VISVESVARAYA TECHNOLOGICAL UNIVERSITY

JNANA SANGAMA, Belagavi-590018, Karnataka

Project Report

On

"SMART FARMING: IMAGE BASED CROP DISEASE DETECTION"

Submitted in partial fulfillment of the requirement for the award of the degree of

Bachelor of Engineering

In

Electronics and Communication Engineering

Submitted by

CHANDANA K H	1VI20EC011
DEEPIKA M V	1VI20EC017
VANAMPALLI KARTHIK REDDY	1VI20EC077
Y KIRAN KUMAR REDDY	1VI20EC081

Under the guidance of

Prof. SHRUTHI M

Assistant Professor

Department of ECE

Department of Electronics & Communication Engineering

VEMANA INSTITUTE OF TECHNOLOGY

(Affiliated to VTU & Approved by AICTE)

#1, Mahayogi Vemana Road, Koramangala, Bengaluru– 560034

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VEMANA INSTITUTE OF TECHNOLOGY

(Affiliated to VTU & approved by AICTE)

#1, Mahayogi Vemana Road, Koramangala, Bengaluru-34

Accredited by NBA

Department of Electronics and Communication Engineering

CERTIFICATE

Certified that the Project entitled **"Smart Farming: Image Based Crop Disease Detection"** is carried out by **Chandana K H (1VI20EC011)**, **Deepika M V (1VI20EC017), Vanampalli Karthik Reddy (1VI20EC077),** and **Y Kiran Kumar Reddy (1VI20EC081)** in partial fulfilment for the award of Bachelor of Engineering degree in Electronics and Communication Engineering, Visvesvaraya Technological University (VTU), Belagavi during the academic year 2023. The Project report hasbeen approved as it satisfies the academic requirements in respect of the project work prescribed for thesaid degree.

Guide	**Head of the department**	**Principal**
(Prof. Shruthi M)	(Dr. Parameshwara M C)	(Dr. Vijayasimha Reddy B G)

EXTERNAL VIVA

Name of the Examiners	Signature with date
1. ______________________	______________________
2. ______________________	______________________

ABSTRACT

Crop diseases is a significant threat to global food security, impacting agricultural yields and causing substantial economic losses for farmers worldwide. The increasing need for sustainable agriculture, early detection and management of crop diseases are critical. A network of sensors is deployed within the greenhouse environment to monitor various parameters such as temperature, humidity, and soil moisture. Additionally, images of tomato plants and fruits are captured at regular intervals using cameras installed within the greenhouse. The captured images undergo preprocessing to enhance quality and extract relevant features. Subsequently, a CNN-based algorithm is employed for disease detection. CNNs are well-suited for image analysis tasks due to their ability to automatically learn and extract hierarchical features from images. Transfer learning techniques are also utilized to leverage pre-trained models and improve detection accuracy, particularly in scenarios with limited labeled data. The effectiveness of the proposed approach in accurately identifying common diseases affecting tomato leaves and fruits, such as leaf mold, curl virus etc. The CNN model achieves high classification accuracy, enabling timely intervention to mitigate disease spread and minimize yield losses. Moreover, the integration of greenhouse monitoring systems enhances overall agricultural management by providing real-time data on environmental conditions and crop health status. The fusion of greenhouse monitoring with image-based disease detection, powered by CNN algorithms, offers a promising solution for sustainable agriculture. By enabling early detection and precise management of crop diseases, this approach contributes to improving yield quality and quantity while reducing the environmental impact of agricultural practices.

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CHANDANA K H	**(1VI20EC011)**
DEEPIKA M V	**(1VI20EC017)**
VANAMPALLI KARTHIK REDDY	**(1VI20EC077)**
Y KIRAN KUMAR REDY	**(1VI20EC081)**

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Chapter 1

INTRODUCTION

Sustainable agriculture helps in the encouragement of farming practices and approaches to help sustain farmers and resources. This plays a significant role in preserving natural resources, halting biodiversity loss. A frequently-used option for implementing these systems is the Raspberry Pi, an affordable, compact, and flexible computer. Greenhouse monitoring involves continuously observing and controlling environmental parameters inside a greenhouse, such as temperature, humidity, light intensity, soil moisture, and CO2 levels. These factors directly influence plant health, growth, and yield. By closely monitoring and managing these parameters, farmers and growers can create ideal conditions for plants, leading to increased productivity and reduced resource wastage. The Raspberry Pi runs a Linux-based operating system, usuallyRaspbian or Raspberry Pi OS. Programs can be written in languages like Python or use existing open-source libraries to interact with sensors, collect data, and control actuators. The Raspberry Pi's GPIO (General Purpose Input/Output) pins allow easy integration with external sensors and actuators. Further, these sustainable practices are integrated with technological advancements. The major challenges of agriculture/farming across the worldcan be resolved in an efficient and effective manner. The idea is to enable farmers more reliable monitoring their fields remotely, allowing the operation of several facilities at onetime Farmers don't need to repeat the same crop cultivation always instead, they can choosethe crop as per their farm soil nature/condition. Farmers no longer have to apply water, fertilizers, and pesticides excess across their fields. Instead, they can use the minimum quantities required and target very specific areas, or even treat individual plants differently.

1.1 Aim and Objectives

1.1.1 Aim

The aim is to conduct a comprehensive analysis of Image-Based crop disease detection methodologies with a focusing on understanding the current state of techniques, challenges, and recent advances.

1.1.2 Objectives

1. The primary objective of smart agriculture monitoring system is to create an optimal growing environment for plants by monitoring and controlling environmental factors such as temperature, humidity, light intensity, Smoke, PH levels, water level and NPK Sensor.

2. To detect and monitor crop diseases and nutritional deficiencies.

3. To develop user interface to choose a particular crop, set values for different parameters or load data.

4. To enhance efficiency, reduces labour requirements and allows farmers to manage their operations.

1.2 Plan of Action for Project

- Python and its respective libraries are installed.
- Design and development of greenhouse model using Python.
- Testing the Raspberry Pi Pico for accuracy and efficiency.
- Successfully implementing the greenhouse monitoring and control system model.

1.3 Problem Statement

The main existing problem now a days in agriculture are lack of real time monitoring and decision making. To address the associated technologies to enable precisionfarming, automate agricultural processes, enhance resource management, facilitate early pest and disease detection, and provide farmers with data driven insights for informed decision making.

1.4 Structure of Report Chapter

1: Introduction Chapter

2: Literature Survey Chapter

3: Design Methodology Chapter

4: Requirement specifications Chapter

5: Results and discussion Chapter

6: Conclusion

Chapter 2

LITERATURE SURVEY

2.1 Pradyumna K. Tripathy, Ajaya K. Tripathy, Aditi Agarwal and Saraju P. Mohanty "An IOT-Enabled Smart Greenhouse for Sustainable Agriculture" – [FEB 2021]

KEYWORDS: Multimodel data aggregator, PH sensor, NPK Sensor, Decision Support system (DSS).

The IoT has revolutionized agriculture by enhancing productivity, optimizing resource usage, and reducing production costs. This paper focuses on sensors and IoT in greenhouse farming, monitoring parameters like humidity, water nutrient levels, pH, temperature, UVlight intensity, CO2 levels, and insecticide/pesticide amounts. A decision support system (DSS) acts as a control operating system, enabling early fault detection and diagnosis. Green house proposes solutions for challenges in greenhouse rose farming, improving productivity and reducing costs compared to manual processes. IoT automation minimizesmanual work and data gathering, refining accuracy.

2.2 Sadhana Tiwari, Neha Sharma "Real Time Monitoring of Smart Greenhouse Environment using IOT for Sustainable Agriculture" [SEPTEMBER 2020]

KEYWORDS: IOT, Arduino UNO, ESP32, WSN, Greenhouse effect.

This paper explores IoT-based greenhouse technology in agriculture, replacing manual monitoring with efficient cultivation regardless of conditions. The model protects plants from extreme weather and pests. Sensor data is processed and sent to the cloud for displayon a customized webpage. The model comprises hardware (ESP32, sensors, etc.) and software modules. Real-time monitoring of greenhouse parameters enables pesticide-free crops, incubation control, and temperature-dependent sex determination. The system can be installed by individuals without farming knowledge, even on rooftops.

2.3 Saraswathi Shelvane, Madhuri Shedage, Akshada Phadtare "Greenhouse monitoring using Raspberry Pi" - [APRIL 2019]

KEYWORDS: Raspberry Pi, Android App, Greenhouse monitoring, DHT11 Sensor,Two electrode Sensor, Light dependent resistor

A Raspberry Pi is used to continuously monitor and control environmental parameters suchas temperature, soil moisture, light intensity, and humidity in a greenhouse. This enables optimal plant growth throughout the year. Sensors like DHT11 and soil moisture sensors provide accurate data for temperature, humidity, and water content in the soil. Raspberry Pi is connected to a cooling fan, artificial light, and a motor pump, making use of IoT technology for remote control and monitoring.

