Artificial Intelligence Based Greenhouse System

For Precision Agriculture

A BS Final Year Project by

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June, 2023

Certificate of Approval

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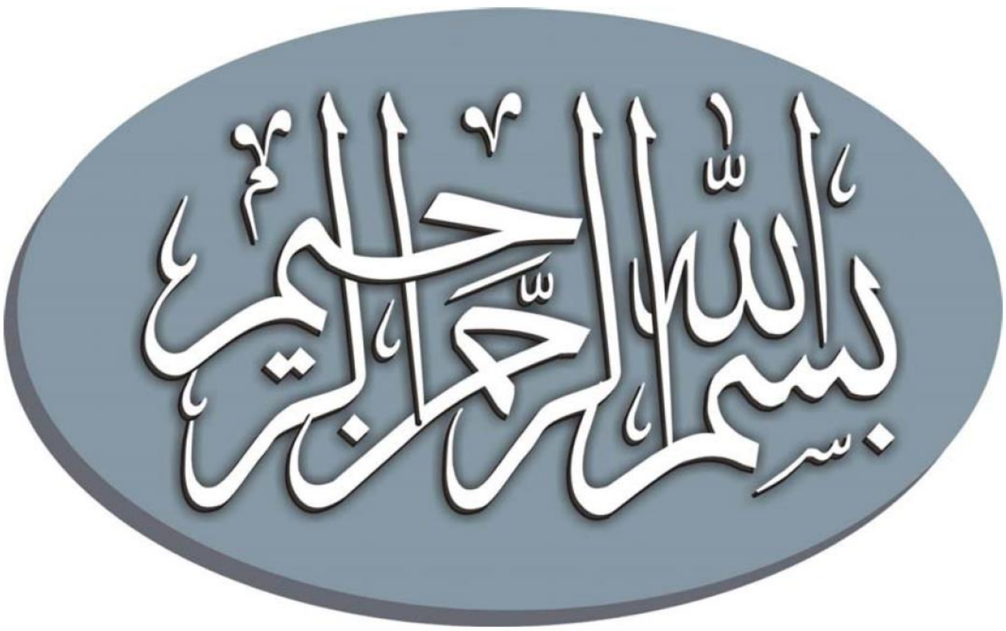

In the name of Allah (SWT), the most beneficent and the most merciful

A BS Final Year Project submitted to the

Department of Electrical and Computer Engineering

International Islamic University, Islamabad

In partial fulfillment of the requirements

For the award of the degree of

Bachelor of Science in Electrical Engineering

Declaration

We hereby declare that this work, neither as a whole nor as a part thereof has been copied out from any source. No portion of the work presented in this report has been submitted in support of any application for any other degree or qualification of this or any other university or institute of learning. We further declare that the referred text is properly cited in the references.

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Acknowledgments

This BS thesis in Electrical Engineering has been conducted at Department of Electrical and Computer Engineering, Faculty of Engineering and Technology, International Islamic University, as part of the degree program. We would like to thank Engr. Ubaid Umer for providing us an opportunity to work on this project, under his supervision and guidance throughout the project. We would also like to thank Engr. Muhammad Asad for his help, efforts and dedicated support throughout the project. Further we are particularly thankful to Almighty Allah and grateful to our parents, brothers and sisters who always supported and encouraged us during our project and studies at IIUI.

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Date Started: September, 2022

Date Completed: June, 2023

Tools Used:

- Arduino IDE
- Proteus
- Py-Charm (Python)

Abstract:

The objective of this project is to develop an Automated Greenhouse System which will control the parameters required for the better growth of the plant, Will monitor the health of the plants by taking pictures via camera, the extraneous growth of the unwanted plants will also be monitored so they won't exhaust the nourishment of the plant. The soil moisture sensor will sense the moisture of the soil and will interrupt water pump to inflow water into the fields. Apart from these, the contained environmental factors like temperature, light intensity & humidity level, soil Ph level will also be monitored with the help of appropriate sensors. The temperature will be set to an acceptable level with the help of fan. The humidity sensor, will make humidity level at check. Lights will be turned on if it senses darkness. In order for a person to have a peek at the parameter's values and status of the devices, the website will be used to display all the parameters for remote monitoring using IOT.

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List of Abbreviations

LDR	Light Dependent Resistor
I2C	Inter-Integrated Circuit
LCD	Liquid Crystal Display
IoT	Internet of Things
AI	Artificial Intelligence
PCB	Printed Circuit Board

Chapter 1

System Overview

1.1 Introduction

Farming helps in getting fresh edible fruits and vegetables that are important for health. Currently, indoor farming is a method of growing crops or plants, often on a large scale, entirely indoors. This method of farming typically uses growing techniques such as hydroponics and uses artificial lights to give plants the amount of nutrients and light they need to grow If grown indoors, times many farmers appreciate environmental control more than using traditional farming methods. Micronutrients, nutrient levels, temperature and water levels can all be controlled by the farmer when growing crops indoors. Indoor farming/vertical indoor farming is considered as the future of farming where both plant growth and its health will be controlled by a farmer. Through indoor farming we not only can save the necessary growing resources but also minimize the use of pesticides, and utilize about 70 percent of less water. The indoor farming also helps farmers grow crops in the places where the conventional farming fails, like for an instance, in extreme weathers of Balochistan desert and Gilgit's cool breeze. The farmers may also prevent the natural calamities like floods that may render the fields useless.

In this project we intend to develop an automated greenhouse system which will be monitored remotely. Basically, a greenhouse is a wall and roof structure made of soft materials for growing plants. These plants require climate control. When the greenhouse is exposed to sunlight, the internal temperature rises significantly from the outside temperature, protecting materials from the elements The inspection, heating, cooling and lighting systems in the greenhouse can be controlled by computer overall to maximize plant growth and then greenhouse fitness scores, comfort -A variety of techniques are used to analyze parameters, such as air temperature, humidity, and humidity deficits, to reduce the risk of crops will be produced before a crop is produced. So, we will use different types of sensors to monitor the crops inside the greenhouse and also use the actuators to counter the extreme physical conditions that a crop faces so the plant has ideal conditions for the optimal growth.

1.2 Problem Statement

Agriculture plays a very important role for Pakistan's economy and development. About 48% of the workforce is directly engaged in agriculture. It is therefore the main source of livelihood or income of a large part of the economic population. About 70% of the population is directly or indirectly related to agriculture.

Reckless weather conditions play a vital role in crop reduction. The harmful effects therefore lead to the inability of farmers to repay loans, which are life-threatening for farmers as they lead to suicide. Advancement in agricultural atmosphere has been recommended as a major need to control this swelling problem. Today, the term "greenhouse" is a widely accepted system for meeting food inflation in both seasonal and non-seasonal vegetables, fruits and other crops. So, the purpose of this project was to make it easier to grow food at home.

In conventional indoor farming, many farmers are assigned task to look after a field. These fields are prone to get damaged by diseases, natural calamities or other factors. The human negligence also plays part in the poor yield of the crops. Those can be prevented to some extent if they are monitored using latest technologies. The main goal of this project is to minimize the human care needed for the plant by automating the greenhouse and monitor the in-house environment status.

One of the most important challenges in greenhouses is the equitable distribution of rainwater, creating problems for farmers in ensuring equal irrigation of all crops across the region One flying solution an effective way to overcome this is to implement an irrigation system. However, continuous monitoring is necessary to keep the environment favorable for different crops. Any changes in environmental conditions must be dealt with promptly and in balance to meet the specific requirements of the crop.

Now our aim to propose an Automated Greenhouse System that will be completely doing everything required for the better growth of crops automatically using artificial intelligence, by which it will be able to change the parameters itself according to the different climatic conditions. Also, we will use a camera to monitor the growth and identify the diseases if any. This system will have no need of labor even if the grower is not there for an extended period of time and everything will be going on intelligently.

1.3 Project Objective

Our goal is to create a complete growth plan that maintains the optimal growing conditions. This includes controlling and maintaining factors such as temperature, light, humidity and soil moisture levels to ensure plants grow in conditions suited to their specific needs. We are not only doing that but also to monitor these conditions using an IOT web server.

Furthermore, we intend to develop an Automated Greenhouse which will check the health of the plants by taking pictures via camera. The extraneous growth of the weeds will also be monitored so they won't exhaust the nourishment of the plant. The soil moisture sensor will sense the moisture of the soil and will interrupt water pump to inflow water into the fields. Apart from these the contained environmental factors like temperature, light intensity & humidity level will all be monitored with the help of appropriate sensors. The temperature will be set to an acceptable level with the help of bulb or fan. The ventilation and watering of the plant will make humidity level at check. LEDs will be turned on in case if it senses darkness. In order for a person to have a peek at the parameter's values and status of the devices, the website will be made, that will display all the parameters for remote monitoring.

Here are some lists of silent features and objectives of the project

- Monitor and control the temperature, soil moisture, humidity, light intensity.
- The soil moisture sensor will be used to monitor the soil moisture and start motor to water the plants.
- The health and growth will be monitored using a camera. We can make it take decisions accordingly for betterment of crops.
- It will increase the crops yield because it sets the best parameters automatically for the crops according to the environment.
- This system will enable growers to monitor their crops, the current environmental parameters and the health of the crops.
- It will help growers to use much less (more than 50%) water than that used in typical irrigation.

1.4 Project Methodology:

Objective:

This project aims to develop an advanced greenhouse automation system using AI techniques. Combining sensors, microcontrollers and machine learning algorithms, the system will optimize environmental conditions and enhance plant growth and productivity.

Hardware Options:

In this project, we used Arduino microcontroller for sensor automation and control, Raspberry Pi for intelligent decision making and data analysis The Arduino will communicate with sensors, including DHT11 for temperature and humidity, soil moisture sensor and LDR for light power measurements including DC fan, relays will be used to control the LEDs and lights.

Sensor Integration:

The sensors will be connected to the Arduino, enabling real-time data acquisition. Through programming, the Arduino will read the sensor values and display them on a serial monitor for monitoring. This allows us to collect important environmental data needed for healthy plant growth.

Actuator use:

Using Arduino, we will control the actuators based on sensor readings. For example, if the temperature rises above a certain threshold, the Arduino will activate a DC fan to maintain the proper temperature. Similarly, LED lighting can be adjusted based on the light intensity required for optimal plant growth.

Data collection and storage:

The Arduino will connect to the Raspberry Pi, which will act as a data hub. The Raspberry Pi will receive the sensor data from the Arduino through a series of connections and store it in a database for further analysis. This data set will be the basis for training and testing our machine learning algorithms.

