division multiple access (TDMA) technique for communication purpose. A GSM digitizes and reduces the data, then sends it down through a channel with two different streams of client data, each in its own particular time slot. The digital system has an ability to carry 64 kbps to 120 Mbps of data rate.

Figure 2.7: GSM module

2.4.3 ESP32 CAM

The ESP32-CAM is a very small camera module with the ESP32-S chip that is in-expensive. Besides the OV2640 camera, and several GPIOs to connect peripherals, it also features a microSD card slot that can be useful to store images taken with the camera or to store files to serve to clients.

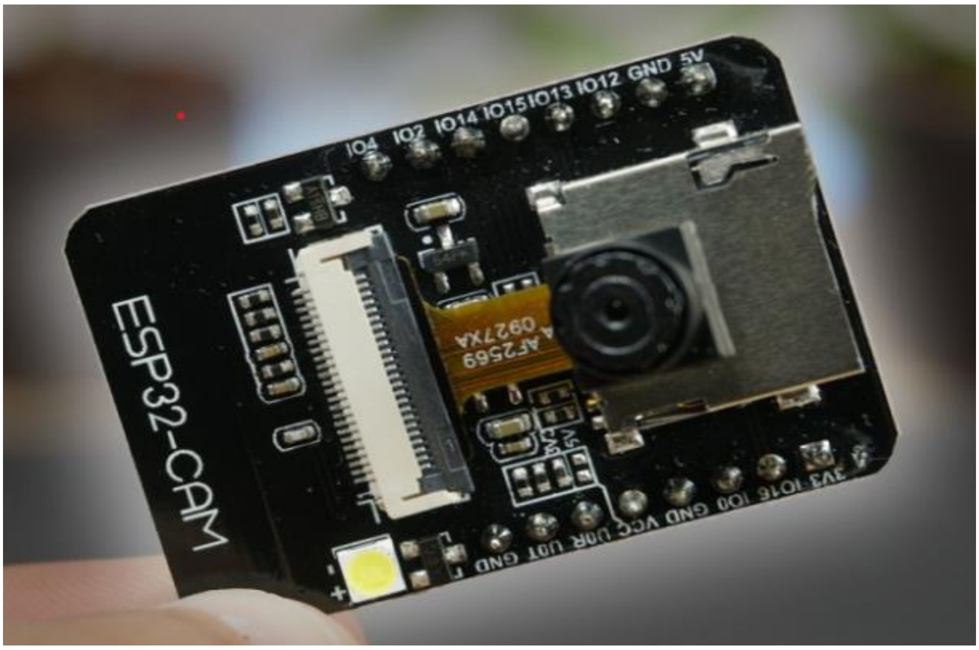

Figure 2.8: ESP32-CAM

<u>ESP32-CAM features:</u>

The smallest 802.11b/g/n Wi-Fi BT SoC module

Low power 32-bit CPU, can also serve the application processor

Up to 160MHz clock speed, summary computing power up to 600 DMIPS

Built-in 520 KB SRAM, external 4MPSRAM

Supports UART/SPI/I2C/PWM/ADC/DAC

Support OV2640 and OV7670 cameras, built-in flash lamp

Support image WiFi upload

Support TF card

Supports multiple sleep modes

Embedded Lwip and FreeRTOS

Supports STA/AP/STA+AP operation mode

Support Smart Config/AirKiss technology

Support for serial port local and remote firmware upgrades (FOTA)

2.4.4 ESP 32 node mcu

The ESP32 NodeMCU is a popular open-source development board that has gained significant attention in the field of Internet of Things (IoT) and embedded systems. This literature review aims to provide an overview of the key features, capabilities, and applications of the ESP32 NodeMCU.

Key Features of the ESP32 NodeMCU

Microcontroller: The ESP32 NodeMCU is powered by the Espressif ESP32 microcontroller, which features a dual-core 32-bit Xtensa LX6 microprocessor, running at a frequency of up to 240 MHz.

Wireless Connectivity: The ESP32 NodeMCU supports both Wi-Fi (802.11 b/g/n) and Bluetooth (Bluetooth 4.2 and Bluetooth Low Energy) connectivity, allowing for seamless integration with various IoT devices and cloud platforms.

GPIO Pins: The board offers a rich set of GPIO (General Purpose Input/Output) pins, including analog-to-digital converters (ADCs), digital-to-analog converters (DACs), and various communication interfaces such as UART, SPI, and I²C.

Memory and Storage: The ESP32 NodeMCU comes with 4 MB of flash memory and 520 KB of SRAM, providing ample storage and memory for your projects.

Low Power Consumption: The ESP32 chip is designed with low power consumption in mind, making it suitable for battery-powered IoT applications.

Development Ecosystem: The ESP32 NodeMCU benefits from a thriving development ecosystem, with a wide range of libraries, frameworks, and tools available, such as Arduino, MicroPython, and ESP-IDF (Espressif IoT Development Framework).

Applications of the ESP32 NodeMCU

The versatility of the ESP32 NodeMCU makes it a popular choice for a wide range of IoT applications, including:

Smart Home Automation: The ESP32 NodeMCU can be used to develop smart home devices, such as smart lights, thermostats, and security systems, enabling remote control and monitoring.

Industrial Automation: The board's connectivity and processing power make it suitable for industrial automation projects, such as sensor monitoring, data logging, and remote control of industrial equipment.

Wearable and Fitness Devices: The ESP32 NodeMCU can be integrated into wearable devices, like fitness trackers and smartwatches, to enable features like activity tracking, heart rate monitoring, and wireless communication.

Environmental Monitoring: The ESP32 NodeMCU can be used to develop systems for monitoring environmental parameters, such as temperature, humidity, air quality, and soil moisture, with potential applications in agriculture, urban planning, and environmental conservation.

Wireless Sensor Networks: The board's wireless capabilities and low power consumption make it an excellent choice for building wireless sensor networks, where multiple nodes can communicate and transmit data to a central monitoring system.

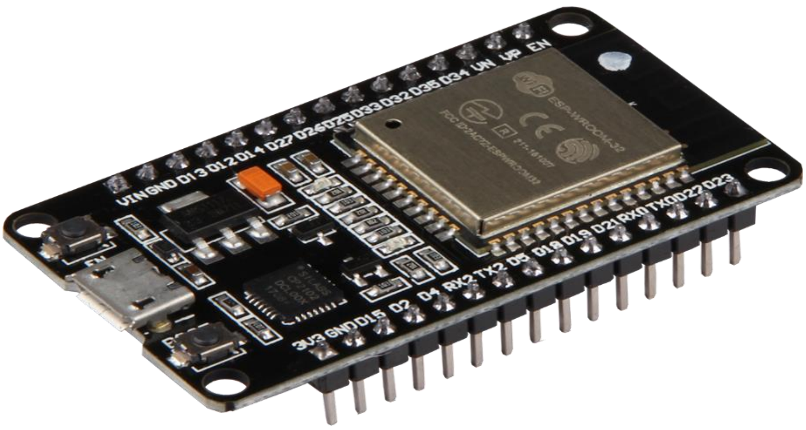

Figure 2.9: ESP 32-NODE MCU

2.4.5 Colour sensor

Colour sensor is used to detected colour of objects. The colour sensor mainly has RGB and utilises the colours to come up with the rest of the colour spectrum. When an object is irradiated with light containing RGB components, the colour of the reflected light will change depending on the colour of the object. For example, if the object is red, the reflected light component will be red. For a yellow object, the reflected light will be red and green, and if the object is white all three components will be reflected.