2.4 B. Lanitha, E. Poornima, R. Sudha, D. Beulah David, K. Kannan, R. Jegan, Vijaykumar Peroumal, R. Kirubagharan and Meroda Tesfaye "IoT Enabled Sustainable Automated Greenhouse Architecture with Machine Learning Module"- [JUNE 2022]

KEYWORDS: Node MCU, Blynk Server, Cloud Storage, DHT11, MQ2

This paper proposes a sustainable and automated greenhouse architecture using JOT technology and machine learning. The conventional offline techniques are replaced with cloud-based and wireless systems. The architecture enables continuous monitoring of various aspects of the irrigation control system, such as pH, electrical conductivity, and flow rate. By integrating fertigation and disease prevention systems, crop yield can be increased by 50%. The greenhouse management system utilizes continuous sensing, data sharing, and communication between devices, allowing growers to predict future conditions and take appropriate actions to prevent outbreaks. Mathematical models integrated with BOT-based sensor data aid in minimizing risks.

2.5 Muhammed Shoaib Farooq, Rizwan Javid, Shamyla Riaz and Zabihullah Atal "IoT Based Smart Greenhouse Framework and Control Strategies for Sustainable Agriculture"- [September 2022]

KEYWORDS: Internet of Things (IOT), Sensors, Communication Protocols. Cloud Computing, Security Attacks

This paper presents an IoT-based smart greenhouse framework for sustainable agriculture. It utilizes IoT technology, sensors, and communication protocols to monitor various aspectsof the greenhouse, including humidity, disease, pests, plant growth, seedling tracking, weather conditions, and pest control. By integrating sensors with mathematical models, growers can predict and prevent crop diseases caused by factors like rainfall, high temperatures, fog, and unexpected climate conditions. The use of soil moisture, electrochemical, optical, electromagnetic, and other sensors allow for precise measurement of greenhouse conditions. These technologies help reduce labour requirements and mitigate the impact of abrupt climate changes on farmers and agriculturalactivities.

2.6 Pandu Naik, Sujana SR, Amal Murali, Sagar Shetty, Sanjana Vasu Naik “Greenhouse Monitoring using IoT”- [JULY 2021]

KEYWORDS: Atmospheric Sensors, Iot, Arduino UNO, Website or Cloud, DC Motor, Relay.

In this paper the proposed system, environmental parameters within the greenhouse are monitored and can be controlled either manually or through a dedicated Android application. If any climate values fluctuate the precautionary measures will be taken by the user. The relationship between reference estimations and sensor flags, breaking down the developments. In android app the display console shows the measured values of moisture and temperature. The cloud stores all the details about the growth of plants.

Chapter 3

CROP DISEASE DETECTION

3.1 Introduction of Image based crop disease detection.

In modern agriculture, the integration of technology for enhanced crop monitoring and disease detection is becoming increasingly vital to ensure high yield and quality produce. One of the crops that significantly benefit from such technological advancements is tomato. Tomato plants are susceptible to a variety of diseases that can affect both the fruit and leaves, potentially leading to substantial economic losses. Early and accurate detection of these diseases is crucial for effective management and mitigation.

To optimize the growing conditions and enhance disease detection, a comprehensive greenhouse monitoring system is implemented. This system continuously monitors various environmental parameters such as temperature, humidity, light intensity, and soil moisture. By integrating these data points with the visual information from the plant images, it is possible to create a robust system for maintaining plant health and ensuring early disease detection.

The Advancements in image processing and machine learning techniques have enabled the automated and precise detection of plant diseases. Image-based disease detection involves capturing images of tomato plants and analyzing these images to identify signs of diseases on fruits and leaves. This approach utilizes the capabilities of Convolutional Neural Networks (CNNs), a type of deep learning algorithm that excels in image recognition tasks.

Convolutional Neural Networks (CNNs) are employed for their efficiency in image classification tasks. The CNN model is trained using the labeled database, learning to recognize patterns and features associated with different diseases. During the training process, the model adjusts its weights through backpropagation, minimizing the error between predicted and actual labels. Once trained, the CNN can analyze new images of tomato plants, accurately detecting and classifying diseases based on learned features.

To implement an image-based disease detection system, the first step is to collect a comprehensive dataset. This involves capturing thousands of images of tomato plants under different conditions and at various stages of growth. These images must include healthy plants as well as plants affected by different diseases. The images are labeled with relevant information about the disease type and its level of impact, creating a rich database that serves as the foundation for training the CNN model.

The integration of image-based disease detection using CNN algorithms with a comprehensive greenhouse monitoring system represents a significant advancement in modern agriculture. This approach not only enhances the ability to detect diseases early but also optimizes growing conditions, ultimately leading to healthier crops and higher yields. By leveraging technology, farmers can make more informed decisions, reduce losses, and improve the overall efficiency of tomato cultivation.

3.2 Block Diagram of crop disease detection

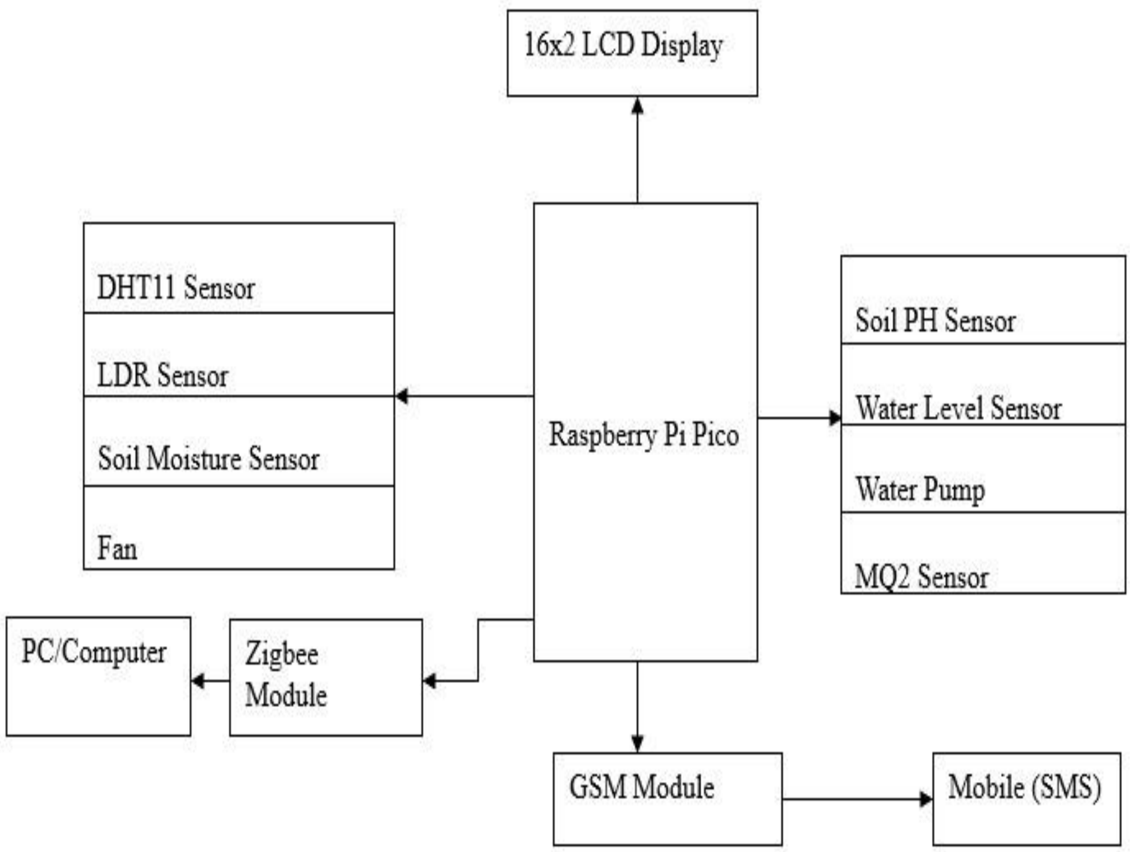

Figure 3.2 Block Diagram of crop disease detection.

The block diagram of crop disease detection is shown in the figure 3.2. Designing a block diagram for a crop disease detection system in tomato crops involves integrating various sensors and components to monitor and manage the crop environment effectively. The different types of components used in the system are as follows:

Sensors:

- **DHT11 Sensor:** Measures temperature and humidity. These environmental factors are crucial as certain diseases thrive in specific temperature and humidity ranges.
- **LDR (Light Dependent Resistor):** Monitors light intensity. Adequate light is essential for the growth of tomato plants and can also affect disease prevalence.
- **Soil Moisture Sensor:** Measures the moisture content in the soil to ensure optimal watering and to detect conditions that might favor disease development.
- **Soil pH Sensor:** Monitors the pH level of the soil, as certain pH levels can make plants more susceptible to diseases.
- **MQ2 Gas Sensor:** Detects the presence of harmful gases (like methane, butane, LPG, and smoke) which can be indicators of poor air quality or pest infestation.

Actuators:

- **Water Pump:** Controlled based on the soil moisture readings to ensure the plants are watered adequately without overwatering.
- **Fan:** Used for temperature and humidity control, activated based on the readings from the DHT11 sensor.

Modules:

- **GSM Module:** Sends alerts or updates to the farmer's mobile phone about the condition of the crop, enabling remote monitoring and control.
- **Zigbee Module:** Facilitates wireless communication between various components, enabling data transfer and control commands across the system.
- **PC/Computer:** Acts as the central control unit, processing data from the sensors, making decisions based on predefined thresholds, and controlling the actuators. It also stores historical data for analysis.
- **Mobile:** Receives notifications from the GSM module and can also be used to send commands to the system.

Display:

- **16x2 LCD Display:** Shows real-time data from the sensors (temperature, humidity, soil moisture, soil pH, etc.) and system status for on-site monitoring.

Data Collection:

Sensors (DHT11, LDR, Soil Moisture, Soil pH, MQ2) collect environmental and soil data. The collected data is sent to the PC via the Zigbee module for processing.