Machine learning algorithm of choice:

We will train a machine learning algorithm using the collected data to make intelligent decisions and automatically monitor plant growth. Depending on the objective, we will choose an appropriate algorithm such as regression, classification, or time series analysis. This algorithm will allow us to predict optimal environmental conditions to maximize plant growth.

Sample training and testing: The collected data will be pre-processed to prepare for training. We will clean the data, fix missing values, and divide it into training and testing sessions. The machine learning model will be trained with the training set, and its performance will be evaluated with the test set. Metrics such as accuracy, precision, recall, or mean squared error will be used to evaluate model effectiveness.

Connecting a Raspberry Pi:

Once the model is trained, it will be added to the Raspberry Pi system. The Raspberry Pi will continuously receive real-time sensor data from the Arduino and make a decision based on the trained model. It will regulate environmental factors such as temperature, humidity and light levels to create optimal conditions for plant growth.

IoT Integration:

To manage the greenhouse remotely, we harness IoT capabilities by configuring a Raspberry Pi to connect to a cloud-based IoT platform such as Thing-Speak. This allows us to visualize the sensor data and get a report or alert if a parameter falls in the desired range.

Implementation and Management:

When the system is fully implemented, it will be used in the greenhouse. The system is continuously monitored to monitor performance, make adjustments as needed, and gather insights for further improvements.

1.5 Application Areas:

- Commercial Agriculture
- Urban Agriculture
- Sustainable Agriculture
- Environmentally sustainable Agriculture

- Research and Development in Botany
- Gardening and Floriculture
- Regular meals
- Crop rotation and yield increase
- Smart Greenhouses
- Precision Agriculture

Chapter 2

Literature Review

2.1 Background of Project

The advent of artificial intelligence (AI) has transformed industries, and agriculture is no exception. With increasing demand for sustainable and efficient agricultural practices, there is growing interest in developing AI-based solutions for greenhouse systems These systems aim to provide agricultural policy varieties, increase yields and reduce inputs to ensure environmental sustainability Traditional greenhouses rely heavily on manual processes, which can be labor intensive, time consuming and prone to human error.

Furthermore, the unpredictability of weather and the complexity of plant growth dynamics pose significant challenges for greenhouse operators to address these challenges, the proposed work focuses on the development of an AI-based automated greenhouse system. Leveraging the power of AI algorithms and real-time data analysis, the system aims to create an intelligent environment where plants can thrive, while reducing human intervention and waste on the system will use sensors to collect data on various environmental parameters such as temperature & humidity, light intensity, moisture of the soil etc.

This data will be further fed into AI algorithms, which will then it will be analyzed and interpreted to make appropriate decisions on irrigation, ventilation and lighting management by doing so, the system will provide the plants with the best environment to grow, and promote their yield and quality high. A-based automated greenhouse systems offer many potential advantages over conventional methods. It can improve resource efficiency, reduce energy consumption, reduce water consumption, and provide sustainable crop yield.

The development and implementation of such a system holds great promise for the future of sustainable agriculture. By integrating state-of-the-art AI technology with greenhouse management, we can pave the way for more efficient and environmentally friendly agricultural practices, ensuring food security, reducing environmental impact so that we contribute to a greener and more sustainable future.

2.2 Greenhouse System

Figure 1: Greenhouse

2.3 The Greenhouse Effect

Greenhouses maintain heat by solar radiations rays coming from the sun and by enclosing warm air. When the sun rays shine on the roof or walls of greenhouse, it heats up the ground by passing heat through the glass or transparent materials of greenhouse in the form of short-wavelength Infrared (IR) radiations. Warm air rises, as we all know, and this is exactly what occurs when the air closest to the earth heats up. Then, at ground level, colder air replaces the heated air, and that heats up as well, in a continual cycle.

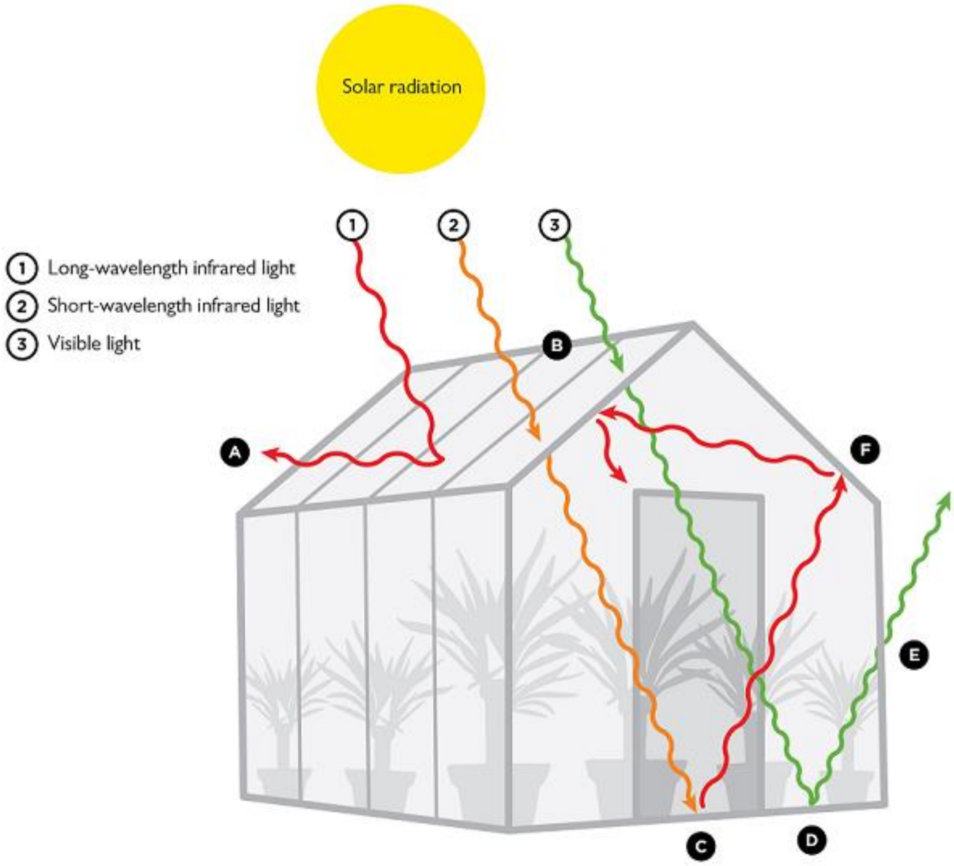


Figure 2: Greenhouse Effect

Convection is another term for this.

Below is the explanation of the steps of greenhouse effect:

A. The glass/Sheet reflects infrared light with a long wavelength.

B. The glass/sheet allows visible light and short-wavelength infrared to pass through.

C. During the absorption process, short-wavelength infrared light is converted back to its original form, long-wavelength infrared light.

D. Reflection of visible light occurs.

E. Visible light is reflected and passed through the glass.

F. Infrared light with a Glass reflects long wavelengths and effectively traps them within the greenhouse, creating a greenhouse effect.

In addition, the short-wavelength IR light absorbs by all of the plants in the greenhouse, causing them to get warmer. As a result, they begin to produce infrared light with a long wavelength, which passes through the glass and is absorbed. The glass then warms up and emits infrared light with a large wavelength. Instead of passing through the glass, infrared light with a long wavelength bounces back into the greenhouse. [3]

2.4 A Review of Related Works

Many researchers have contributed to the development of AI-based automated greenhouse systems, providing valuable insights and new perspectives. The following work illustrates further developments in this area.

Vimal and Shivaprakasha (2017) proposed an IoT-based greenhouse environment monitoring and controlling system using the Arduino platform. The system aimed to enable real-time monitoring and control of environmental parameters in greenhouses through the integration of IoT technology. The authors utilized Arduino and GSM modem for data transmission and employed sensors to collect data on various parameters. The system demonstrated the potential to enhance greenhouse operations by providing remote monitoring and control capabilities.

Dedeepya et al. (2018) presented a smart greenhouse farming system based on IoT. The system aimed to improve the efficiency and productivity of greenhouse farming by leveraging IoT technology. The authors integrated sensors to collect real-time data on environmental parameters such as temperature, humidity, and soil moisture. Through the integration of IoT devices and cloud-based platforms, the system facilitated remote monitoring and control of greenhouse conditions. The study demonstrated the potential of IoT-based solutions in optimizing greenhouse farming practices.

Chamra and Harmanani (2020) proposed a smart greenhouse control and management system utilizing IoT technology. The system aimed to optimize the cultivation environment in greenhouses by monitoring and controlling various parameters in real-time. Through the integration of IoT devices and wireless communication, the system enabled remote access and control of greenhouse conditions. The authors emphasized the potential of IoT-based solutions in enhancing greenhouse management and improving crop yield.

Bersani et al. (2020) investigated the application of model predictive control (MPC) in smart greenhouses to achieve near-zero energy consumption. The study focused on optimizing energy consumption through advanced control algorithms based on predictive modeling. By considering environmental parameters and plant requirements, 28the MPC algorithm adjusted heating, ventilation, and other control variables to minimize energy usage while maintaining optimal growing conditions. The research highlighted the potential of MPC as a promising approach for achieving energy-efficient greenhouse operations.

Chaudhari (2020) developed an IoT-based greenhouse monitoring and alerting system using Raspberry Pi. The system aimed to provide real-time monitoring of environmental parameters in greenhouses, such as temperature, humidity, and soil moisture. Through the integration of sensors, data was collected and transmitted to a RaspberryPi for processing and analysis. The system generated alerts and notifications based on pre-defined thresholds, enabling timely interventions and ensuring optimal growing conditions. The study demonstrated the feasibility of using Raspberry Pi and IoT technology for greenhouse monitoring and management.

Benyezza (2018) presented a smart irrigation system based on the integration of ThingSpeak and Arduino. The system aimed to optimize water usage in agricultural practices by utilizing IoT technology. Through the integration of sensors and actuators, the system monitored soil moisture levels and controlled the irrigation process accordingly. The author demonstrated the effectiveness of the systemin automating irrigation operations and improving water efficiency.

Ozbafli and Ozbay (2021) conducted a comprehensive review on the applications of artificial intelligence (AI) in greenhouse environments. The study explored various AI techniques, including machine learning and deep learning, and their potential applications in optimizing greenhouse operations. The authors discussed the use of AI in greenhouse climate control, disease detection, yield prediction, and resource management. The review emphasized the significant role of AI in improving productivity and sustainability in greenhouse farming.