Figure 2.10: colour sensor

Working Principle of Colour Sensor

To detect the colour of material three main types of equipment are required. A light source to illuminate the material surface, a surface whose colour has to be detected and the receivers which can measure the reflected wavelengths.

Colour sensors contain a white light emitter to illuminate the surface. Three filters with wavelength sensitivities at 580nm, 540nm, 450nm to measure the wavelengths of red, green and blue colours respectively.

Based on the activation of these filters, the colour of the material is categorized. A light to voltage converter is also present in the sensor. The sensor responds to colour by generating a voltage proportional to the detected colour.

Another way of detecting colour is by illuminating the material surface by Red, Blue and Green LED's one at a time. Here the sensor contains no filters but light to voltage converter. The highest amount of light reflected back by the material surface while illuminated with the red, blue and green light is calculated to detect the colour.

2.4.6 Infrared sensor

Infrared (IR) sensors are electronic devices that measure and detect infrared radiation, which is electromagnetic radiation with longer wavelengths than visible light. IR sensors are widely used in various applications, including remote control systems, motion detection, night vision, and temperature measurement.

<u>Principles of IR Sensing</u>

IR sensors operate by converting infrared radiation into an electrical signal that can be measured and processed. They typically consist of a photodetector, such as a photodiode or a pyroelectric sensor, which generates a voltage or current in response to the absorbed IR radiation. The intensity of the IR radiation detected by the sensor is proportional to the electrical output signal.

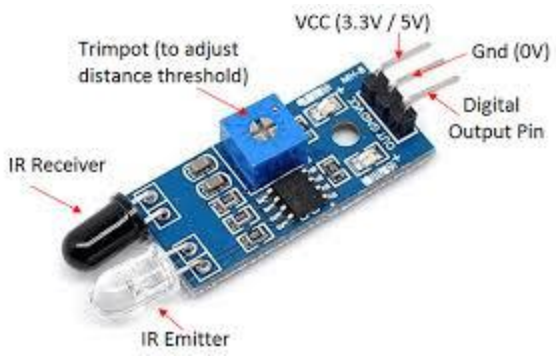

Figure 2.11: Infrared Sensor

2.4.6 Submersible pump

Submersible pumps are specialized pumping devices designed to operate while submerged in a liquid, typically water. These pumps are widely used in various applications, including water treatment, wastewater management, mining, construction, and residential water supply.

<u>Principles of Submersible Pump Operation</u>

Submersible pumps are constructed with a waterproof and pressure-resistant design that allows them to function effectively while submerged. They typically consist of a motor, an impeller, and a pump housing, all sealed within a watertight casing. The motor drives the impeller, which in turn creates a suction force that draws the liquid into the pump and discharges it through the outlet.

Figure 2.12: Submersible pump

2.4.7 Ultrasonic sensor

An ultrasonic sensor is a device that emits ultrasonic sound waves and analyzes the echo that bounces back to the sensor to determine characteristics of the target object or distance.

Operating Principle:

The sensor generates high-frequency sound waves, typically in the range of 20 kHz to 400 kHz, which are above the audible range for humans.

It then measures the time it takes for the sound wave to hit an object and reflect back to the sensor. By calculating the time-of-flight of the sound wave, the sensor can determine the distance to the object.

Figure 2.13: ultrasonic sensor

2.4.8 Soil moisture sensor

A soil moisture sensor is an electronic instrument that measures the moisture level in soil. It quantifies the volumetric water content or the water potential of the soil.

Operating Principle:

Soil moisture sensors typically work by measuring the electrical conductivity or dielectric constant of the soil, which varies with the soil's water content.

Common sensor types include capacitance sensors, resistance sensors, and time-domain reflectometry (TDR) sensors.

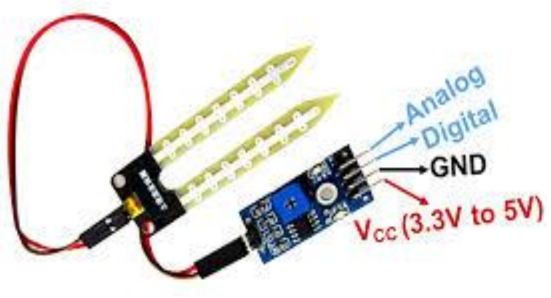

Figure 2.14: soil moisture sensor

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2. Vijai singh, Varsha, A.K.MishradzDetection of unhealthy region of plant leaves using image processing and genetic algorithmdz, ´T5,)CACEA,)ndia. K. Elissa, DzTitle of paper if known,dz unpublished.

3. Monica Jhuria, Ashwani kumar and Rushikesh Borse, dz)mage processing for Smart farming, detection of Disease and Fruit Grading,dz proceeding of the 2013, IEEE, second international conference on image Information processing.

4. https://jusst.org/wp-content/uploads/2021/02/A-Novel-IoT-Enabled-System-For-detection-of-Infected-Leaf-for-Smart-Agricultural.pdf

5.https://dspace.aiub.edu/jspui/bitstream/123456789/870/1/Capstone%20Project%20Book%202022.2.22.pdf

CHAPTER 3: SYSTEM DESIGN

3.1Introduction

In this chapter, there will be a clear description of how the prototype came to life. From the simulation stage to the printed circuit board designing stage and to the actual physical device or prototype. This chapter also describes the various methods used to create tracks on a printed circuit board like etching and computerised numerical control milling.