Data Processing:

The PC receives the sensor data and processes it to determine the current condition of the crop environment. The PC stores the data for historical analysis and sends relevant information to the 16x2 LCD display for real-time monitoring.

Decision Making:

Based on predefined thresholds and algorithms, the PC decides if any action is needed (e.g., activating the water pump if the soil moisture is low, or turning on the fan if the temperature is too high).

Actuator Control:

The PC sends control signals to the water pump, fan, or other actuators based on its analysis. Actuators respond by adjusting the environment to optimal conditions.

Remote Monitoring and Control:

The GSM module sends alerts and updates to the farmer’s mobile device about the crop conditions. The farmer can send commands back to the system via the mobile, allowing for remote control of the actuators if necessary.

Display and Local Monitoring:

The 16x2 LCD display shows current sensor readings and system status, allowing for immediate on-site monitoring.

This system provides a comprehensive solution for monitoring and managing the health of tomato crops by integrating various sensors and actuators with communication modules. The PC acts as the central hub, processing data and controlling the environment to prevent diseases and optimize growth conditions. Remote monitoring and control via GSM and Zigbee modules ensure that the farmer can manage the crop effectively from any location. The 16x2 LCD display provides a straightforward way to view real-time data on-site.

3.3 Flow Chart

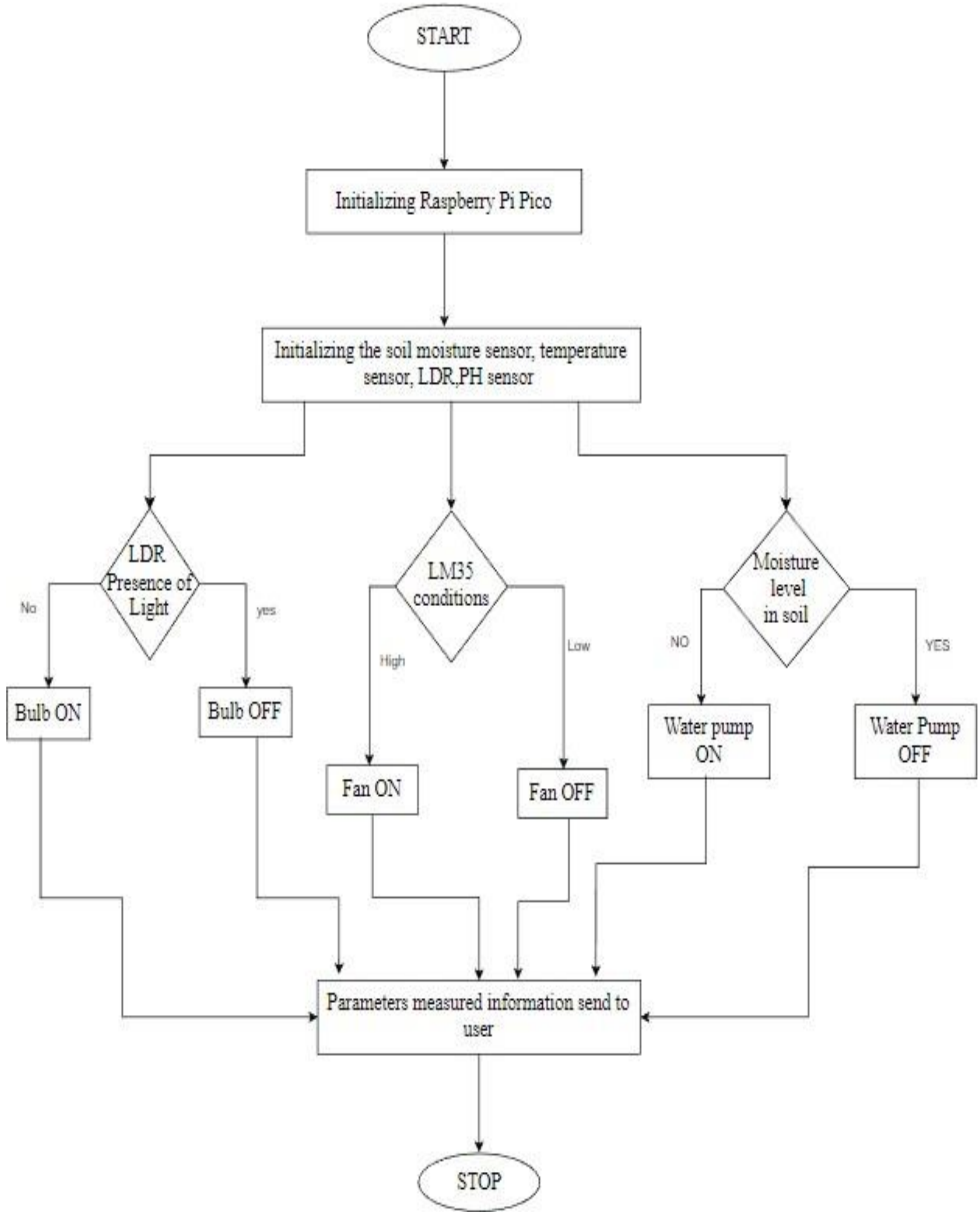

Figure 3.3 Flow Chart of crop disease detection.

The implementation of image-based crop disease detection for a tomato plant using a Raspberry Pi Pico involves several steps. Below is an explanation of each step and component in the process:

Start:

- The process begins.

Initialize Raspberry Pi Pico:

- The Raspberry Pi Pico microcontroller is initialized. This sets up the device for further operations and ensures all libraries and hardware interfaces are ready.

Initialize Sensors:

- All sensors connected to the Raspberry Pi Pico are initialized. This includes Light Dependent Resistor (LDR), soil moisture sensor, and LM35 temperature sensor.

LDR - Presence of Light:

- The LDR sensor checks for the presence of light.
- No (Bulb On): If there is no light detected, the system turns on a bulb to ensure proper lighting for the camera to capture clear images.
- Yes (Bulb Off): If light is present, the bulb remains off.
- Check Soil Moisture Level:
- The soil moisture sensor checks the moisture level in the soil.
- No (Water Pump On): If the soil moisture is low, the water pump is turned on to irrigate the plant.
- Yes (Water Pump Off): If the soil moisture is adequate, the water pump remains off.

Check Temperature with LM35:

- The LM35 temperature sensor checks the ambient temperature.
- High (Fan On): If the temperature is too high, a fan is turned on to cool down the plant environment.
- Low (Fan Off): If the temperature is within acceptable limits, the fan remains off.

Capture Image of Tomato Plant:

- The system captures an image of the tomato plant using a camera module.

Process Image for Disease Detection:

- The captured image is processed using a machine learning model to detect any diseases on the tomato plant.

Parameters Measured:

- All measured parameters (light, soil moisture, temperature) and the results of the disease detection are compiled.

Send Information to User:

- The compiled information, including the status of the sensors and disease detection results, is sent to the user via a predefined communication channel (e.g., SMS, email, or a mobile app).

End:

- The process ends, and the system waits for the next cycle to start again.

The flowchart for image-based crop disease detection on a tomato plant using a Raspberry Pi Pico involves initializing the microcontroller and sensors, checking environmental conditions (light, soil moisture, temperature), capturing and processing an image for disease detection, and sending the compiled information to the user. This system ensures that the plant receives the necessary care and that the user is informed about the plant's status and any detected diseases.

Chapter 4

REQUIREMENT SPECIFICATIONS

4.1 Hardware Requirements

4.1.1 Raspberry pi Pico

Raspberry Pi Pico is a development board built around this powerful yet low-cost RP2040 microcontroller. Like Raspberry Pi computers, Raspberry Pi Pico features a pin header with 40 connections,along with a new debug connection enabling you to analyse your programs directly from another computer (typically by connecting it directly to the GPIO pins on a Raspberry Pi).

Figure 4.1.1 Raspberry pi Pico Microcontroller Board

Features

- RP2040 microcontroller chip designed by Raspberry Pi in the United Kingdom
- Dual-core ARM Cortex-M0+ processor, flexible clock running up to 133MHz.
- 264kB of SRAM, and 2MB of on-board flash storage
- Castellated module allows soldering direct to carrier boards.
- USB 1.1 Host and Device support.
- Low-power sleep and dormant modes.
- Drag & drop programming using mass storage over USB.
- 26 multifunction GPIO pins.

- 2× SPI, 2× I2C, 2× UART, 3× 12-bit ADC, 16× controllable PWM channels.
- Accurate clock and timer on-chip
- Temperature sensor
- Fast floating-point libraries in ROM
- 8× Programmable IO (PIO) state machines for custom peripheral support.