Li et al. (2020) proposed an intelligent greenhouse system based on the integration of the Internet of Things (IoT) and deep learning techniques. The system aimed to optimize greenhouse operations by monitoring and controlling various environmental parameters in real-time. Through the use of sensors and IoT devices, data was collected and processed for analysis. Deep learning algorithms were employed to make accurate 29predictions and provide insights for decision-making. The study demonstrated the effectiveness of the intelligent greenhouse system in improving crop yield and resource utilization.

Ashok et al. (2020) conducted a comprehensive review on the application of artificial intelligence (AI) in greenhouse farming. The study discussed the use of AI techniques such as machine learning, image processing, and data analytics in various aspects of greenhouse farming, including climate control, pest management, and yield prediction. The authors highlighted the potential of AI in optimizing resource utilization, reducing environmental impact, and improving overall productivity in greenhouse agriculture.

Khan et al. (2019) conducted a systematic review on the use of Internet of Things (IoT) in greenhouse farming. The study reviewed various IoT-based applications and technologies employed in greenhouse environments, including monitoring systems, automation, and control mechanisms. The authors discussed the advantages of IoT in terms of real-time data collection, remote monitoring, and precision farming. The review highlighted the potential of IoT-based greenhouse farming in improving resource efficiency, crop quality, and yield.

Cao et al. (2018) conducted a review of the application of artificial intelligence (AI) in greenhouse climate control. The study discussed various AI techniques, including fuzzy logic, neural networks, and expert systems, and their use in optimizing greenhouse climate parameters such as temperature, humidity, and CO2 levels. The authors emphasized the potential of AI in providing accurate and timely control actions to create optimal growing conditions and enhance crop productivity in greenhouse environments.

Panda et al. (2017) presented a study on the implementation of a smart greenhouse using the Internet of Things (IoT). The study focused on the integration of sensors, actuators, and IoT technologies to monitor and control greenhouse environmental parameters. The authors discussed the system architecture, data acquisition, and control mechanisms employed in the smart greenhouse. The results highlighted the effectiveness of the IoT-based approach in optimizing resource utilization, improving crop yield, and reducing manual labor in greenhouse farming.

Patil et al. (2017) presented a smart greenhouse monitoring and controlling system using IoT. The study focused on the integration of sensors, IoT devices, and cloud-based platforms to monitor various parameters such as temperature, humidity, soil moisture, and light intensity. The authors discussed the system architecture, data acquisition, and control algorithms used in the smart greenhouse. The results demonstrated the effectiveness of the IoT-based system in real-time monitoring and efficient control of greenhouse conditions.

Han et al. (2016) proposed a wireless sensor network (WSN)-based greenhouse monitoring system for monitoring environmental parameters in a plant factory. The study focused on the deployment of a network of wireless sensors to collect data on temperature, humidity, light intensity, and CO2 levels in real-time. The authors discussed the system architecture, sensor deployment, and data analysis techniques used in the greenhouse monitoring system. The results demonstrated the effectiveness of the WSN-based approach in providing accurate and timely information for greenhouse management.

Ferreira et al. (2016) presented a study on the integration of the Internet of Things(IoT)and wireless sensor networks (WSNs) for monitoring greenhouse environments. The study focused on the deployment of wireless sensors to collect data on temperature, humidity, soil moisture, and light intensity. The authors discussed the integration of WSNs with cloud-based platforms for data processing and analysis. The results highlighted the potential of IoT-WSN integration in providing real-time monitoring and efficient management of greenhouse conditions.

Biswas et al. (2015) proposed the design of an intelligent greenhouse environment monitoring system. The study focused on the integration of various sensors to monitor environmental parameters such as temperature, humidity, light intensity, ands oil moisture in real-time. The authors discussed the system architecture, sensor deployment, and data analysis techniques used in the intelligent greenhouse system. The results demonstrated the effectiveness of the proposed system in providing accurate monitoring and control of greenhouse conditions to optimize crop growth and productivity.

By leveraging IoT, sensor integration, predictive control algorithms, and intelligent controllers, these experiments contribute to the development of sustainable and efficient greenhouse farming practices.

2.5 Project Contribution

The proposed AI-based automated greenhouse system aims to contribute significantly in the field of greenhouse farming and automation. The main contributions of this work are described as follows.

Developing an integrated AI system:

The project involves an integrated AI system that integrates sensor technology, data analysis, and control algorithms This system enables environmental monitoring and environmental analysis in real time in the greenhouse, facilitating informed decisions about plant quality.

Make more efficient use of resources:

AI systems actively monitor and control factors such as temperature, humidity, soil moisture, and lighting conditions. By dynamically adjusting these parameters, the system optimizes resource management, reducing energy consumption and water consumption. This contributes to sustainable agricultural practices and reduces environmental impact.

Increased crop yield and quality:

By continuously monitoring and adjusting environmental conditions, the AI system improves plant growth. This increases yields and improves yields, ensuring consistent production and meeting market demands.

Human intervention and error reduction:

By automating various greenhouse effects, the project greatly reduces the need for human intervention. This not only reduces labor requirements, but also reduces the chances of human error, enabling more accurate and reliable greenhouse operations.

Application of AI algorithms and control techniques:

The project explores the application of AI algorithms to monitor and maintain optimal greenhouse conditions, such as predictive control and fuzzy logic.

Sustainable Agriculture Contribution:

The AI-based automated greenhouse system conforms to the principles of sustainable agriculture by optimizing resource use, reducing waste and improving overall efficiency Contributes to agricultural production environmentally friendly practices that promote food security and environmental sustainability.

Overall, the project grant is geared towards implementing AI-based automated greenhouse systems that increase crop yields, improve resource management, reduce human error, and promote sustainable agriculture.

2.6 Summary

The AI-based automated greenhouse system developed in this project combines the power of AI, IoT, imaging technologies to create an efficient and sustainable environment for greenhouse farming The system combines various elements, such as Arduino and AI and Wi-Fi module (ESP) for IoT connectivity And Raspberry Pi with Pi camera for image processing capabilities

Through the integration of IoT and Arduino, the system enables real-time environmental monitoring and environmental monitoring in the greenhouse.

Sensors connected to the Arduino collect data such as temperature, humidity, light intensity and soil moisture. This data is sent to Thingspeak, a cloud platform for storage and analysis, allowing users to access real-time information and make informed decisions remotely. The AI component, powered by the Raspberry Pi, plays an important role in optimizing the plant’s growing conditions.

Using AI algorithms, the system analyzes collected sensor data to make intelligent decisions about irrigation water, air and light use This provides plants with the optimal growing conditions, it increases yields and improves the yield.

Additionally, the Raspberry Pi's image processing capabilities, coupled with the Pi camera, enable the system to detect and monitor plant health, detect diseases and manage pests.

By taking photos of plants and applying imaging applications a are used to diagnose, the system is able to provide rapid identification of potential issues, enabling timely intervention and preventive measures.

Holistic system design focuses on maximizing resource utilization, reducing waste, and improving overall efficiency. By automating processes and ensuring precise environmental control, the system minimizes human intervention and reduces the risk of human error. This contributes to sustainable agricultural practices, improves food security and contributes to environmental sustainability.

In conclusion, the AI-based automated greenhouse system developed in this work uses the capabilities of IoT, AI, and image processing technologies to create an advanced and intelligent environment for greenhouse farming using Arduino, Raspberry Pi, and sensors and actuators to be integrated, so this system improves resource utilization, increases yield and quality, and encourages environmentally friendly agriculture.

Chapter 3

System Design and Implementation Details/Design Procedures

3.1 System Design:

In this project, we design the greenhouse environment such that it can be monitored as well as controlled in real-time, we can also adjust various environmental parameter such as temperature and humidity at a suitable level automatically. If the temperature is higher than the required threshold temperature, the fan would turn ON, otherwise, the fan stays off. We can also monitor data by phone or webpage through the network remotely wherever the users want. This project consists of different modules like Sensors, Relay module, Raspberry Pi, Arduino Uno, Battery, Power Supply etc.

This project is developed based on Arduino and Raspberry Pi mainly, (which is the brains behind the automated greenhouse) coupled with other electric devices. For the Automation Purposes we are using an Arduino Controller which will manage the sensors, relays and elements like water pump, fan, and lights etc. We are using ESP 32 module to integrate wifi with the arduino for the remote monitoring and control of the greenhouse system.

Raspberry Pi is used here for the purpose of Image Processing and Artificial Intelligence, which will monitor the health and growth of the plant/crop inside the closed greenhouse system, our closed system has a metal frame which is covered with a transparent sheet from all sides.

Arduino Uno:

The Arduino Uno is used as a microcontroller board based on the ATmega328P chip. It is a popular choice for beginning and experienced builders because of its flexibility, versatility and broad community support. The Arduino Uno comes with digital and analog input/output pins, which can be connected to sensors, actuators, and other electronic components. It can be programmed using the Arduino IDE and provides a user-friendly environment for writing and coding. With plenty of availability, plenty of documentation, and a large collection of libraries and examples, the Arduino Uno is suitable for a wide variety of projects, from simple prototyping to complex embedded systems.

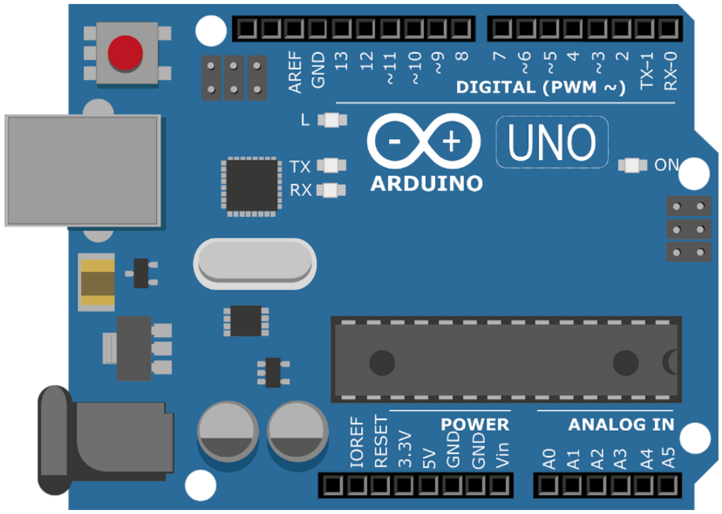


Figure 3: Arduino Uno

Raspberry Pi

The Raspberry Pi is an inexpensive, credit-card-sized computer that plugs into a computer monitor or TV, and uses a standard keyboard and mouse.