3.2 hardware design

3.2.0 Block Diagram

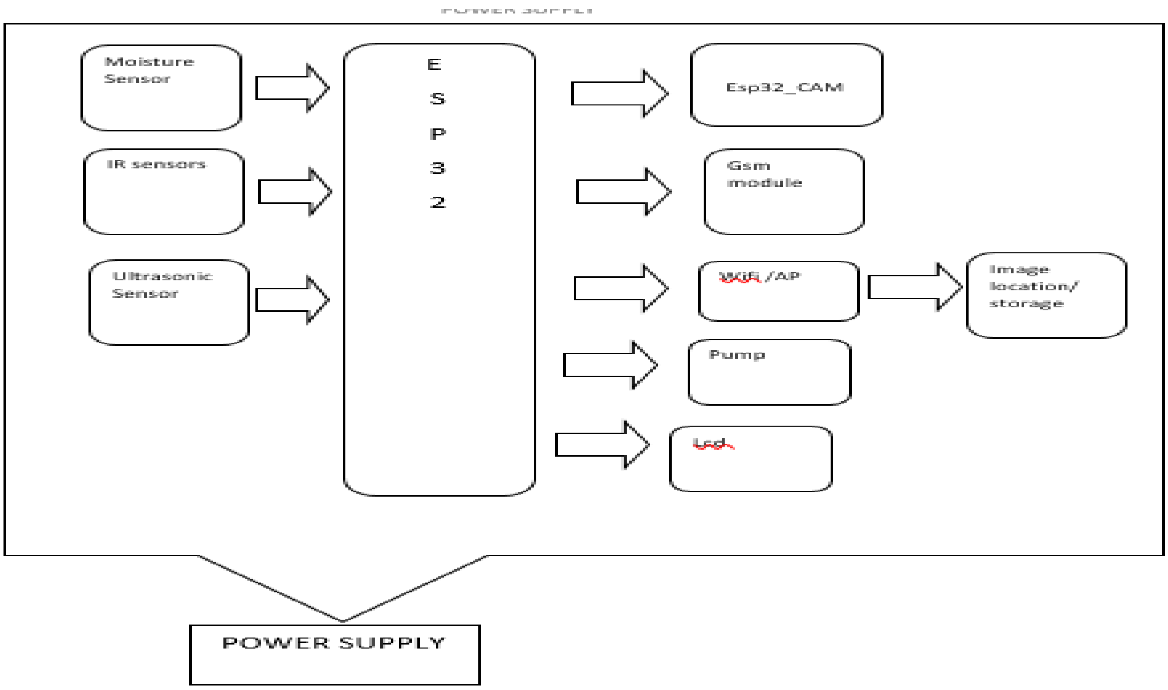


Figure 3.1 block diagram

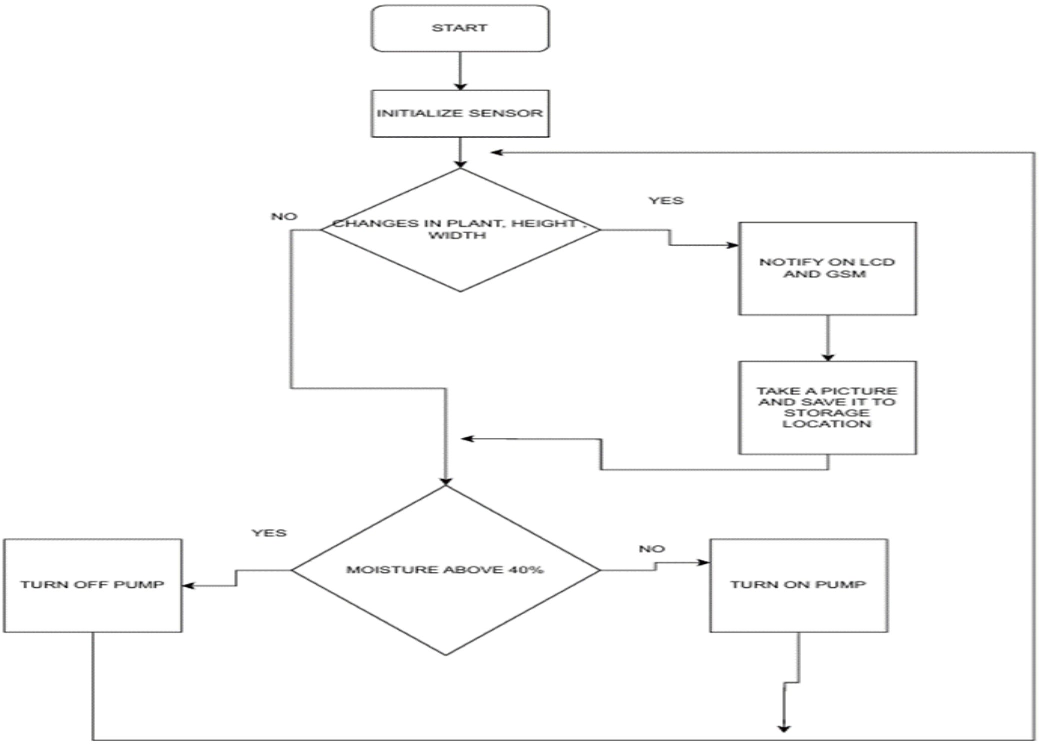
The block diagram above is comprising of three sections namely the input section, the processing unit and lastly the output section.

The input section consists of sensors that will be measuring the physical parameters. For the sensors we have the camera module, which will be used to take pictures of the plant for further image processing of the leaf size and leaf density. The image is processed by the ESP32 cam controller. For further accuracy, a colour sensor is placed onto the system such that farm owner can monitor colour changes of plants when young through maturity. The height and stem width of the plant are measures by an adjustable infrared sensor and a variable infrared sensor respectively. The height sensor is used to measure crop growth over a period of time.

The processing unit consists of two microcontrollers, one is an ESP 32 controller and the other one is the node mcu. The ESP 32 cam is specifically used to process images taken by the camera and tell at which stage of growth the plant is at. The other microcontroller is the node mcu or ESP 8266 which will be used to handle other sensors like height sensor, stem width sensor as well as the colour sensor. It is also in control of most output modules like the GSM module and LCD.

For the outputs of the system we have the LCD and the GSM module. The GSM module is used to send messages to the farm owner to inform of plants growth. The lcd is there to display crop information so that farm workers can also interpret the growth pattern of the plants. The images taken are sent to the base station near the farm so that they are stored and can be saved for further analysis.

FLOW CHART



Flow chart above describe clearly how the code and the whole system will be working. The system will be constantly monitoring the plant's growth. It does this using the camera module that takes a picture and that image will be processed by the esp32 which has an algorithm that is specifically coded to depict colour changes during a plant life cycle. The system will be also informing farm owner of any changes in growth through the gsm module that sends informative messages. A localized display is placed onto the system such that any worker can easily monitor the plant through the lcd.

3.3 Recommendations for future work

The system works well as described in this project. There are a few additions that would make the system more reliable. The use of long range modules that can cover a wide distance whilst sending image data to the farm owner. The Long Range modules do not require internet connection which makes them economical.