Pin Configuration of Raspberry pi Pico

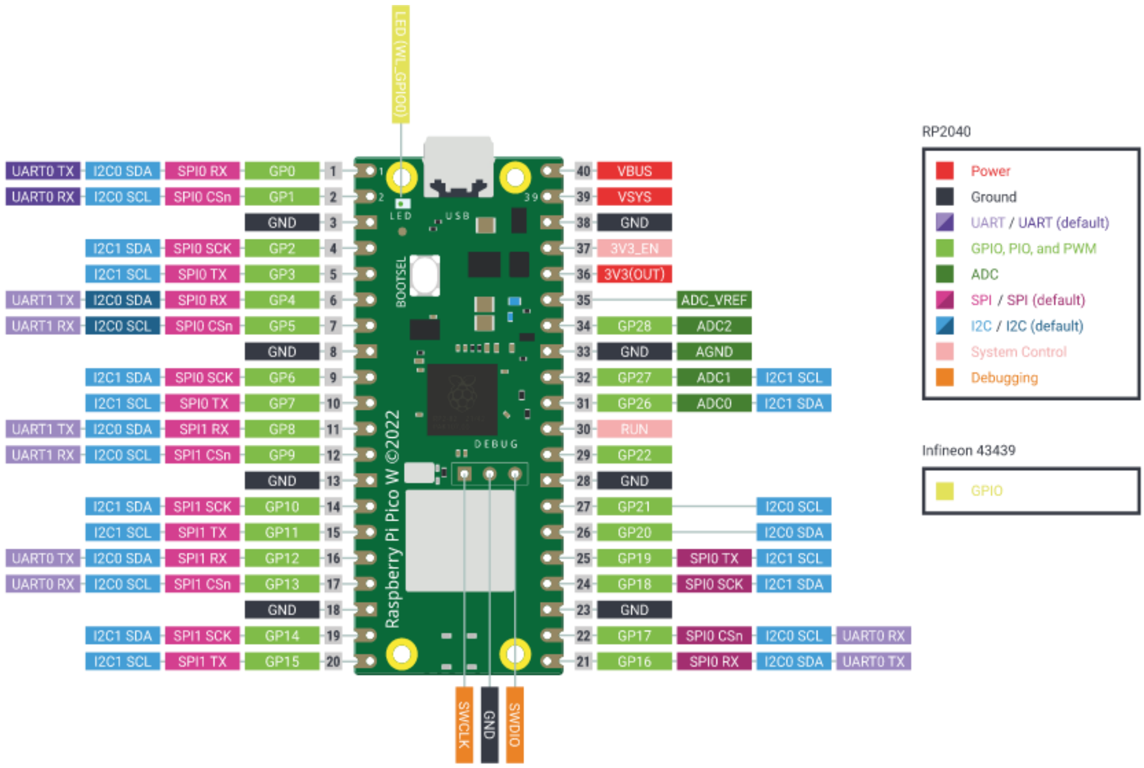

Figure 4.1.1: Pin Configuration of Raspberry pi Pico

4.1.2 LDR Sensor

The **Light Dependent Resistor (LDR)** or also popularly known as Photoresistor is just another special type of Resistor and hence has no polarity so they can be connected in anydirection. They are breadboard friendly and can be easily used on a perf board also. The symbol for LDR is like Resistor but includes inward arrows as shown in the figure 4.1.1 LDR pinout diagram. The arrows indicate the light signals.

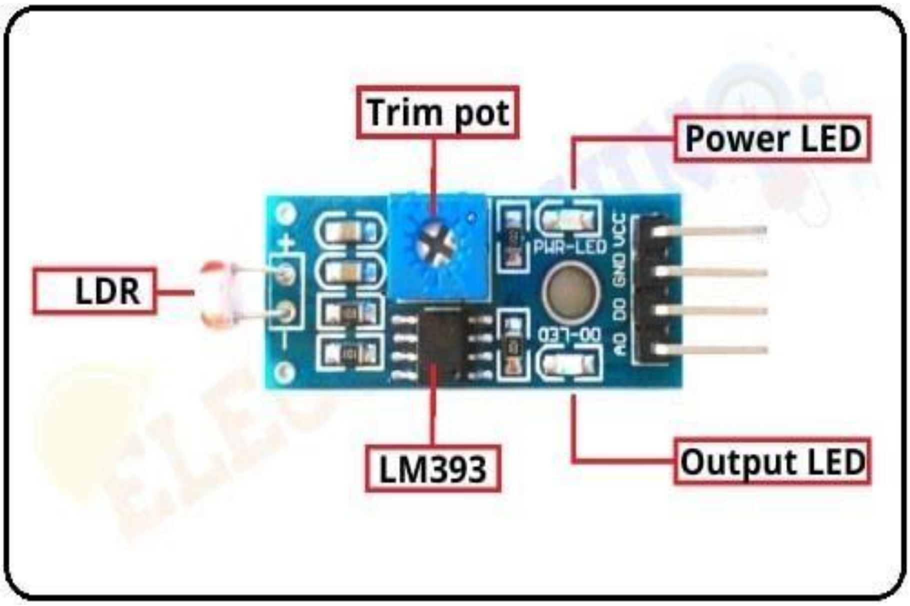

Figure 4.1.2: LDR Sensor

LDR Features:

- Can be used to sense Light.
- Easy to use on Breadboard or Perf Board.
- Easy to use with Microcontrollers or even with normal Digital/Analog IC.
- Small, cheap, and easily available.
- Available in PG5, PG5-MP, PG12, PG12-MP, PG20 and PG20-MP series.

4.1.3 MQ2 sensor

MQ2 gas sensor can be used to detect the presence of LPG, Propane and Hydrogen, also could be used to detect Methane and other combustible steam, it is with low cost and suitable for different application. Sensor is sensitive to flammable gas and smoke. Smoke sensor is given 5 volts to power it. Smoke sensor indicates smoke by the voltage that it outputs. More smoke more output. A potentiometer is provided to adjust the sensitivity. Sn02 is the sensor used which is of low conductivity when the air is clean. But when smoke exist, an analog output is produced based on the concentration of smoke. The circuit has a heater. Power is given to heater by VCC and GND from power supply. The circuit has a variable resistor, and the resistance across the pin depends on the smoke in air in the sensor. The resistance will be lowered if the content is more and voltage is increased between the sensor and load resistor.

Features:

- Operating Voltage is +5V.
- Can be used to Measure or detect LPG, Alcohol, Propane, Hydrogen, and even methane.
- Analog output voltage: 0V to 5V
- Digital Output Voltage: 0V or 5V (TTL Logic)
- Preheat duration 20 seconds.
- Can be used as a Digital or analog sensor.

Advantages:

- Safety of home.
- Control of air quality.
- Measurement of gas level.

Figure 4.1.3: MQ2 Sensor

4.1.4 DHT11 Sensor

The DHT11 is a commonly used Temperature and humidity sensor. The sensorcomes with a dedicated NTC to measure temperature and an 8-bit microcontroller to outputthe values of temperature and humidity as serial data. The sensor is also factory calibratedand hence easy to interface with other microcontrollers. The sensor can measure temperature from 0°C to 50°C and humidity from 20% to 90% with an accuracy of ±1°C and ±1%. If the measurement needs to fall within this range, then this sensor couldn’t be the perfect.

Figure 4.1.4: DHT11 Sensor

DHT11 Features:

- Operating Voltage: 3.5V to 5.5V
- Operating current: 0.3mA (measuring) 60uA (standby)
- Output: Serial data
- Temperature Range: 0°C to 50°C
- Humidity Range: 20% to 90%
- Resolution: Temperature and Humidity both are 16-bit
- Accuracy: ±1°C and ±1%

4.1.5 Soil PH Sensor

Soil pH sensors are essential devices used to measure the acidity or alkalinity of soil, relying on either glass electrode or solid-state sensors to detect pH levels based on the concentration of hydrogen ions in the soil solution. They typically offer a measurement range covering the pH scale from acidic to alkaline conditions, with accuracy and precision varying across different models. Proper installation and periodic calibration are necessary for accurate readings, and data output can be in digital, analog, or wireless formats for remote monitoring. Soil pH sensors find wide applications in agriculture, environmental monitoring, and research, aiding in optimizing soil conditions for plant growth and assessing soil health. Regular maintenance ensures their reliability, and they can be integrated with other sensors for a more comprehensive soil monitoring system.

Features:

- Maximum power consumption: 0.5W (24V DC power supply).
- Measuring range: 3-9 PH.
- Operating temperature: -20℃~60℃.
- Response time: ≤10s.

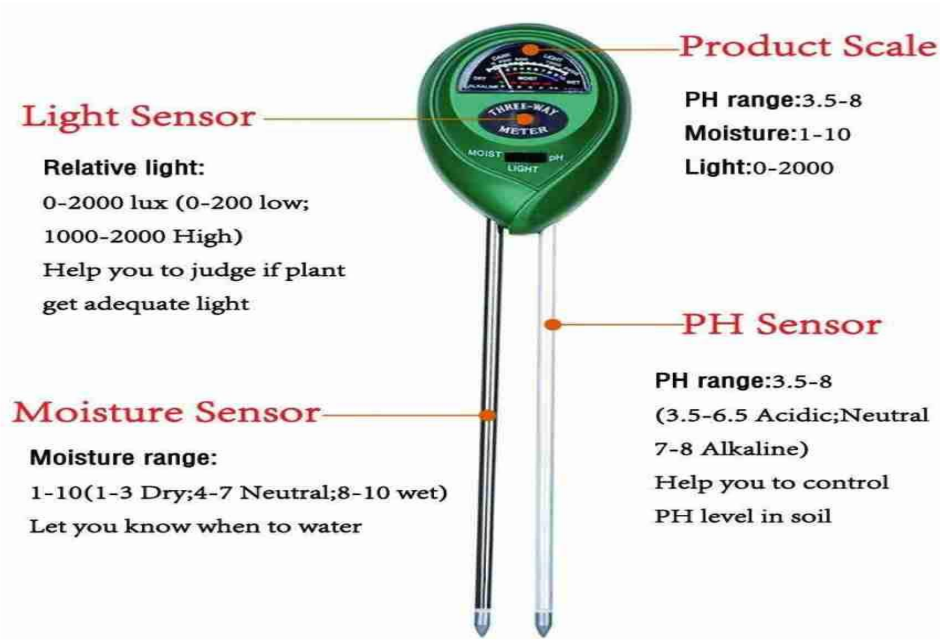

Figure 4.1.5: Soil PH Sensor

4.1.6 Zigbee Module

A Zigbee module serves as a compact wireless communication device operating on the Zigbee protocol, facilitating low-power, low-data-rate communication within networks. Typically comprising a microcontroller unit (MCU), Zigbee radio transceiver, and antenna, these modules enable devices to form mesh networks, allowing for robust and reliable communication via intermediary nodes. Their low-power design makes them suitable for battery-powered applications, and they support interoperability between devices from different manufacturers. Configurable via AT commands or a serial interface, Zigbee modules offer flexibility in network setup and parameter customization. Developers can leverage the MCU to implement custom functionality, while integration with host systems allows seamless incorporation into larger applications. Security features ensure data confidentiality and integrity, making Zigbee modules a versatile solution for wireless connectivity across various domains.