We are using **Raspberry Pi 4 Model B** in our project for the purpose of growth monitoring of the plant and to set the optimal parameters for different conditions automatically. Furthermore, we are capturing the real time picture of the plant's leaves using Raspberry Pi camera to detect different diseases that can affect the growth or damage the plant.

Moreover, we also monitor our environmental parameters using sensors connected to the Arduino, and we've set different thresholds for them, allowing us to do things like switch on the fans and heater etc., among other things.

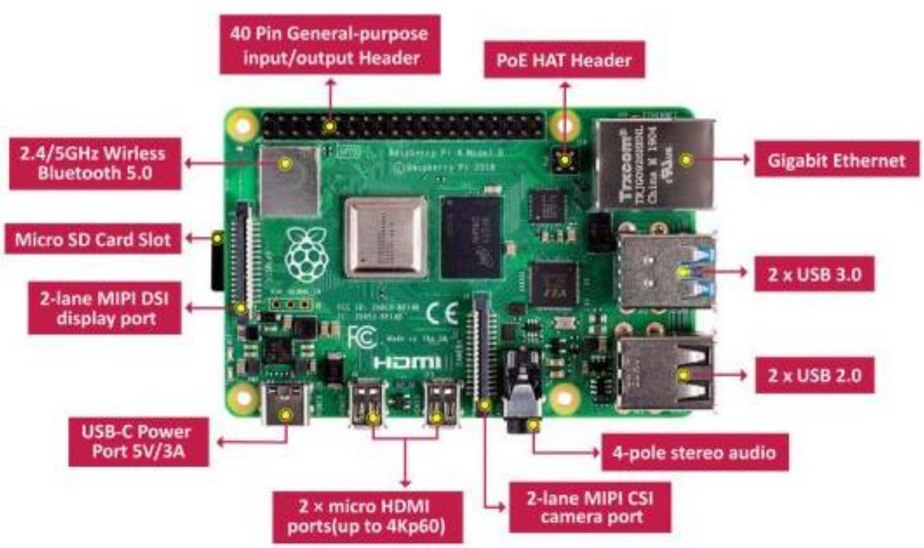
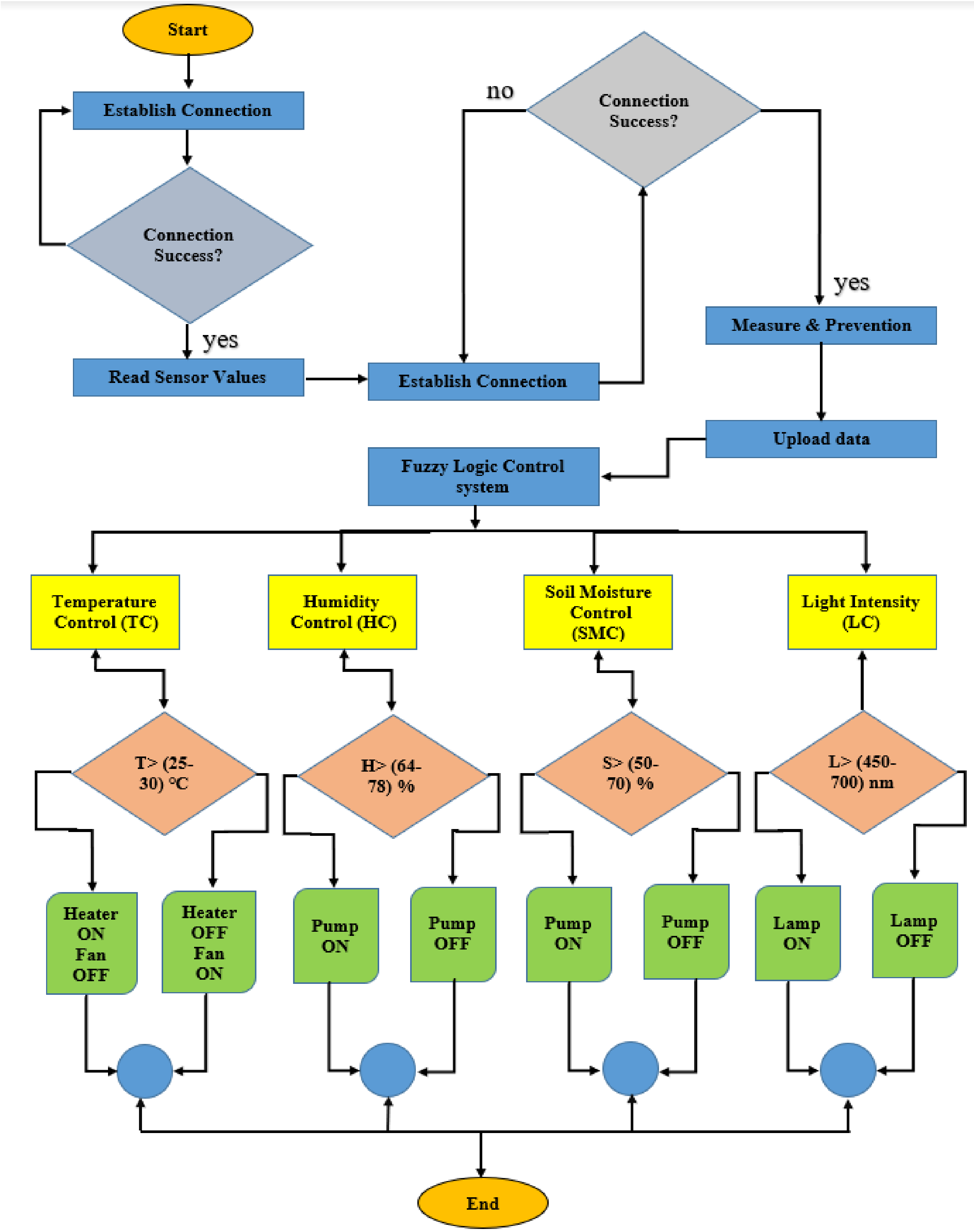


Figure 4: Raspberry PI

3.2 System Architecture/Flow Diagram:



3.3 Hardware Components:

1.Sensors Used:

We use different sensors like Temperature & humidity (DHT11), light (LDR), pH sensor and Soil Moisture Sensor.

PH Sensor

Figure 5: pH Sensor

Soil Moisture Sensor

Figure 6: Soil Moisture Sensor

Temperature and Humidity sensor DHT11

Figure 7: DHT11

Light Intensity Sensor

Figure 8: LDR Sensor

2. 5V Power Supply:

We are using a power supply which is AC 220V to DC 5V which will be used to power all the sensors and relays.

Figure 9: 5V Adapter Power Supply

3. Relay Module:

The Arduino's relay is an electronic switch that allows low-power signals from the Arduino to control high-power devices such as fans, lights, or motors, via an electromagnet in exchange for switching. We have used relays for each switching function like turning on a DC Pump, DC fan and LEDs.

Figure 10: Relay Module

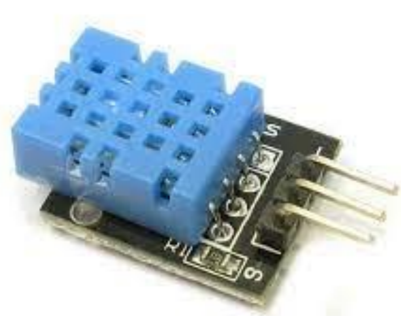
4. ESP32 Module:

For the purpose of IOT or we say remotely controlling of the system we have used the ESP32 Module which is a WiFi Device having a transceiver for end point IoT developments. We have connected this module with the Arduino Uno Controller and configured with the Thingspeak to monitor and control our system remotely using WiFi.

Figure 11: ESP32

5. DHT11 Sensor:

DHT11 sensor is an inexpensive digital temperature and humidity sensor widely used in various industries. It can measure temperatures from 0°C to 50°C and relative humidity from 20% to 90%. This connection uses a digital wireless control protocol and has four pins: VCC (power supply), GND (ground), Data (connection), and NC (no connection). The sensor needs a pull-up resistor for proper data transmission. Libraries and example codes are available for microcontrollers. Although DHT11 has limitations in terms of accuracy and response time, it is a popular and inexpensive choice for basic temperature and humidity detection.



6. Light Sensor (LDR):

An LDR sensor, also known as a light-based resistor or photoresistor, is a type of resistor whose resistance changes in response to the amount of light measuring light intensity and typically has a measurement range of several lux (light units) to thousands of lux depending on the particular sensor.

7. Soil Moisture Sensor:

A soil moisture sensor is a device that measures the amount of moisture in the soil. It typically consists of two probes inserted into the soil, and the sensor monitors the electrical conductivity between the probes to determine moisture content Soil moisture sensor measurements can vary, but generally cover 0% (dry soil) to 100% (a saturated soil) water.

8. pH Sensor:

pH sensor An electronic device used to measure the acidity of a solution. It detects the concentration of (H+) ions in the solution and gives the corresponding pH value. The pH sensor is a flexible electrode that responds to changes in hydrogen ion concentration and produces an electrical signal. These signals are then processed and converted to a numerical pH value indicating the acidity (pH < 7), neutrality (pH = 7), or alkalinity (pH > 7) of the solution using the pH sensors typically agriculture, environmental monitoring, water treatment, chemical analysis, and scientific research in a variety of environments, ensuring proper pH control and maintaining optimal conditions into for various strategies and systems.