3.5 Prototype design

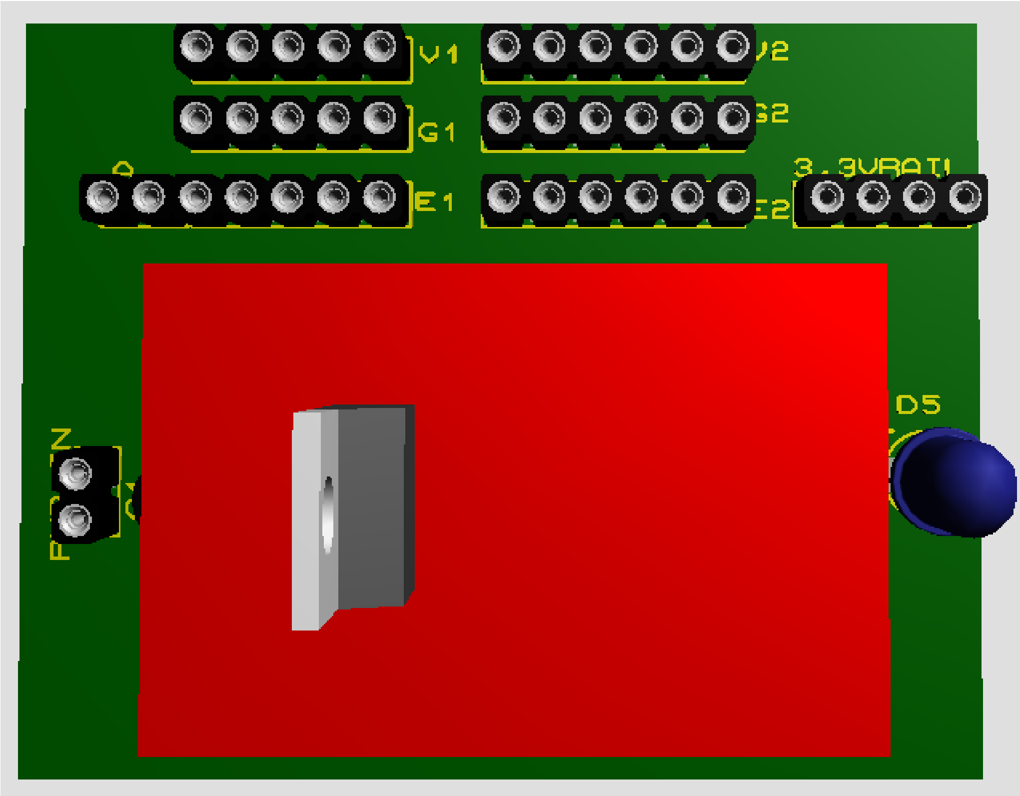


Figure 3.2: 3D view of the printed circuit board

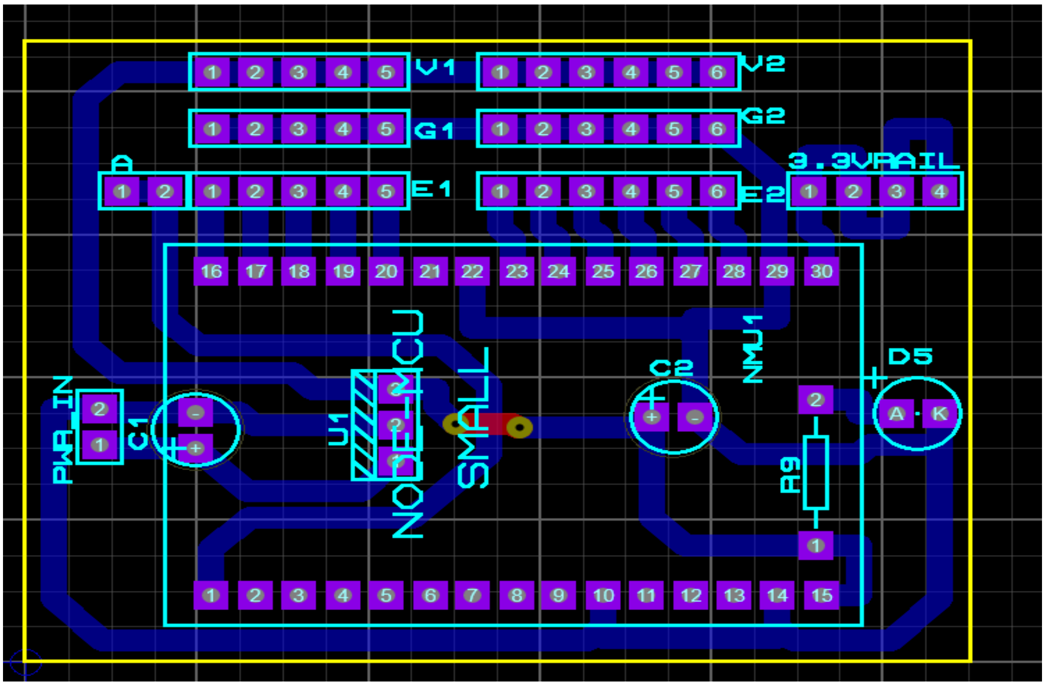


Figure 3.3: Printed circuit board layout

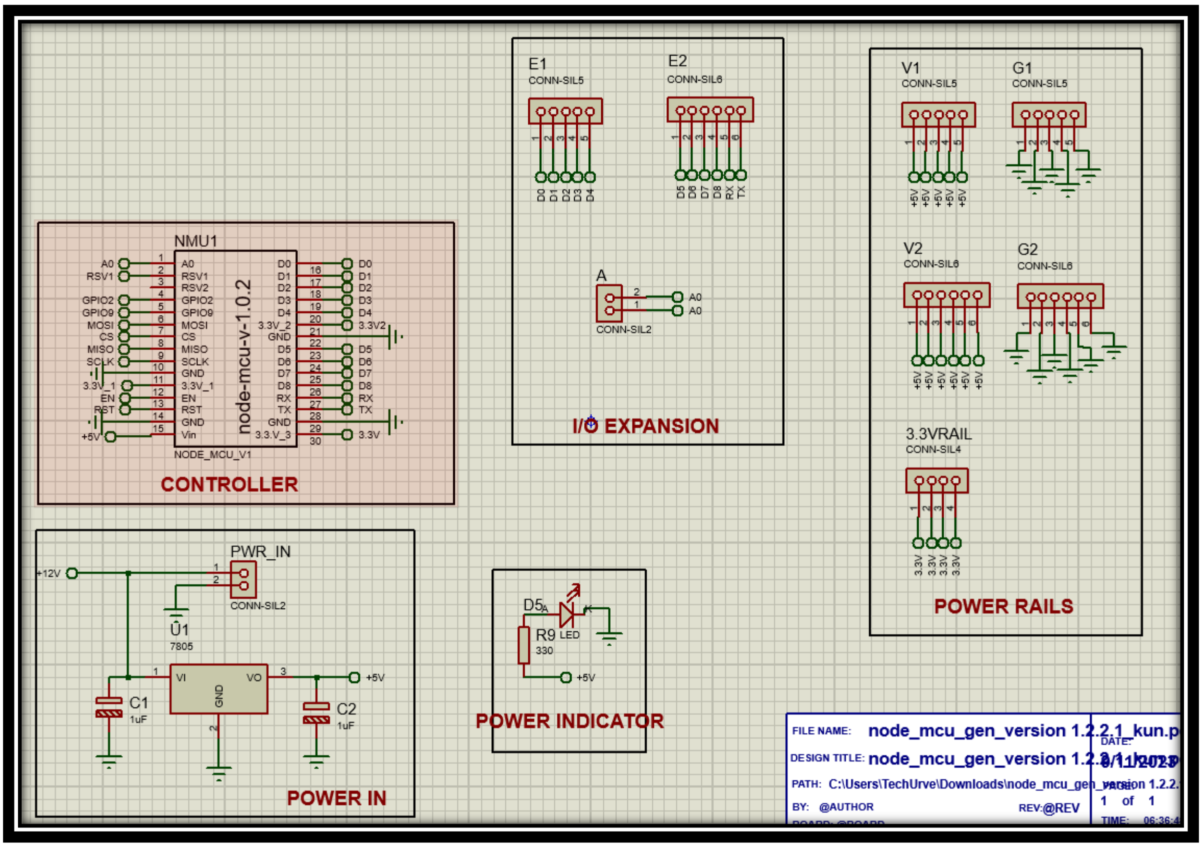


Figure 3.4 circuit diagram

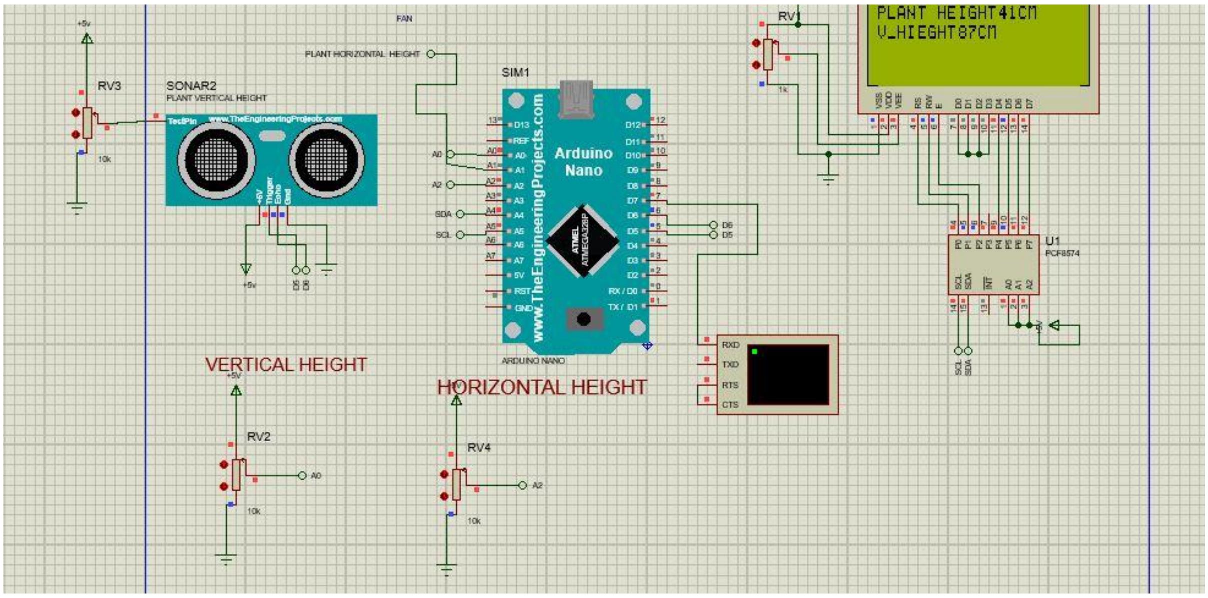


Figure 3.5: height and width simulation

Figure above shows the height and width of the plant simulations. The arduino nano was used in place of the ESP32 node mcu controller for simulation purposes. The vertical height and horizontal height in this case are detected by an ultrasonic sensor which then displays a different value whenever the variable resistor reading is change from one or both heights.

For the development of the system, there were steps that where followed.

Firstly there was a decision to be made on which components to use.

The simulation of the system was the next step to follow. After simulation it was time to design a schematic and a pcb layout. The software used for pcb designing and simulation was proteus version 8.9. after designing the pcb it was time to put the pcb layout on a physical copper board. The system that transferred the pcb onto the board was the computerised numerical control system together with the candle software that controls the cnc machine.

The next step was to drill holes for the component placements and populating the board itself with specific components for the project. The testing phase soon followed and corrections where made till the system was fully functional.

3.5 Summary of the work