Features:

- Data Rate (Mbps):0.25.
- Power Consumption:10-100mW.
- Spread spectrum: DSSS.
- Number of nodes: 65000.
- Encryption: 128-bit AES.

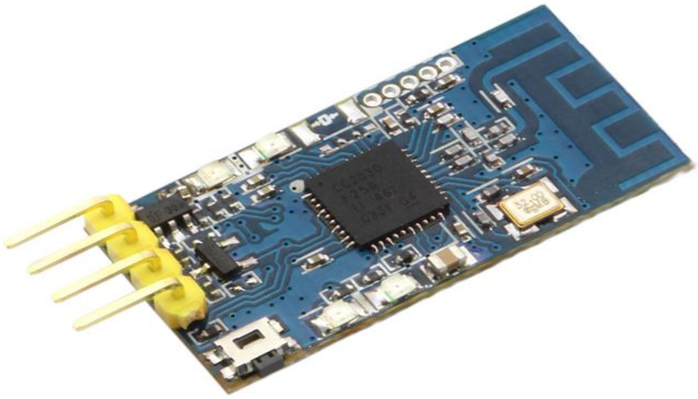

Figure 4.1.6: Zigbee Module

4.1.7 GSM Module

A GSM (Global System for Mobile Communications) module is a compact electronic device that enables mobile communication using GSM standards, consisting of a GSM modem and supporting components like SIM card slots and antenna connectors, these modules allow devices to transmit and receive data, make voice calls, and send SMS messages over cellular networks. They typically operate on standard GSM frequencies and support various communication protocols such as GSM, GPRS (General Packet Radio Service), and SMS. GSM modules are widely used in applications such as remote monitoring, telemetry, vehicle tracking, and IoT (Internet of Things) devices where cellular connectivity is required. They can be interfaced with microcontrollers or embedded systems using serial communication protocols like UART, allowing for integration into larger systems. With features like low power consumption, compact form factor, and widespread network coverage, GSM modules provide a reliable and cost-effective solution for wireless communication in a variety of applications.

Features:

- Operating Frequency: GSM 850 MHz, EGSM 900 MHz, DCS 1800 MHz.

- Operating Voltage Rating: 3.2V-4.8V DC.
- Output Pin Voltage: 5V DC.
- Output Pin Current: 25mA.

Communication Mode: UART Interface, Configured for full duplex asynchronous mode.
Baud Rate: supports auto bauding,9.6kb/s used.

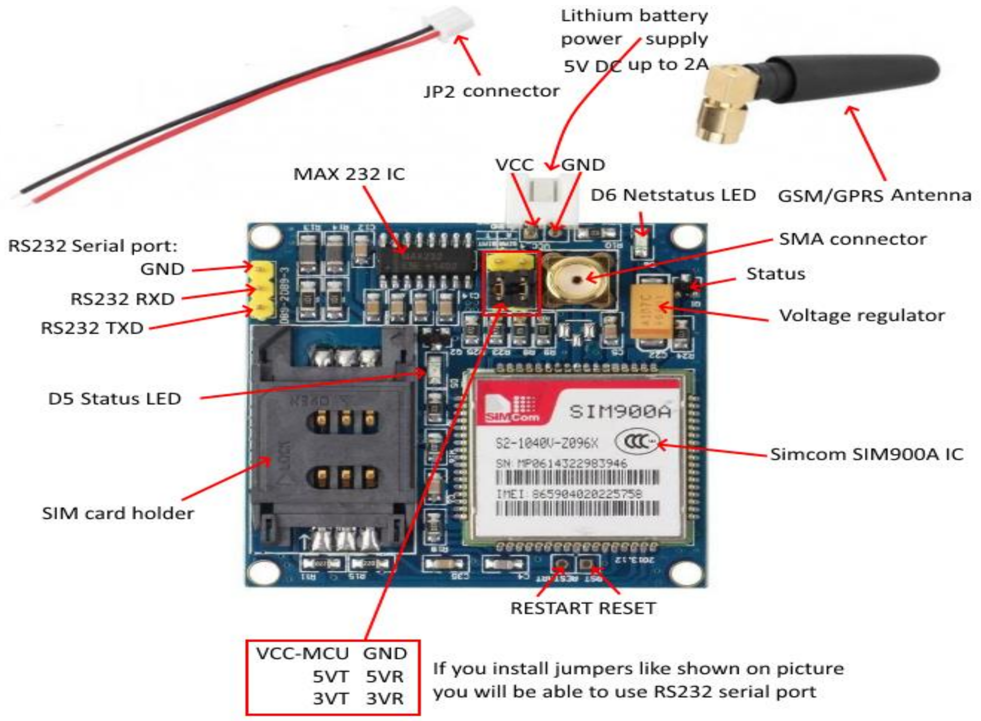

Figure 4.1.7: GSM Module

4.1.8 Water Level Sensor

A water level sensor is a device that is used to measure the level of water in a container or body of water. It is commonly used in various applications, including water tanks, reservoirs, wells, and industrial processes. The sensor works by detecting changes in the water level and converting them into electrical signals. There are different types of water level sensors available, including:

Water level sensors are typically connected to monitoring systems or control panels, where the data is displayed or used for various purposes. They are essential for maintaining water levels, preventing overflow or shortages, and enabling efficient water management.

Figure 4.1.8: Water Level Sensor

Features:

- No moving parts.
- Water resistant enclosure.
- Rugged design for long term use.
- Precise measurement.
- Instantaneous results.
- Output Voltage is proportional to liquid level.
- Can Measure large changes in water level.
- Low cost.

4.1.9 Soil Moisture Sensor

The soil moisture sensors are utilized to measure the amount of water present in the soil without the need for complex gravimetric measurements involving drying and weighing samples. This determines soil moisture indirectly by assessing factors like dielectric constant, electrical resistance, or neutron interaction. The relationship between these measured properties and soil moisture levels may vary and require adjustment based on environmental conditions such as temperature, soil type, and electrical conductivity. These sensors, often used in agriculture and hydrology, rely on microwave emissions affected by soil moisture for their operation. They are primarily used for assessing volumetric water content, while another category of sensors, known as soil water potential sensors, measures a property called water potential. Examples include gypsum blocks and tensiometers.

Figure 4.1.9: Soil Moisture Sensor

Features:

- Operating Voltage: 3.3V to 5V DC.
- Operating Current: 15mA.
- Output Digital - 0V to 5V, Adjustable trigger level from present.
- Output Analog - 0V to 5V based on infrared radiation from fire flame falling on thesensor.
- LEDs indicating output and power.
- PCB Size: 3.2cm x 1.4cm.
- LM393 based design.
- Easy to use with Microcontrollers or even with normal Digital/Analog IC.
- Small, cheap, and easily available.

4.1.10 Water Pump

The water pump plays a crucial role in maintaining the right conditions for plant growth. It helps in automating the irrigation process, ensuring that plants receive consistent and adequate water. The pump can be connected to soil moisture sensors, which detect when the soil is dry and automatically activate the pump to water the plants. This ensures that plants are never under-watered or over-watered. Additionally, water pumps support other greenhouse systems like nutrient delivery and climate control by maintaining optimal humidity levels. By using a water pump, greenhouse operations become more efficient, saving time and labor while promoting healthy plant growth. The automated nature of the pump helps in creating a stable environment, leading to better crop yields and resource management. Overall, water pumps are essential for effective greenhouse monitoring and plant care.

1. DC voltage: 2.5-6v
2. Maximum lift: 40-110cm/15.75″-43.4″
3. Flow rate: 80-120L/H
4. Outer diameter of effluent: 7.5mm/0.3″

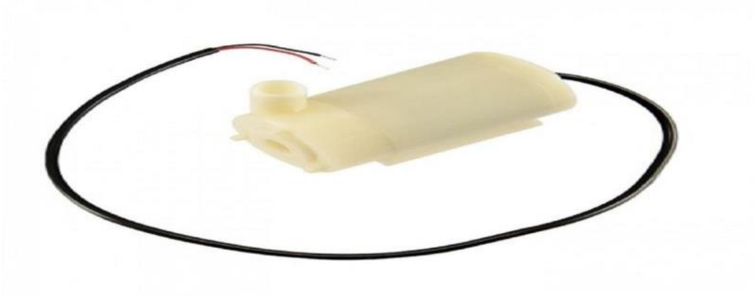

Figure 4.1.10 Water Pump

4.1.11 CPU Fan

It helps pull and blow hot air off the processor, helping keep it cooler. Power supply fan - a fan located inside a power supply. The power supply fan blows hotter air out of the power supply.