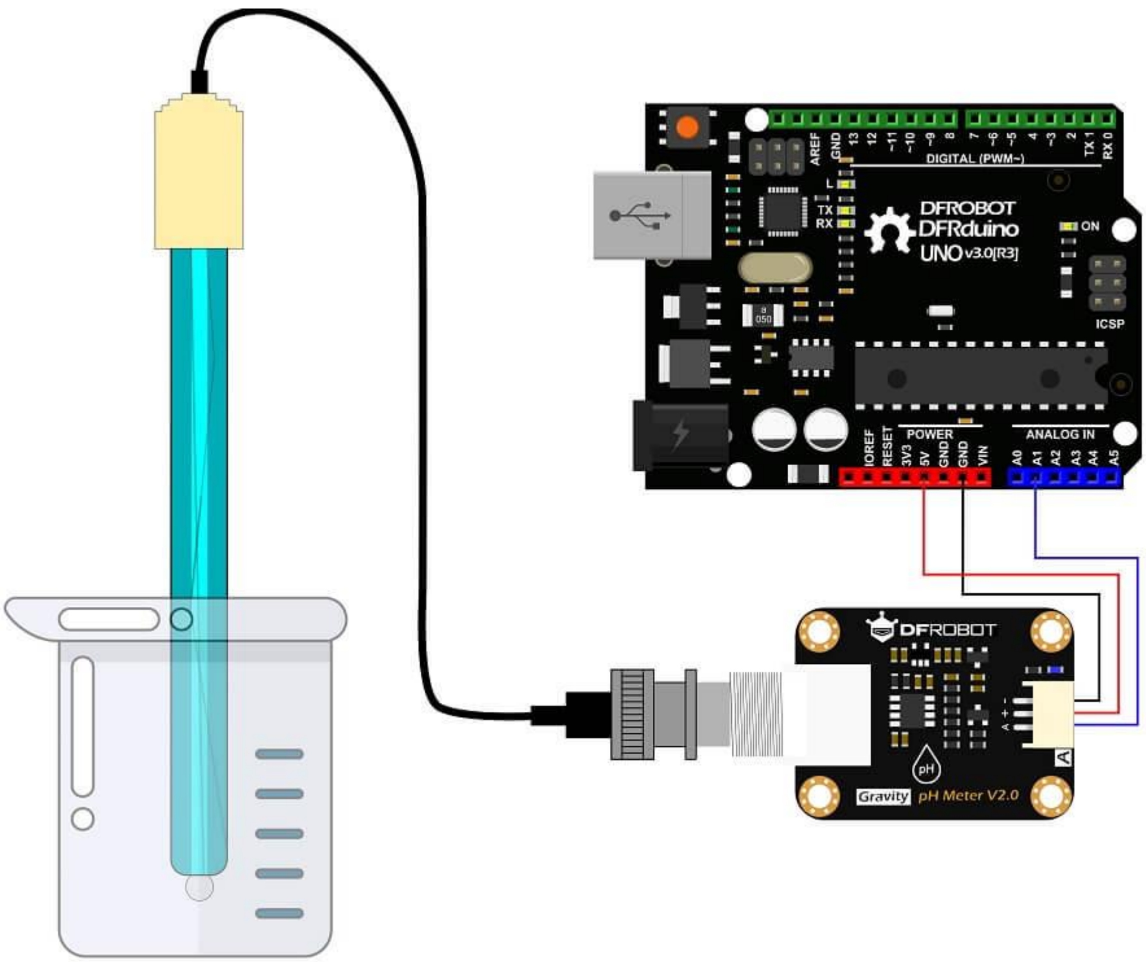


Figure 12: pH Sensor Module

9. LCD 20x4:

The LCD 20x4 is a liquid glass display module with a screen size of 20 characters and 4 characters per line. It is commonly used to display alphanumeric information in services and applications. The module typically operates on a 5V power supply and communicates with microcontrollers and other devices via a parallel interface. It provides a large area for displaying data and messages, making it suitable for projects requiring detailed display capabilities.

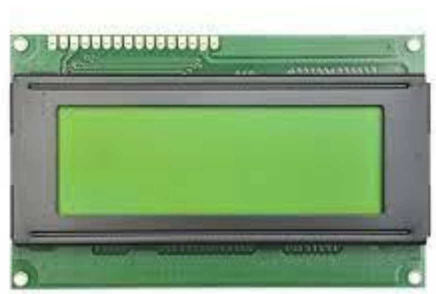


Figure 13: 20x4 LCD

10. I2C LCD Adapter:

The I2C LCD adapter is a module that allows easy connectivity between the LCD (Liquid Crystal Display) and the microcontroller using the I2C communication protocol It acts as a bridge between the LCD and the microcontroller, reducing the number of pins required for communication on. I2C LCD adapters typically have an integrated I2C chip that handles communication between the LCD and the microcontroller, simplifying wiring and facilitating the viewing and display of information on the LCD screen

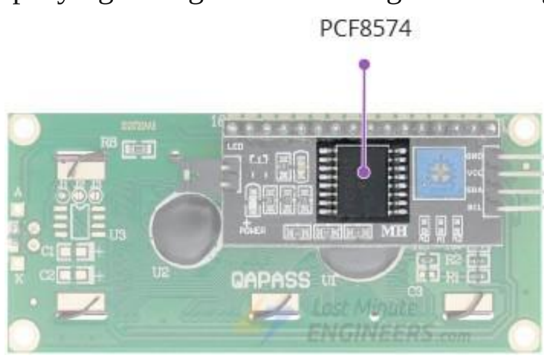


Figure 14: I2C LCD Adapter

11. Grow Bag:

A grow bag is a container made of soft fabric or plastic that is specially designed for planting and growing plants. It is often used in gardens and gardens as an alternative to traditional pots or pans. Growing bags are typically made of breathable fabric to improve air and drainage, prevent runoff and promote healthy root growth Available in a variety of sizes, shapes and materials, they are commonly used to grow vegetables, herbs, flowers and shrub. Grow bags are small, portable, and easy to use, making indoor and outdoor gardening easy.

Figure 15: Grow Bag

3.4 Experimental Details:

1. First of all, we interfaced all our sensors with Arduino Uno controller.
2. All the actuating devices like LEDs, Fan, DC Pump etc are interfaced with the Arduino using relay modules.
3. Then we used the Power Supply to power all these Modules and Sensors.
4. We showed the real time data on 20x4 LCD.
5. We Created a dataset through Arduino Serial Monitor.
6. We trained that dataset in order to measure Growth of Plants.
7. Then we interfaced Raspberry Pi with our Greenhouse
8. After training we used an AI algorithm to monitor and control the parameters automatically.
9. The tested dataset has been embedded in AI Algorithm.

10. Then for IOT Purpose, we integrate Wi-Fi Module with our microcontroller.

11. For IOT purpose, we used Thing Speak Cloud Server.

12. We Created a Channel on Thing Speak Server and put the API key of the channel in the program of the microcontroller.

3.4 Hardware/Development Setup:

The Dimension of the Greenhouse Frame is 5 feet in length, 3 feet in width and 4 feet in height. These measurements determine the size and shape of the Greenhouse structure.

Figure 16: Greenhouse Frame

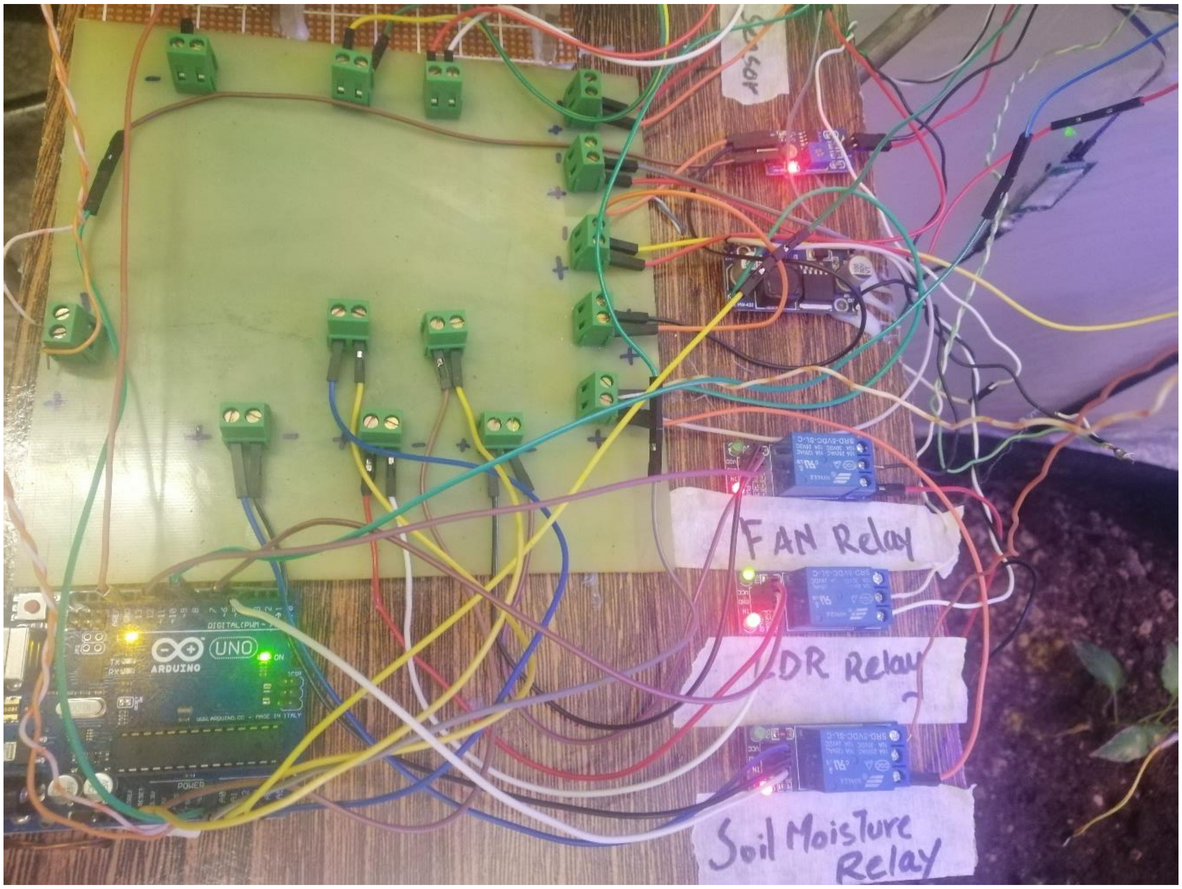


Figure 17: Final Circuit

3.5 IOT:

The Internet of Things (IoT) plays a key role in our smart greenhouse system, enabling us to create a seamlessly connected environment where data from sensors are collected, analyzed and used to grow plants conditions are good. Let us open up the realm of possibilities. In this discussion, we will explore the importance of IoT in our business and how it improves the overall efficiency and impact of our smart greenhouse system.

1. **Real-time data collection:**

One of the main advantages of IoT in our greenhouse system is our ability to collect real-time data from multiple sensors. By integrating IoT-enabled devices, such as the Arduino, we can monitor a variety of environmental factors, including temperature, humidity, soil moisture, light intensity, and etc. This constant information provides a detailed understanding of the environmental conditions of the greenhouse and the plant -Can make data-driven decisions to optimize growing conditions

2. **Remote monitoring and control:**

IoT enables remote monitoring and monitoring, allowing us to access and monitor greenhouse systems anytime and anywhere. By connecting Arduino sensors to an IoT server like ThingSpeak we can remotely monitor sensor values and greenhouse conditions through a web-based interface or mobile application This remote approach ensures that we can monitor greenhouse environment encountering, receiving alerts, intervention as needed and we can do it, even when it’s even physically far from a greenhouse.