The simulations worked as expected. Designing of the pcb was a success though a few challenges were faced. The tracks made by a cnc machine are a bit too close to each other meaning there were a lot of contacts between adjacent copper tracks. There was need to manually remove or the unwanted contacts between tracks. The prototype was developed with only thing left to do was testing it with all the sensors present.

3.6 Recommendations for future work

When milling a printed circuit board with a lot of tracks it is best to use the etching method to reduce time taken in designing the pcb overall. Using larger track sizes (T-80) is helpful in soldering components and drilling holes to place the components.

CHAPTER 4: IMPLEMENTATION

4.1 Introduction

The implementation phase is crucial in translating the design concept into a functional reality. This chapter outlines the key steps involved, from prototype development to system integration and testing. The prototype phase will focus on material selection, manufacturing techniques, and validation of the design's performance. System integration will address the assembly and configuration of the various components and subsystems. Finally, the chapter will emphasize the importance of thorough testing and the strategies for transitioning the project to the final delivery stage.

4.2 Hardware implementation

Figure 4.1 plain copper board

Figure 4.2 Copper/Vero board

The diagram above shows the copper/vero board before any component is soldered on it. This specific copper board has no holes drilled on it which makes it difficult for first timers to solder components. The board also consist of strands offer copper that will be used to carry current across the system.