Air Flow : 98 ~ 115 CFM
Static Pressure: 0.29 ~ 0.4 inch-
H2O Noise : 43 ~ 50 dB(A)
Bearing : Ball or Sleeve
Weight : 320g

Figure 4.1.11 CPU Fan

4.1.12 Four-Channel Relay Module

The four-channel relay module contains four 5V relay and the associated switching and isolating components, which makes interfacing with a sensor easy with minimum components and connections. There are two terminal blocks with six terminals each, and each block is shared by two relays.

The four relays on the module are rated for 5V, which means the relay is activated when there is approximately 5V across the coil. The contacts on each relay are specified for 250VAC and 30VDC and 10A in each case, as marked on the body of the relays.

The switching transistors act as a buffer between the relay coils that require high currents, and the inputs which don't draw much current. The indicator LEDs glow when the coil of the respective relay is energized, indicating that the relay is active. The optocouplers form an additional layer of isolation between the load being switched and the inputs. The isolation is optional and can be selected using the V_{CC} selector jumper. The input jumper contains the main V_{CC}, GND, and input pins for easy connection using female jumper wires.

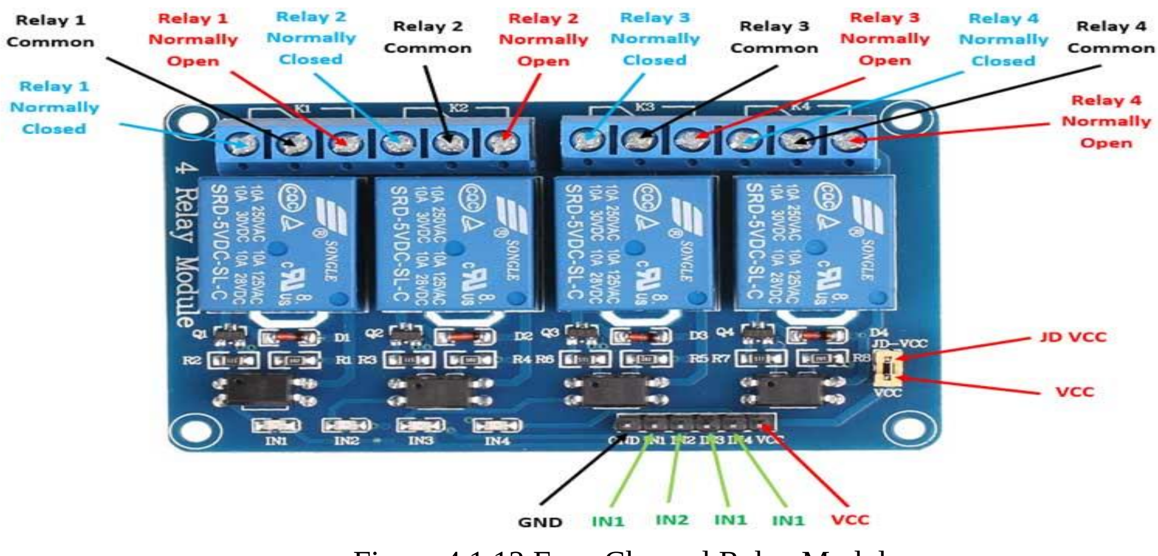

Figure 4.1.12 Four-Channel Relay Module

Specifications:

- Supply voltage – 3.75V to 6V.
- Trigger current – 5mA.
- Current when the relay is active - ~70mA (single), ~300mA (all four)
- Relay maximum contact voltage – 250VAC, 30VDC.
- Relay maximum current – 10A.

4.2 SOFTWARE REQURIMENTS

4.2.1 Software Language

Programming language – Python

Assembly languages were developed to provide mnemonics or symbols for the machine level code instructions. Assembly language programs consist of mnemonics; thus, they should be translated into machine code. A program that is responsible for this conversion is known as assembler. It is basically a compiled code that can be executed by the CLR. An assembly is a collection of types and resources that are built to work together and form a logical unit of functionality.

4.2.2 Software Tool: Python Idle

The program works on Windows, macOS and Linux. It is available as binary bundle including the recent Python interprete or pip-installable package. It can be installed via the operating-system package manager on Debian, Raspberry Pi, Ubuntu, and Fedora.

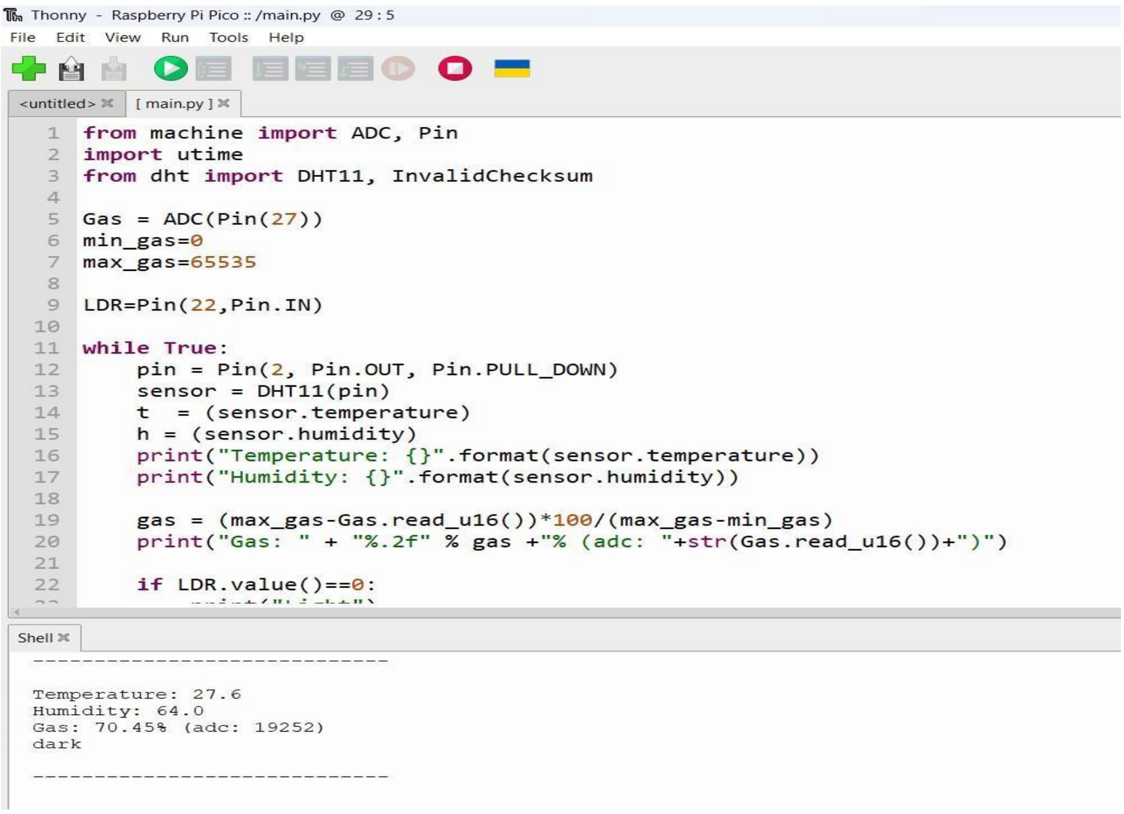

Figure 4.2.2: Workspace of Python Software tool

Chapter 5

RESULT AND DISCUSSION

5.1 Software Results of Smart Farming

Using Python and Image processing, the software implementation results are illustrated in Figure 5.1.1, and shows the readings obtained for several parameters within the Smart farming. Specifically, it provides information on the presence of light, moisture levels in the soil, smoke detection, pH level of the soil, and the room temperature. These readings serve as valuable feedback for monitoring and managing the Smart farming, aiding in maintaining optimal conditions for plant growth and ensuring effective environmental control. The figure highlights the successful utilization of Python and Image processing in obtaining these essential measurements.