3. **Proactive Interventions:**

Real-time data collected through IoT integration allows us to take priority measures to ensure healthy plant growth. By monitoring sensor values remotely, we can detect discrepancies or deviations from the desired parameters. For example, if the temperature exceeds a specified limit, we can remotely trigger the cooling system to maintain the proper temperature. This early action prevents potential damage to plants and creates a stable growing medium.

4. **Data analysis and decision making:**

IoT integration allows us to analyze the collected data to gain valuable insights and make informed decisions. By using cloud computing and data analysis, we can process large amounts of sensor data, identify patterns, and identify relationships between environmental factors and plant growth This analysis allows us to refine our AI algorithms, improve the accuracy of forecasts, and develop optimized control systems in order to improve plant management. It also allows for flexibility.

5. **Efficiencies:**

IoT integration plays an important role in optimizing resources in our smart greenhouse system. By constantly monitoring sensor values, we can ensure efficient use of resources such as water and energy. For example, if soil moisture monitors indicate adequate irrigation, irrigation system operations can be temporarily suspended, thereby conserving available water. Similarly, depending on the intensity of the light, we can adjust the LEDs to provide the necessary brightness, optimizing energy efficiency.

6. **Data visualization and reporting:**

IoT integration makes it easy to visualize data and generate insightful reports. By using IoT platforms, we can create customized dashboards that are visually appealing and easy to understand sensor readings and greenhouse conditions. This graph allows us to track progress, identify production, and obtain a comprehensive overview of environmental greenhouse effects. In addition, report generation based on historical data helps in business analysis and decision-making process.

7. **Interface with external systems:**

IoT integration enables seamless interaction with external systems and services, expanding the capabilities of our smart greenhouse system. For example, by integrating weather forecasting services, we can forecast future weather patterns and adjust greenhouse parameters accordingly. Additionally, by connecting to external databases or APIs we can access and use more agricultural knowledge to improve our decision-making processes.

In **conclusion**, integrating IoT capabilities into our smart greenhouse system offers many benefits, including real-time data collection, remote monitoring and control, proactive intervention, data analysis, resource optimization, enhanced connectivity, data visualization, external Integration also exists with systems IoT empowers us to create truly interconnected intelligent ecosystems where technology and human interventions work in harmony to optimize plant growth conditions , it promotes sustainable development and a greener future.

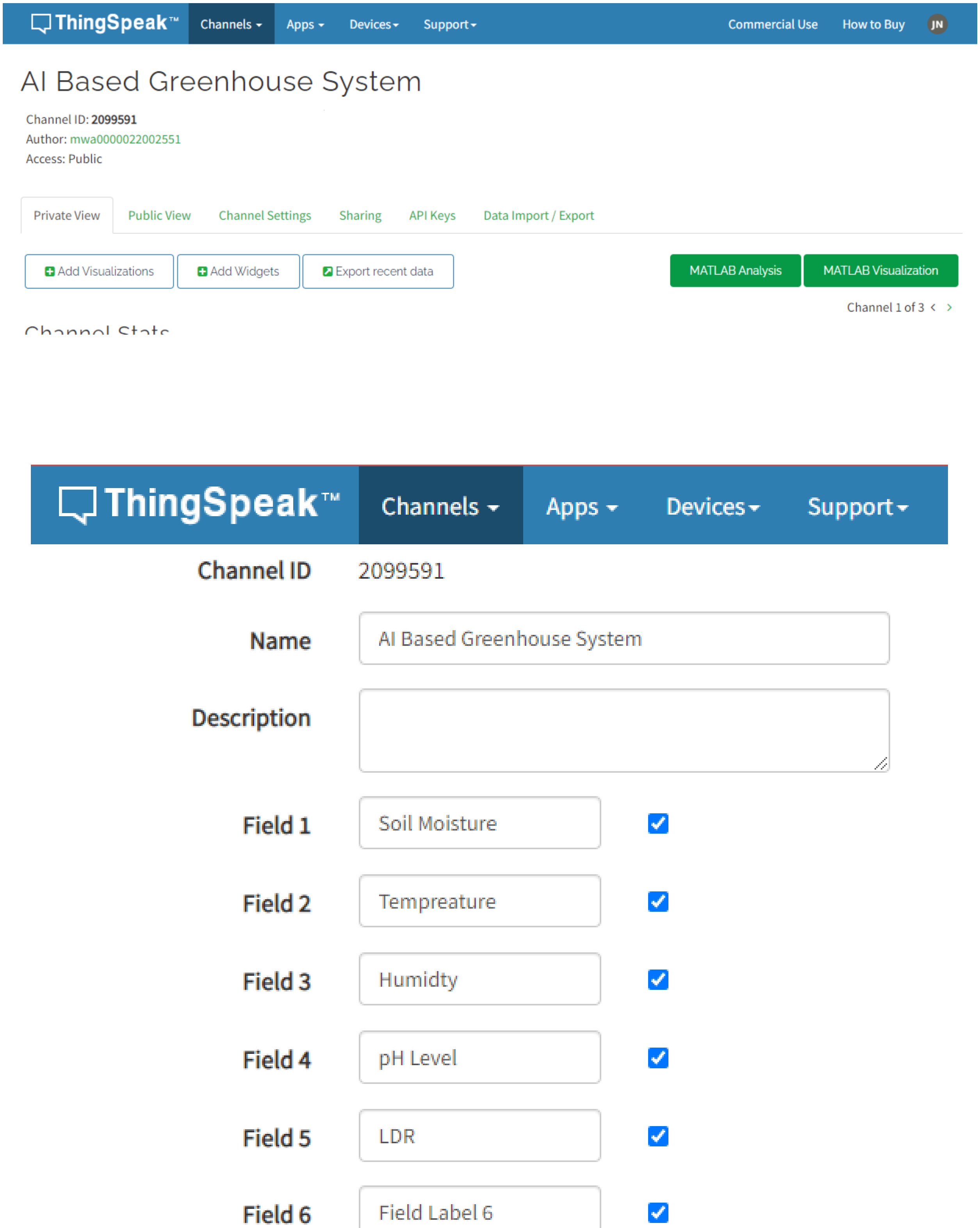


Figure 18: ThingSpeak Server Website

3.6 Software/ Tools:

In our project, we utilized Proteus 8.10 for Simulation purposes and Arduino IDE for Coding purposes.

3.6.1 Proteus:

- Proteus is a software tool used for electronic circuit simulation design.
- Allows users to create virtual representations of electronic circuits and test their functionality before physical use.
- Proteus supports simulation of both analog and digital circuits.
- Offers a large library of accessory electronic components, including microcontrollers, sensors, integrated circuits and passive components.
- Users can drag and drop components into the workspace to create a desired circuit.
- Proteus supports simulation of software-hardware interactions, making it useful for testing microcontroller firmware and software functionality.
- The software provides debugging and analysis tools for analyzing and identifying circuit behavior, waveform analysis, and virtual measurements.
- Proteus includes PCB design modules for converting virtual circuits into physical designs for PCB manufacturing.
- Provides tools for component placement, track routing, and generation of files.
- Proteus is widely used by engineers, designers and hobbyists for circuit design, simulation and PCB design.

PCB for Supply of Sensors:

We Designed the PCB used as a Power Supply for the Sensors and other devices. As all the sensors and devices except DC Fan are running on 5V, so the input of the PCB is set to 5V. For the Fan, we are using Boost Converter that convert 5V into 12V. So, the output of Boost Converter is set to 12V to Operate DC Fan. Supply of Arduino Uno or Esp-32 also given through this PCB.

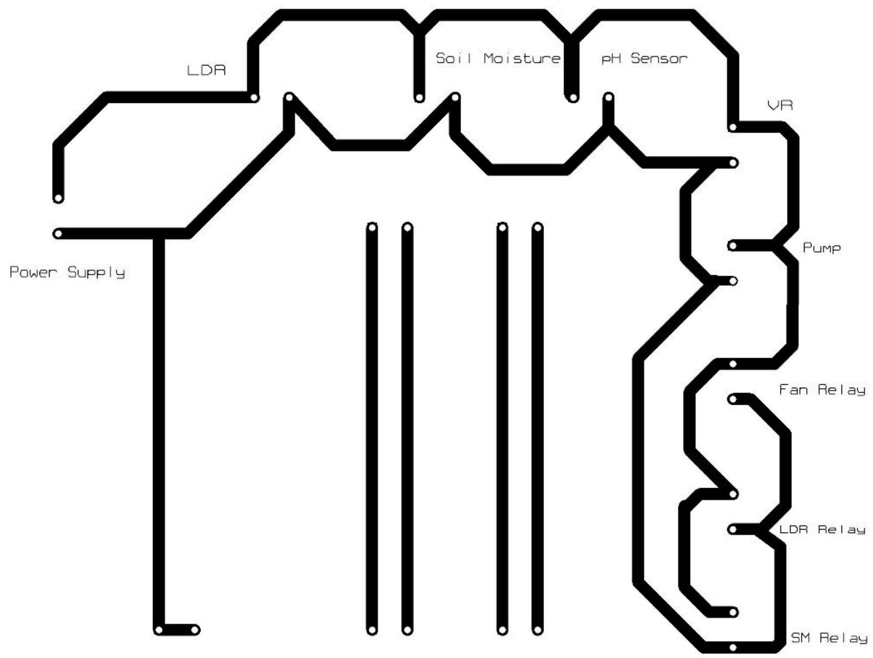


Figure 19: PCB Layout

Simulation of Greenhouse in Proteus:

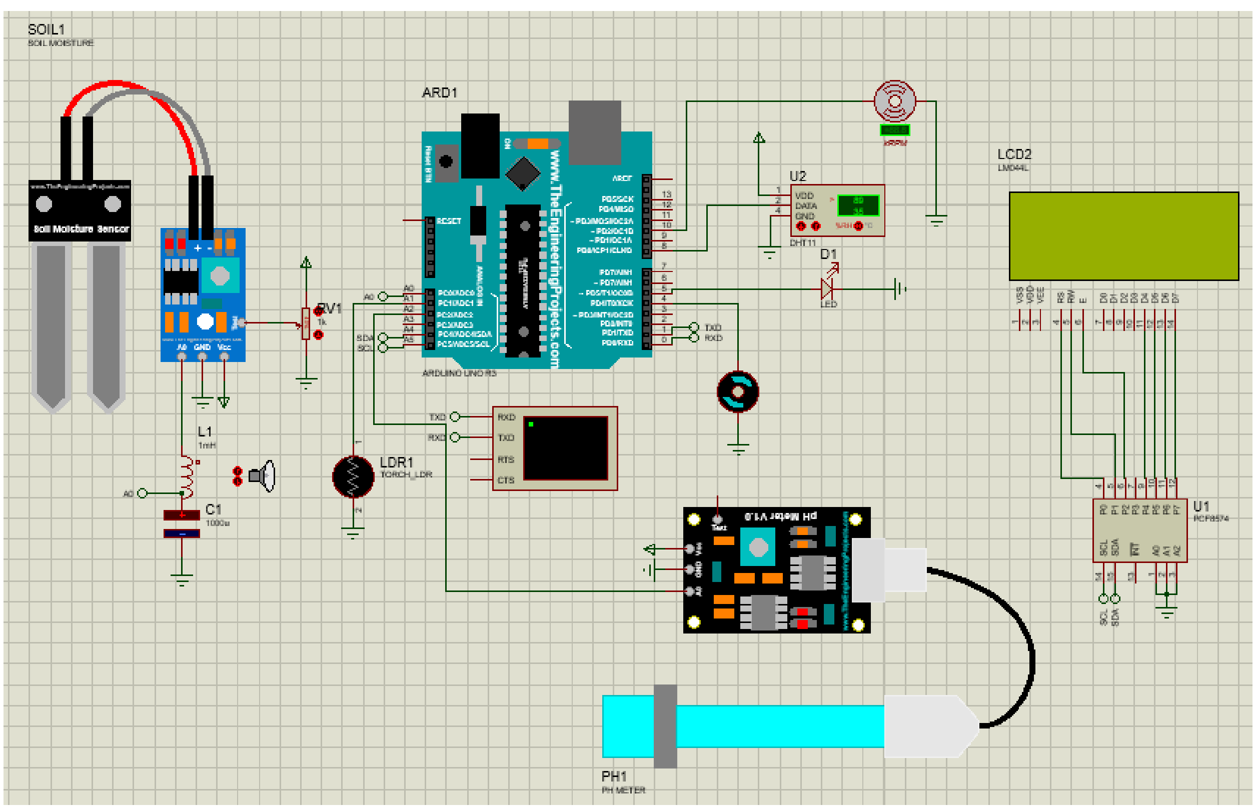


Figure 20: Greenhouse Simulation in Protues

3.7 Codes:

3.7.1 Arduino Code:

Here is the Arduino Code for simulation of the Greenhouse System for Automation Purpose.

```
#include <DHT.h>
#include <DHT_U.h>
#define DHTPIN 8     // what pin we're connected to
#define DHTTYPE DHT11   // DHT 11
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x27,20,4);
DHT dht(DHTPIN, DHTTYPE);
const int MOISTURE_PIN = A0;                    // soil moisture sensor connected to analog pin A0
const int RELAY_PIN_1 = 4;                      // Relay connected to digital pin 4
int moistureValue = 0;                          // variable to store soil moisture sensor value
int sensorValue = 0;
const int LDR_PIN = A1;                         // soil moisture sensor connected to analog pin A1
const int RELAY_PIN_2 = 5;                      // Relay connected to digital pin 5
int LDRValue = 0;                               // variable to store soil moisture sensor value
int phval = 0;
unsigned long int avgval;
int buffer_arr[10],temp;
float ph_act;
float volt;
int t;
int h;
char buf[20];
int Relay_FAN_3=10;

void setup() {
  Serial.begin(9600);
  pinMode(RELAY_PIN_1, OUTPUT); // set relay pin as output
  pinMode(RELAY_PIN_2, OUTPUT); // set relay pin as output
```

```
  pinMode(Relay_FAN_3, OUTPUT);
  dht.begin();
  lcd.init();
  lcd.backlight();
  /*lcd.setCursor(0,0);
  lcd.print("Soil Moisture:");
  lcd.setCursor(15,0);
  lcd.print(moistureValue);
  lcd.setCursor(0, 1);
  lcd.print("Temp:");
  lcd.print(t);
  lcd.print("C.");
  lcd.setCursor(11, 1);
  lcd.print("Humi:");
  lcd.print(h);
  lcd.print("% ");
  lcd.setCursor(0, 2);
  lcd.print("pH Val:");
  lcd.setCursor(8, 2);
  lcd.print(ph_act);
  lcd.setCursor(0, 3);
  lcd.print("LDR OUT:");
  lcd.setCursor(8, 3);
  lcd.print(LDRValue);
*/
}

void loop() {
  sensorValue = analogRead(MOISTURE_PIN);
  moistureValue = map(sensorValue, 0, 1023, 100, 0);
  if (moistureValue < 40) { // if soil is dry (moisture value is low)
    digitalWrite(RELAY_PIN_1, LOW); // turn on relay
  }
```

```
 else {                                              // if soil is moist (moisture value is high)
   digitalWrite(RELAY_PIN_1, HIGH); // turn off relay

 }
 delay(100);                          // wait for 100ms before checking soil moisture sensor again

 LDRValue = analogRead(LDR_PIN); // read soil moisture sensor value
 float ldrPercentage = map(LDRValue, 1023, 0, 0, 100);
 if (ldrPercentage < 40)
{                                               // if soil is dry (moisture value is low)
   digitalWrite(RELAY_PIN_2, LOW); // turn on relay

 }
else { // if soil is moist (moisture value is high)
   digitalWrite(RELAY_PIN_2, HIGH); // turn off relay

 }
 delay(100);              // wait for 100ms before checking soil moisture sensor again

 h = dht.readHumidity();
                                     // Read temperature as Celsius
 t = dht.readTemperature();
                                     // Read temperature as Fahrenheit

 if(t>30)
 {
   digitalWrite(Relay_FAN_3, LOW);    //On the fan when temp is greater than 30 degree

 }
 else
 {
   digitalWrite(Relay_FAN_3, HIGH);    //Off the fan when temp is less than 30 degree
 }
```

```
 for(int i=0;i<10;i++) //Get 10 sample value from the sensor for smooth the value
{
buffer_arr[i]=analogRead(A2);      //pH sensor Pin
delay(30);
}
for(int i=0;i<9;i++) //sort the analog from small to large
{
for(int j=i+1;j<10;j++)
{
if(buffer_arr[i]>buffer_arr[j])
{
temp=buffer_arr[i];
buffer_arr[i]=buffer_arr[j];
buffer_arr[j]=temp;
}
}}
avgval=0;
for(int i=2;i<8;i++)   //take the average value of 6 center sample
avgval+=buffer_arr[i];
volt=(float)avgval*5.0/1024/6; //convert the analog into millivolt
ph_act = 3.5*volt-7.; //convert the millivolt into pH value

 Serial.print("Humidity: ");
 Serial.print(h);
 Serial.print(" %\t");
 Serial.print("   " );
 Serial.print(",");
 Serial.print("Temperature: ");
 Serial.print(t);
 Serial.print(" *C\t ");
 Serial.print(",");
 Serial.print("Moisture=");
```

```
  Serial.print(moistureValue);
  Serial.print("%");
  Serial.print("   " );
  Serial.print(",");
  Serial.print("LDR: ");
  Serial.print(ldrPercentage);
  Serial.print("   " );
  Serial.print(",");
  Serial.print("pH Value =");
  Serial.print(ph_act);
  Serial.println("   " );
  delay(10000);
  lcd.setCursor(0, 0);
  lcd.print("Temp:");
  lcd.print(t);
  lcd.print("C.");
  lcd.setCursor(11, 1);
  lcd.print("Humi:");
  lcd.print(h);
  lcd.print("% ");
  lcd.setCursor(0,2);
  lcd.print("Soil Moisture:");
  lcd.setCursor(15,0);
  lcd.print(moistureValue);
  lcd.setCursor(0, 2);
  lcd.print("pH Val:");
  lcd.setCursor(8, 2);
  lcd.print(ph_act);
  lcd.setCursor(0, 2);
  lcd.print("LDR OUT:");
  lcd.setCursor(8, 3);
  lcd.print(ldrPercentage);
}
```