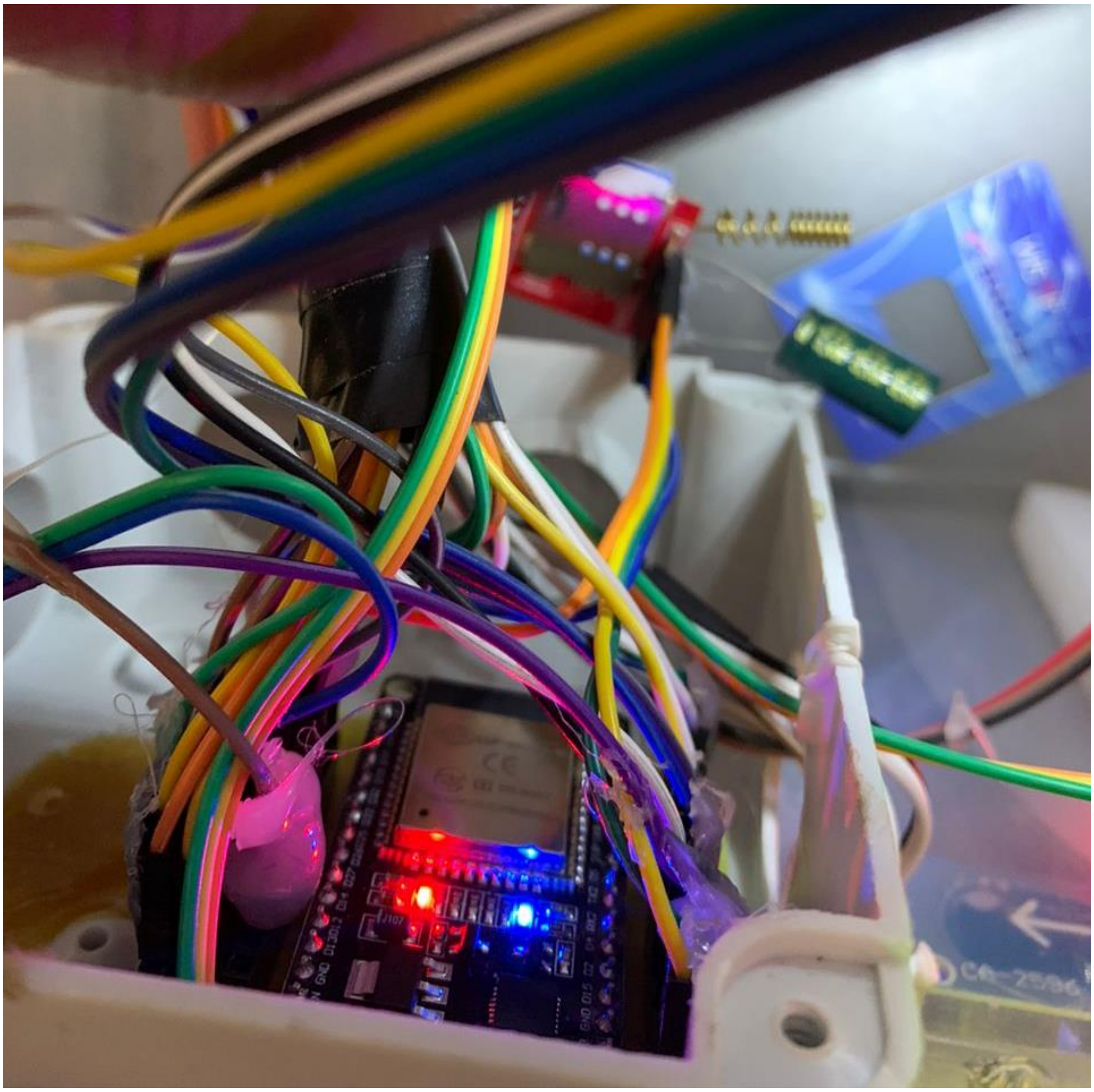


Figure 4.3 components connected to the board to board

The figure above shows the board with components place to it. The copper board below is being used to connect the components together. The component at the centre of the board is the controller(esp32).

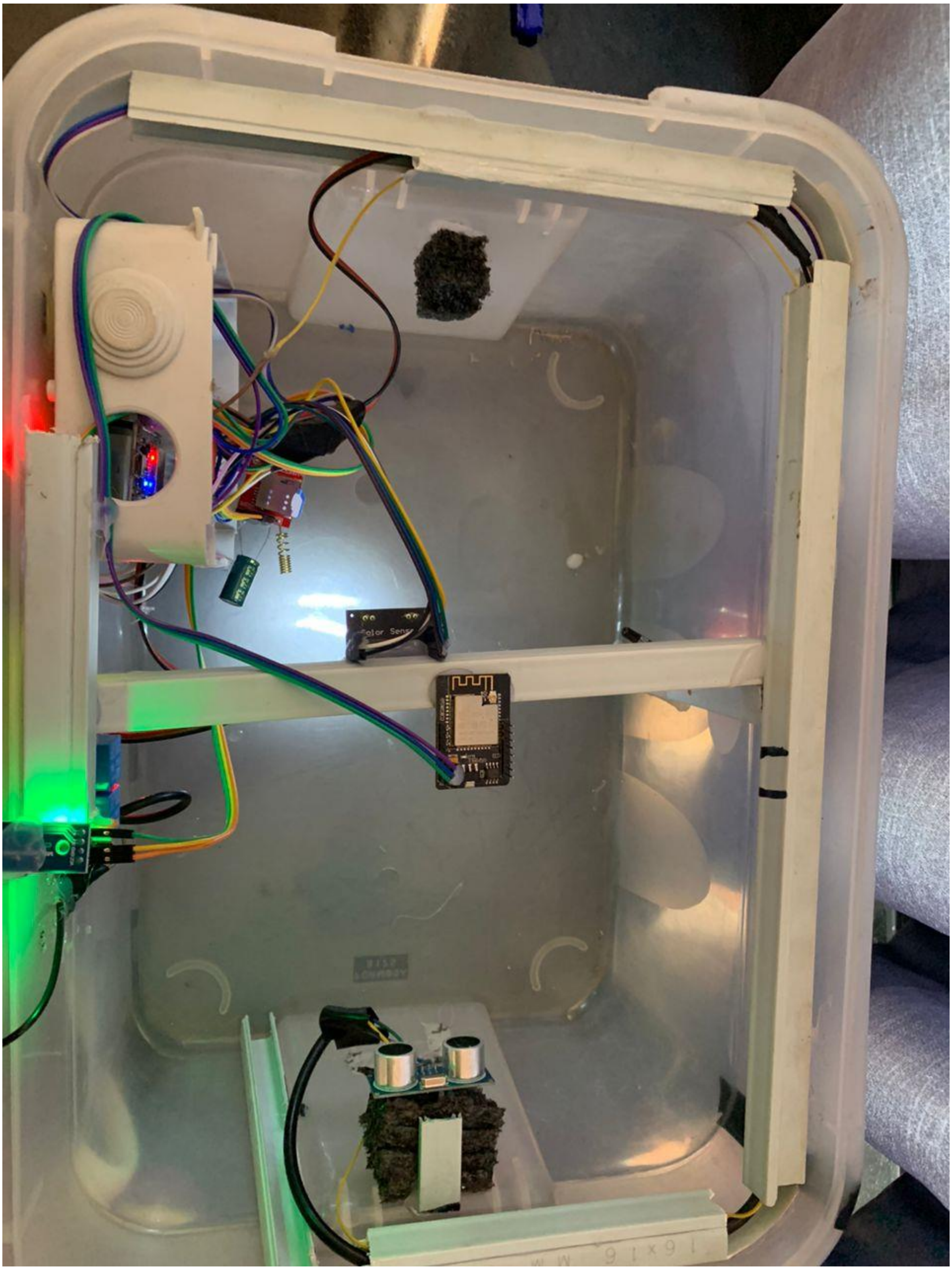


Figure 4.4 sensors connected to system

The figure above shows the sensors carefully places on the copper board. The gsm module uses four pins which are two data pins, ground pin and the vcc pin. The ultrasonic sensor uses 4 pins and are connected using the insulated cable to the main board. The sensor uses two data pins which are the trig and the echo pins.