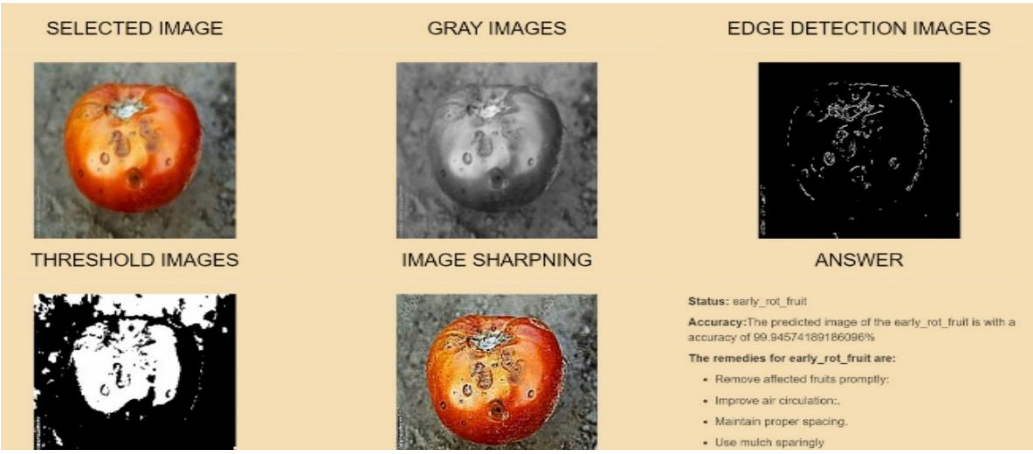

Figure 5.1.1: Disease detection of early rot fruit

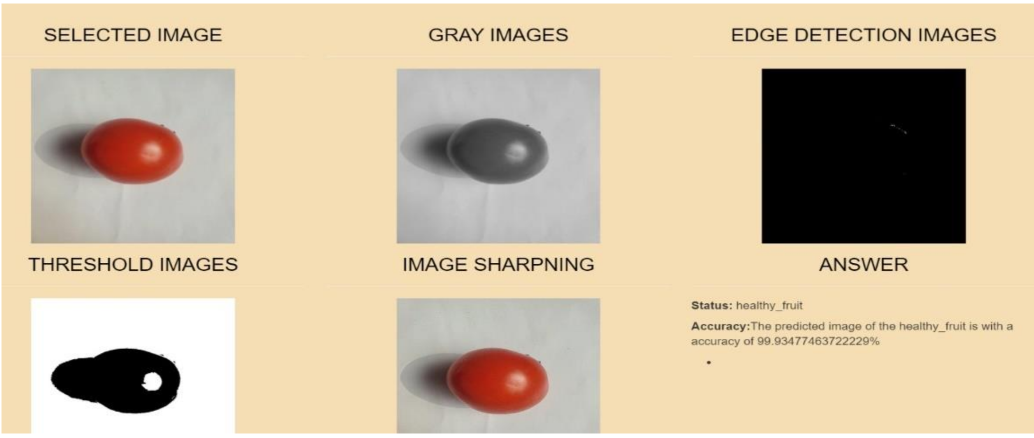

Figure 5.1.2: Disease detection of healthy fruit

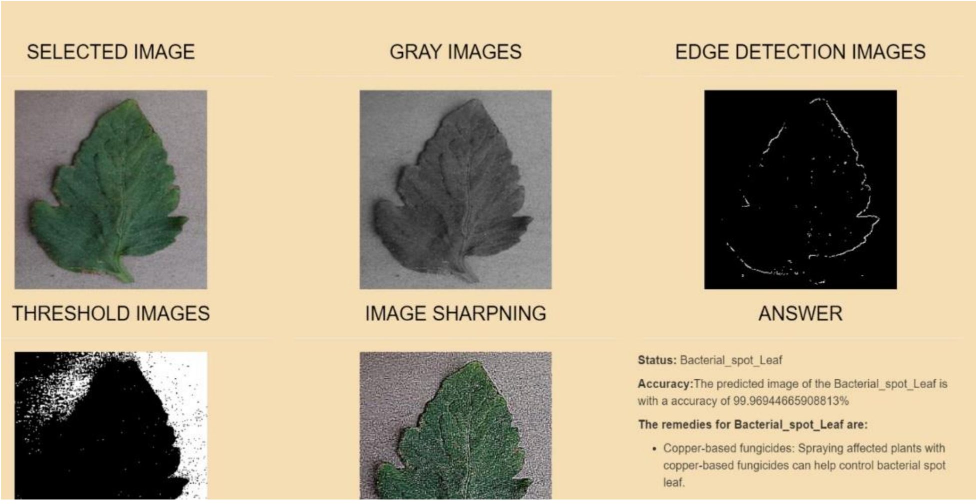

Figure 5.1.3: Disease detection of bacterial spot leaf

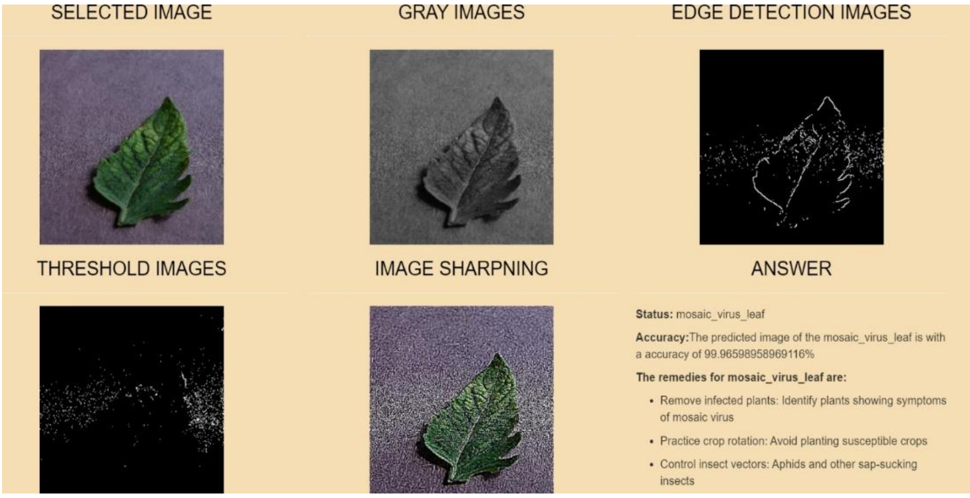

Figure 5.1.4: Disease detection of mosaic virus leaf

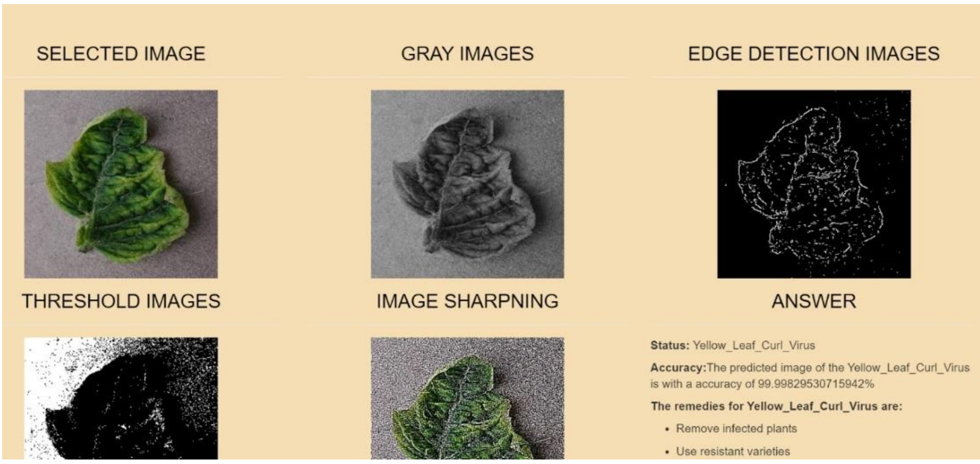

Figure 5.1 5: Disease detection of yellow leaf curl virus

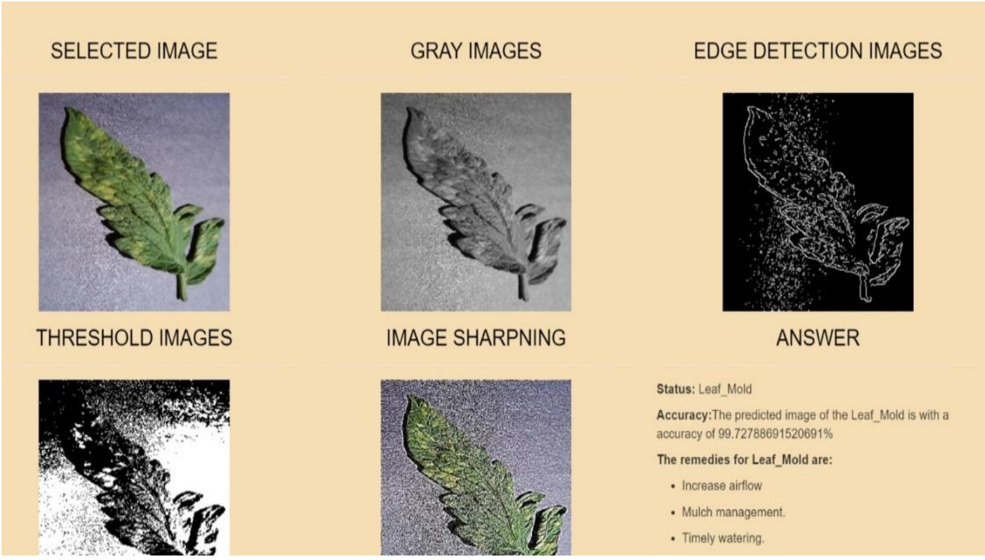

Figure 5.1.6: Disease detection of leaf mold

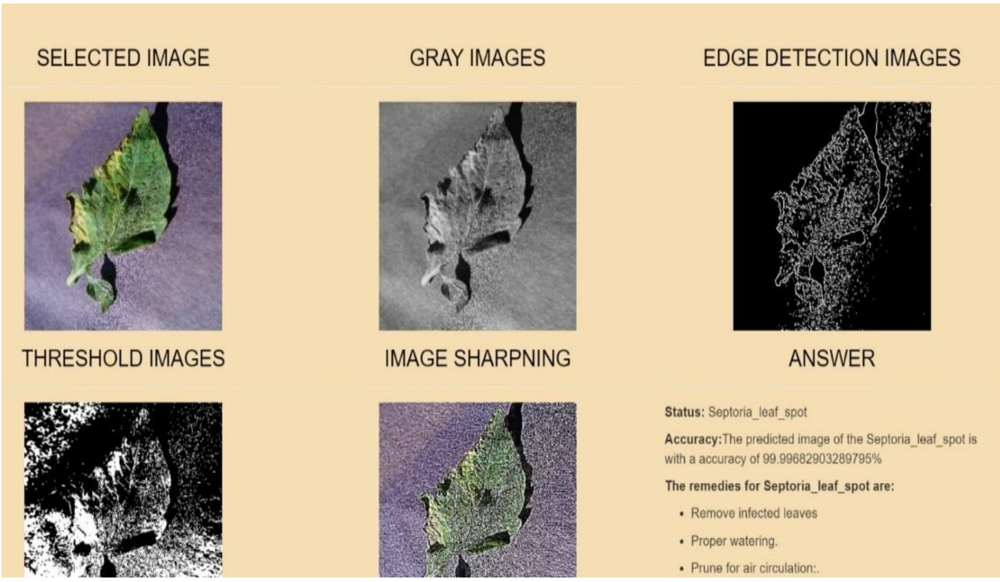

Figure 5.1.7: Disease detection of spectoria leaf spot

The development of an automated system using machine learning and image processing techniques. The system captures images of tomato plants and applies algorithms to identify symptoms of diseases like blight, mosaic virus, and rot. Data is processed to detect patterns and anomalies indicative of disease. The report highlights the model's accuracy, typically trained on a large dataset of diseased and healthy images, achieving high precision and recall rates. It helps farmers detect diseases early, enabling timely interventions and enhancing crop yields.