4.3 Software Implementation

```
// Check if file already exists.
if (file_exists($target_file)) {
  echo "Sorry, file already exists.";
  $uploadOk = 0;
}

// Check file size.
if ($_FILES["imageFile"]["size"] > 500000) {
  echo "Sorry, your file is too large.";
  $uploadOk = 0;
}

// Allow certain file formats.
if($imageFileType != "jpg" && $imageFileType != "png" && $imageFileType != "jpeg" && $imageFileType != "gif'
  echo "Sorry, only JPG, JPEG, PNG & GIF files are allowed.";
  $uploadOk = 0;
}
```

Figure 4.5 php script

This section is for adding an image from the controller to the pc. It uses a server script called xampp that has a build in data base and can handle request such as saving images to pc. The images are then backed up by google drive to the cloud making them available for viewing any time. The language that is being used here is the php script to save images.

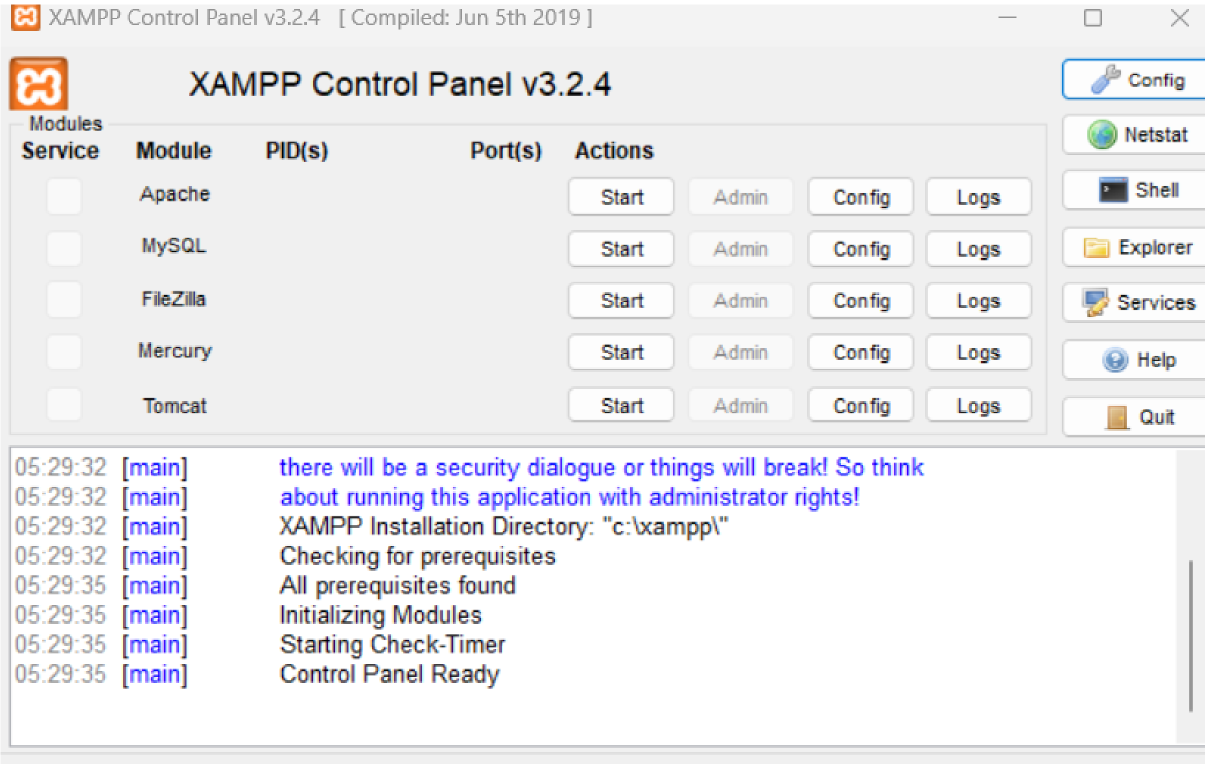


Figure 4.6 xampp

This software is the main engine that handles every image saving request, it has databases and can run php scripts. In this particular project it is being used to run the image saving php script. It directs the images to the folder called esp_images and then it chooses which image format to save them as. The software has built in sql database which allowes us to save as much data as possible.

CHAPTER 5: RESULTS AND DISCUSSIONS

5.1 Introduction

This chapter clearly discuss the behaviour of the system in accordance with the expected results. There will be analysis of the results of the system whether they tallied with the expected outcomes. The chapter also discuss on the way forward of the system and any amendments that needs to be done on the system.

5.2 Evaluation of Results

Conditions	Expected Results	Actual Results
When plant height is above 50cm	A text should be sent, an image should be taken for confirmation, lcd to display that the plant height has reached 50cm.	An image was taken, lcd displayed that the plant height has reached 50cm and the text was sent
When plant left or right width is above 50cm	A text should be sent, an image should be taken for confirmation, lcd to display that the plant width has reached 50cm.	An image was taken, lcd displayed that the plant widthto the left or right has reached 50cm and the sent was sent
When soil moisture is below 40%	Relay for turning on pump should turn on and pump should start irrigating the plant, lcd to display the soil moisture percentage value	Pump turned on and the lcd displayed the soil moisture levels
When soil moisture is above 40%	Pump to turn off	Pump turned off

Table 5.1 results of the system

From the table above, the system performed as expected with most of the desired functionalities working well. The system was very responsive in terms of changes in plant height, width and moisture content of soil. When plant height increased above 50cm and the width above 50cm, the system responded by taking an image and sending it to the cloud, while also sending alert sms which alerted the owner of what was taking place at that particular moment. The system also did nothing when everything was fine showing that it was working properly in according to the values of the moisture sensor.

Figure 5.1 system showing the plant height, left and right width of plant triggered display on lcd

This section shows that the system had detected that plant height and width had increased above 50cm, the lcd was clear displaying the information for the owner to see what was taking place.

Figure 5.2 shows soil moisture sensor reading on lcd

The soil moisture sensor value is above the threshold of 40% moisture hence the relay switch is not active and the pump is off.

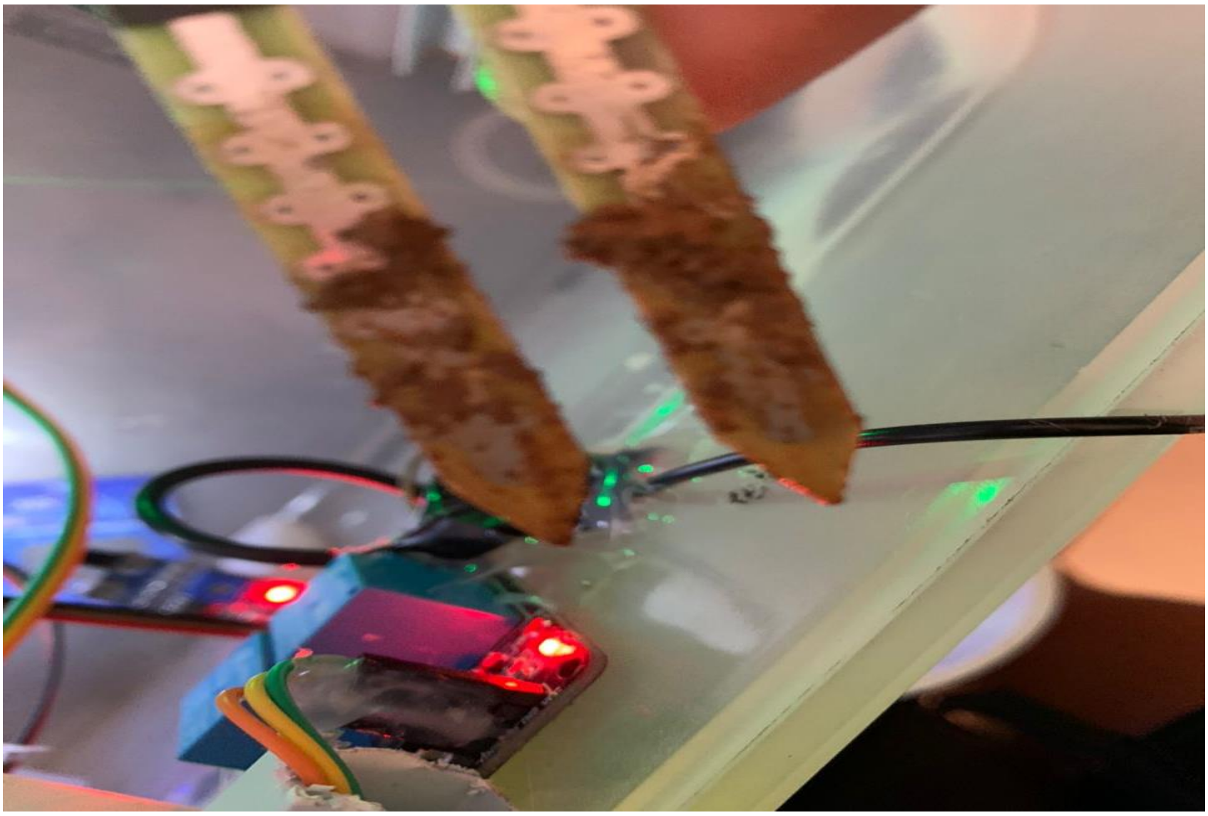


Figure 5.3 shows a soil moisture sensor and an active relay switch

Figure above shows a soil moisture sensor removed from the moist soil hence hols a current reading of 0% moisture hence the reason the relay switch is active to switch on the pump for irrigation.

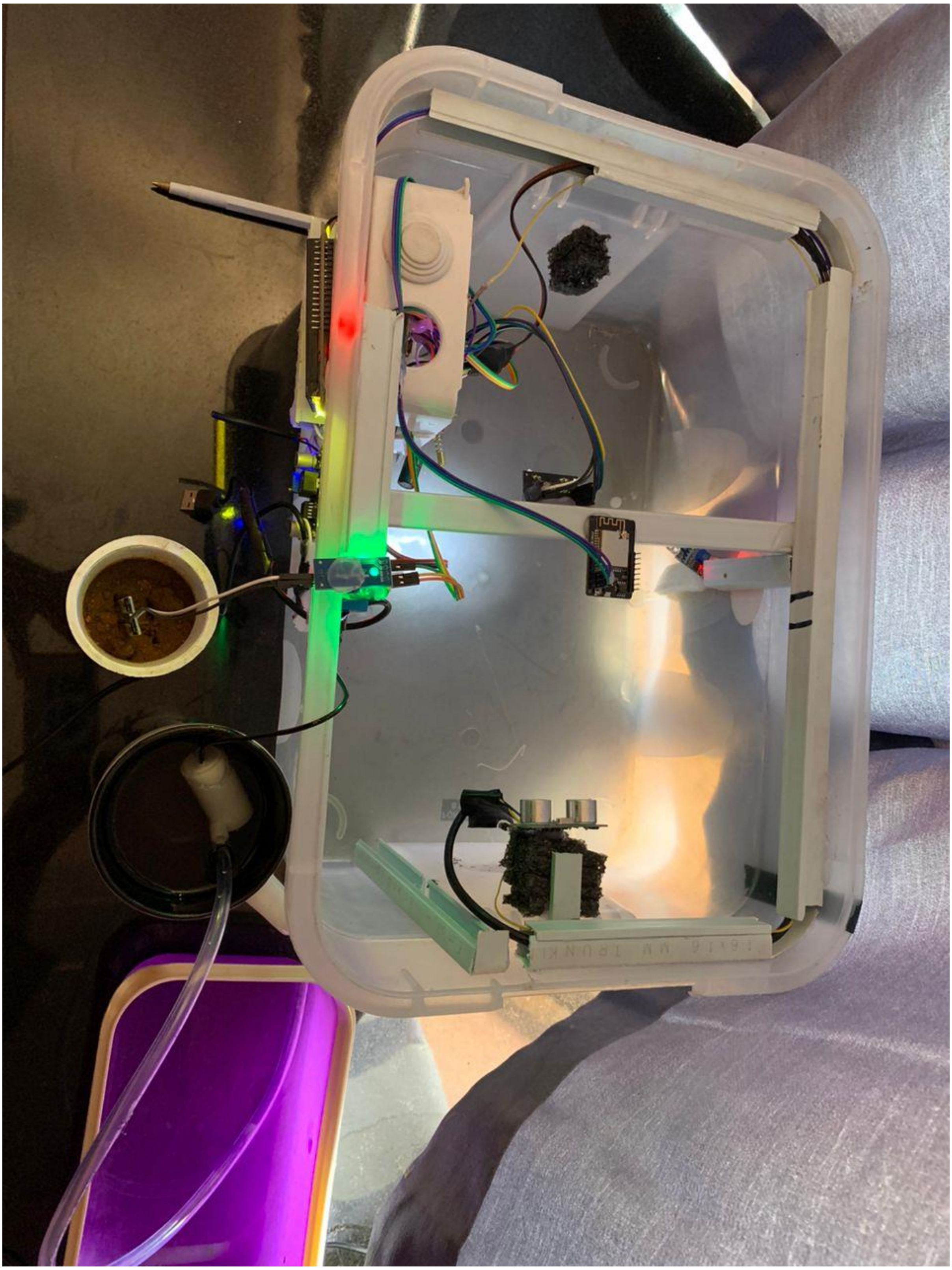


Figure 5.4 complete system

The figure above clearly shows the system in an up view. One can clearly see the gsm module, the esp 32 cam, soil moisture sensor, pump and the ultrasonic sensor situated on side of the casing.

5.3 Conclusion

In conclusion, the project was a success. The system performed well. There were a few challenges faced. One of them being calibrating the ultrasonic sensor which need to determine the maximum distance that can be recorded whilst making distance greater than the required as zero.

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