Input Image	Status/Disease name	Accuracy	Remedies
Leaf	Bacterial spot Leaf	99.9694466%	Copper-based fungicides. Proper sanitation. Crop rotation. Avoid overhead watering.
Leaf	Mosaic virus leaf	99.96598958%	Remove infected plants. Practice crop rotation. Control insect vectors. Maintain plant health.
Leaf	Yellow Leaf Curl Virus	99.99829530%	Remove infected plants. Use resistant varieties. Implement crop rotation. Control whiteflies.
Leaf	Leaf Mold	99.7278869%	Increase airflow. Mulch management. Timely watering. Clean garden tools.
Leaf	Septoria leaf spot	99.9968290%	Remove infected leaves. Proper watering. Prune for air circulation. Mulch with care.
Fruit	Healthy	99.9993477%	
Fruit	Early rot fruit	99.94574189%	Remove affected fruits promptly. Improve air circulation. Maintain proper spacing. Use mulch sparingly.

Figure 5.1.8: Comparative analysis for crop disease detection

5.2 Hardware implementation of Smart Framing

The hardware implementation involves integrating various sensors and modules to ensure optimal conditions for plant growth. The DH11 sensor measures temperature and humidity, while the LDR (Light Dependent Resistor) monitors light intensity. Soil moisture and soil pH sensors track soil conditions, and the water level sensor ensures adequate irrigation. The MQ2 sensor detects gas levels to prevent harmful environments. Data from these sensors is transmitted using a GSM module for remote monitoring and a Zigbee module for wireless communication within the greenhouse. The integrated system allows for real-time monitoring and control, enhancing greenhouse efficiency and productivity.

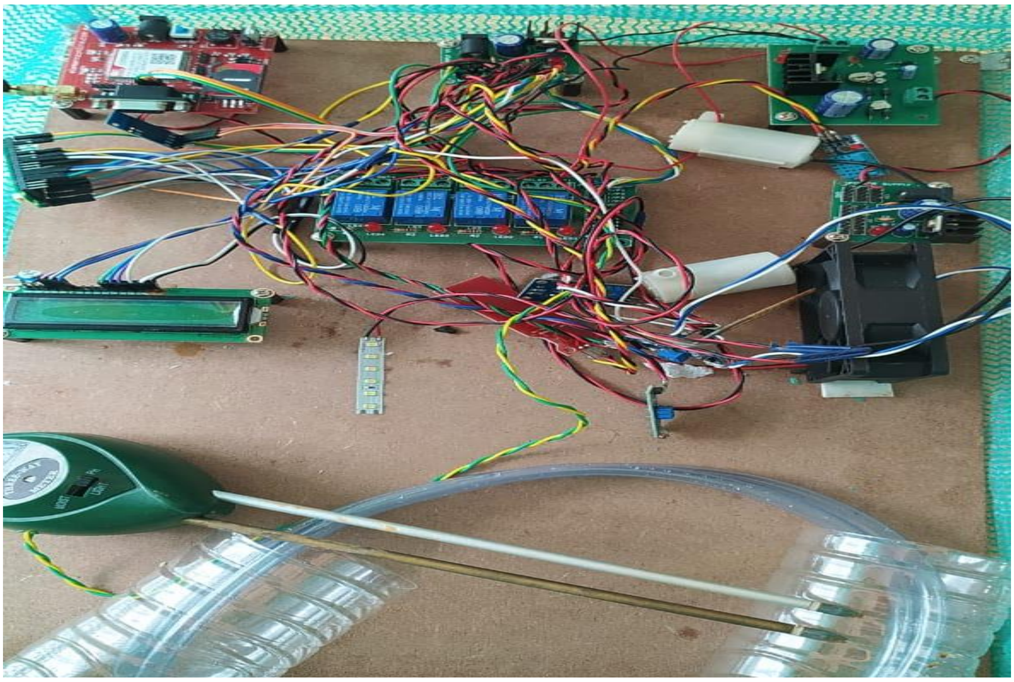

Figure 5.2.1: Implementation of different Hardware models

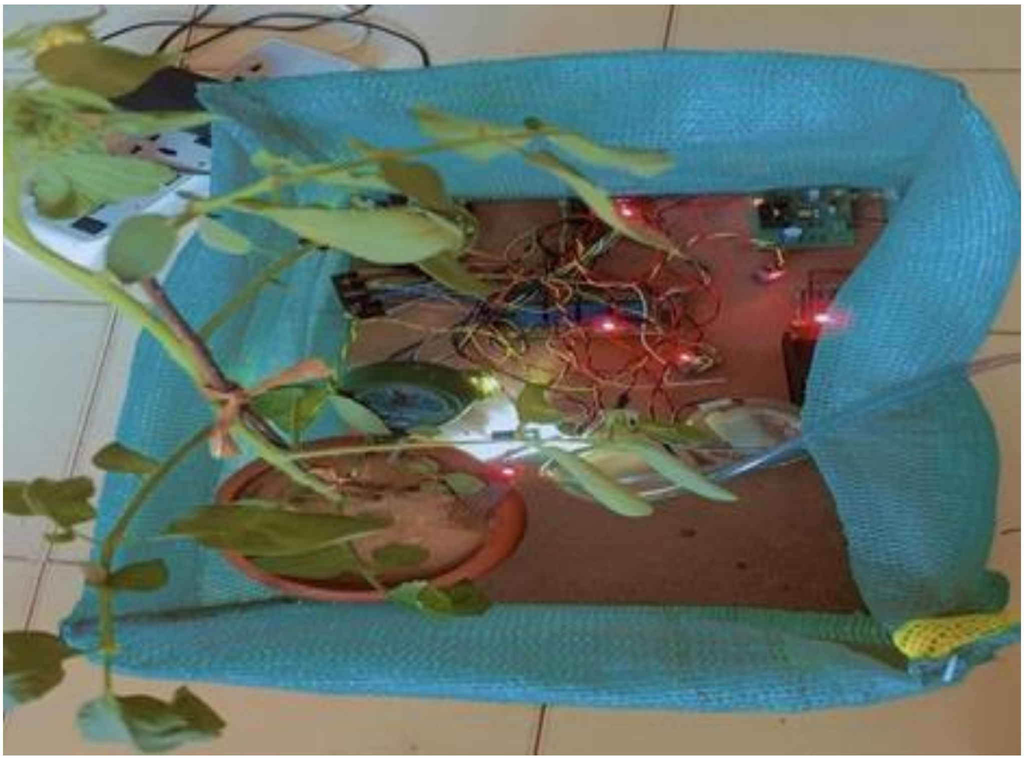

Figure 5.2.2: Hardware implementation of smart farming

Figure 5.2.3: Different parameters sent to user

A greenhouse monitoring system sends alert messages to users to ensure optimal plant conditions. These alerts notify users of critical changes in environmental parameters such as temperature, humidity, soil moisture, and light levels. For instance, if the temperature exceeds or drops below a set threshold, an alert is triggered, prompting immediate action to protect the plants. The system can also warn about equipment malfunctions, such as failing irrigation systems. Alerts are typically delivered via SMS, email, or through a dedicated app, enabling users to respond promptly and maintain a stable growing environment for their crops.

CONCLUSION

The integrating image-based crop disease detection for tomato plants with comprehensive greenhouse monitoring, using sensors like DHT11 (temperature and humidity), MQ2 (gas detection), LDR (light detection), soil moisture, water level, and soil pH sensors, revolutionizes plant cultivation. These sensors ensure optimal growing conditions by precisely controlling irrigation, lighting, temperature, humidity, and soil quality. The image-based system, utilizing camera, CNN and machine learning, monitors the health of tomato fruits and leaves, detecting diseases early for timely intervention. This reduces crop loss and enhances yield quality. The integration of these advanced sensors automates the greenhouse environment, conserving resources and reducing the need for manual monitoring. The technology-driven approach ensures healthier plants and higher productivity, making greenhouse management more efficient and sustainable. Adopting these smart farming techniques benefits farmers with improved yields and resource management, promoting a sustainable and profitable agricultural future.

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