3.7.2 Code for Esp-32:

```
#include <ThingSpeak.h> // Including the ThingSpeak library
#include <Adafruit_Sensor.h>
#include <DHT.h>
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include <WiFi.h>
#include <WiFiClient.h>
#define TS_ENABLE_SSL // For HTTPS SSL connection

const char *api_key = "W2GQVTNTZQ4MPGQC";   //  Enter your Write API key from
ThingSpeak
const char *ssid =  "Fivi Fiber";                    // Replace with your wifi ssid
const char *pass =  "nov@1102";                      // Replace with your wifi password
const char* server = "api.thingspeak.com";
unsigned long My_Channel_ID = 2099591;
int X;
WiFiClient client;
LiquidCrystal_I2C lcd(0x27,20,4);
// Define pins for DHT11 sensor
#define DHTPIN 26
#define DHTTYPE DHT11

// Define pins for soil moisture sensor, LDR sensor, pH sensor, and relays
#define SOIL_MOISTURE_PIN 32
#define LDR_PIN 34
#define PH_PIN 36
#define WATER_PUMP_RELAY_PIN 14
#define LIGHT_BULB_RELAY_PIN 12
#define DC_FAN_RELAY_PIN 13
// Define threshold values for sensors
#define SOIL_MOISTURE_THRESHOLD 30
```

```
#define LDR_THRESHOLD 30
#define TEMPERATURE_THRESHOLD 30.0
#define PH_THRESHOLD 7.0

// Initialize sensors
DHT dht(DHTPIN, DHTTYPE);

void setup() {
  // Initialize serial communication
  Serial.begin(115200);
  delay(1000);

  // Initialize sensors
  dht.begin();
  lcd.init();
  lcd.backlight();
  // Initialize pins for relays
  pinMode(WATER_PUMP_RELAY_PIN, OUTPUT);
  pinMode(LIGHT_BULB_RELAY_PIN, OUTPUT);
  pinMode(DC_FAN_RELAY_PIN, OUTPUT);

Serial.println("Connecting To ");
       Serial.println(ssid);
       WiFi.begin(ssid, pass);

      while (WiFi.status() != WL_CONNECTED)
     {
            delay(500);
            Serial.print(".");
     }
      Serial.println("");
      Serial.println("WiFi Connected");
}
```

```
void loop() {
  // Read sensor values
  float temperature = dht.readTemperature();
  float humidity = dht.readHumidity();
  int soilMoisture = analogRead(SOIL_MOISTURE_PIN);
  int ldrValue = analogRead(LDR_PIN);
  float phValue = analogRead(PH_PIN);

  // Convert sensor readings to percentage
  float soilMoisturePercentage = map(soilMoisture, 1023, 0, 0, 100);
  float ldrPercentage = map(ldrValue, 1023, 0, 0, 100);
  float phPercentage = map(phValue, 0, 1023, 0, 14);



  // Print sensor readings
  Serial.print("Temperature: ");
  Serial.print(temperature);
  Serial.print(" °C");
  Serial.print("   " );
  Serial.print("Humidity: ");
  Serial.print(humidity);
  Serial.print(" %");
  Serial.print("   " );
  Serial.print("Soil Moisture: ");
  Serial.print(soilMoisturePercentage);
  Serial.print("%");
  Serial.print("   " );
  Serial.print("LDR Value: ");
  Serial.print(ldrPercentage);
  Serial.print("%");
  Serial.print("   " );
  Serial.print("pH Value: ");
```

```
  Serial.print(phPercentage);
  Serial.print("pH");
  Serial.print("   " );
delay(1000);
  // Control water pump relay based on soil moisture level
  if (soilMoisturePercentage < SOIL_MOISTURE_THRESHOLD) {
    digitalWrite(WATER_PUMP_RELAY_PIN, HIGH);
    Serial.print("Water pump ON");
    Serial.print("   " );
  } else {
    digitalWrite(WATER_PUMP_RELAY_PIN, LOW);
    Serial.print("Water pump OFF");
    Serial.print("   " );
  }
  // Control light bulb relay based on light level
  if (ldrPercentage < LDR_THRESHOLD) {
    digitalWrite(LIGHT_BULB_RELAY_PIN, HIGH);
    Serial.print("Light bulb ON");
    Serial.print("   " );
  } else {
    digitalWrite(LIGHT_BULB_RELAY_PIN, LOW);
    Serial.print("Light bulb OFF");
    Serial.print("   " );
  }
  // Control DC fan relay based on temperature
  if (temperature > TEMPERATURE_THRESHOLD) {
    digitalWrite(DC_FAN_RELAY_PIN, HIGH);
    Serial.print("DC FAN ON");
    Serial.print("   " );
  } else {
    digitalWrite(DC_FAN_RELAY_PIN, LOW);
    Serial.print("DC FAN OFF");
    Serial.println("   " );
```

```
  }
delay(1000);
  lcd.setCursor(0,0);
  lcd.print("Temp:");
  lcd.print(temperature);
  lcd.setCursor(11, 0);
  lcd.print("Humi:");
  lcd.print(humidity);
  lcd.setCursor(0, 1);
  lcd.print("LDR OUT:");
  lcd.setCursor(8, 1);
  lcd.print(ldrPercentage);
  lcd.setCursor(0, 2);
  lcd.print("Soil Moisture:");
  lcd.setCursor(15, 2);
  lcd.print(soilMoisturePercentage);
  lcd.setCursor(0, 3);
  lcd.print("pH Val:");
  lcd.setCursor(8, 3);
  lcd.print(phPercentage);

  if (client.connect(server, 80)) {
    String data = String (api_key) + "&field1=" + String(temperature) + "&field2=" +
String(humidity) +
                  "&field3=" + String(ldrPercentage) + "&field4=" + String(soilMoisturePercentage)+
"&field5=" + String(phPercentage);
    String url = "/update?api_key=" + String(api_key) + "&field1=" + String(temperature) +
"&field2=" + String(humidity) +
                  "&field3=" + String(ldrPercentage) + "&field4=" + String(soilMoisturePercentage)+
"&field5=" + String(phPercentage);
    client.print("POST " + url + " HTTP/1.1\r\n" +
                 "Host: " + server + "\r\n" +
                 "Connection: close\r\n" +
```

```
              "Content-Type: application/x-www-form-urlencoded\r\n" +
              "Content-Length: " + data.length() + "\r\n\r\n" +
              data);
    client.stop();
    Serial.println("Data sent to ThingSpeak successfully");
  } else {
    Serial.println("Error connecting to ThingSpeak");
  }

  delay(15000);
}
```

Chapter 4

Testing and Validation/Discussion

4.1 Testing

4.1.1 Prototypes

Sensor Prototypes:

1. DHT11 Sensor:
   - Measurement Range: Temperature (0-50°C), Humidity (20-90%)
   - Pin Connections: Data (DHT11 data pin) - Arduino digital pin
2. LDR Sensor:
   - Measurement Range: 0-1023 (analog reading)
   - Pin Connections: Analog Out - Arduino analog pin
3. Soil Moisture Sensor:
   - Measurement Range: 0-1023 (analog reading)
   - Pin Connections: Analog Out - Arduino analog pin
4. pH Sensor:
   - Measurement Range: pH 0-14
   - Pin Connections: Analog Out - Arduino analog pin

Communication Prototypes:

The Arduino Uno communicates with the ESP32 module via serial communication using the SoftwareSerial library.

- Arduino Uno (TX) - ESP32 (RX)
- Arduino Uno (RX) - ESP32 (TX)

Data Upload Prototypes:

The ESP32 module sends sensor data to the Thingspeak server using HTTP GET requests.

- API Endpoint: https://api.thingspeak.com/update
- Parameters: Field1 (Temperature), Field2 (Humidity), Field3 (Light Level), Field4 (Soil Moisture), Field5 (pH Level)

Irrigation System Prototypes:

The irrigation system is controlled based on predefined thresholds and schedules:

- If soil moisture is below a specified threshold, the water pump is activated for a predefined duration.
- The system considers the desired light levels and temperature range to optimize watering schedules.

User Interface Prototypes:

A basic web-based user interface allows users to monitor sensor readings and configure system settings remotely.

4.1.2 Test Case Prototypes:

Test Case	Description	Expected Outcome
1	Verify DHT11 sensor readings	Temperature and humidity readings are within an acceptable range.
2	Validate LDR sensor functionality	The sensor accurately detects light levels corresponding to the ambient conditions.
3	Test soil moisture sensor	The sensor provides accurate readings reflecting the soil moisture content.
4	Validate pH sensor measurements	The pH sensor delivers precise pH level readings for the soil.
5	Test communication with ESP32	The Arduino Uno and ESP32 module establish a stable connection for data transfer.
6	Ensure successful data upload	Sensor data is successfully uploaded to the Thingspeak server with the correct field values.
7	Test irrigation system	The system activates the water pump based on sensor readings and predefined thresholds.
8	Validate user interface (if applicable)	The user interface displays sensor data accurately and allows for system configuration

Each test case is described, along with the expected outcome when the test is performed. The purpose of these test cases is to verify the functionality and accuracy of various components and features in your project.

1**. Test Case: Verify DHT11 sensor readings**

Description: This test ensures that the DHT11 sensor provides accurate temperature and humidity readings.

Expected Outcome: The sensor readings should fall within an acceptable range.

2. Test Case: Validate LDR sensor functionality

Description: This test checks if the LDR sensor accurately detects light levels in the environment.

Expected Outcome: The sensor should provide readings that correspond to the ambient light conditions.

3. Test Case: Test soil moisture sensor

Description: This test evaluates the soil moisture sensor's ability to measure the moisture content of the soil.

Expected Outcome: The sensor readings should reflect the actual soil moisture content accurately.

4. Test Case: Validate pH sensor measurements

Description: This test ensures that the pH sensor delivers precise pH level readings for the soil.

Expected Outcome: The pH sensor should provide accurate measurements of the soil's pH level.

5. Test Case: Test communication with ESP32

Description: This test verifies the stable connection between the Arduino Uno and the ESP32 module.

Expected Outcome: The Arduino Uno and ESP32 should establish a reliable communication link.

6. Test Case: Ensure successful data upload

Description: This test checks if the sensor data is successfully uploaded to the Thingspeak server.

Expected Outcome: The sensor data should be sent to the server with the correct field values.

7. Test Case: Test irrigation system

Description: This test evaluates the functionality of the irrigation system based on sensor readings and predefined thresholds.

Expected Outcome: The system should activate the water pump when the soil moisture falls below a specified threshold.

8. Test Case: Validate user interface

Description: This test ensures that the user interface displays sensor data accurately and allows for system configuration.

Expected Outcome: The user interface should show the correct sensor readings and provide options for system settings.

By performing these test cases, we can ensure that our automatic irrigation system operates as intended and meets the desired functionality and accuracy requirements.

4.2 Results/Output/Statistics

1. The below image Figure1 shows the visual results obtained by the AI-based automated greenhouse system. The photo shows a grow bag filled with a careful mixture of soil, cocoa peat, peat moss and compost. The grow bag contains several small green pepper plants, which means they are best grown in an artificial greenhouse environment. Water tanks are placed near the irrigation bags to facilitate controlled irrigation. The water pump efficiently delivers water from the container to the plant, maintaining a consistent and healthy soil moisture level. This irrigation system is controlled by a soil moisture sensor, which accurately measures moisture levels, and a pH sensor, which monitors the integration of soil pH values.

These sensors provide real-time information for AI algorithms just accurate and practical changes to create the best conditions for continued growth. The combination of these features demonstrates the efficiency of A-based automated greenhouse systems in favorable plant growth conditions Using technology and data-driven decision-making, the system provides efficient resource management, it increases water use efficiency and improves plant growth.

This is a visual representation of the positive results achieved through the use of an AI-based automated greenhouse system, further highlighting its potential for improving crop yields, increasing resource efficiency, and promote sustainable agricultural practices.

Figure 21: Growbag with Plants

2. The accompanying below figure, Figure 2 shows the hardware configuration of an AI-based automated greenhouse system. It is the central control unit Arduino microcontroller, which acts as the brain of the system. There are several relays associated with the Arduino, each of which is labeled with reference labels on the strip, indicating their specific function in the system.

A mixture of cables can be found, neatly arranged and organized, creating connections between different modules and components. These cables facilitate the transmission of data and control signals, providing seamless communication and synchronizing the various components of the system.

To ensure the cleanliness and efficiency of the system, the components are powered by a printed circuit board (PCB) with small connectors. These connections act as connections that supply power to the individual modules, increasing the reliability and stability of the overall system.

These figures represent the careful use of hardware in an AI-based automated greenhouse system.

It focuses on careful configuration of components, intuitive relay labeling, and the use of PCBs for flexible power distribution. Such well-organized and integrated hardware systems contribute to the efficiency and efficiency of a high-efficiency greenhouse system. By identifying the hardware design, this figure illustrates the technical applications and integration of the system components, and also confirms the reliable and efficient operation of the AI-based automated greenhouse system.

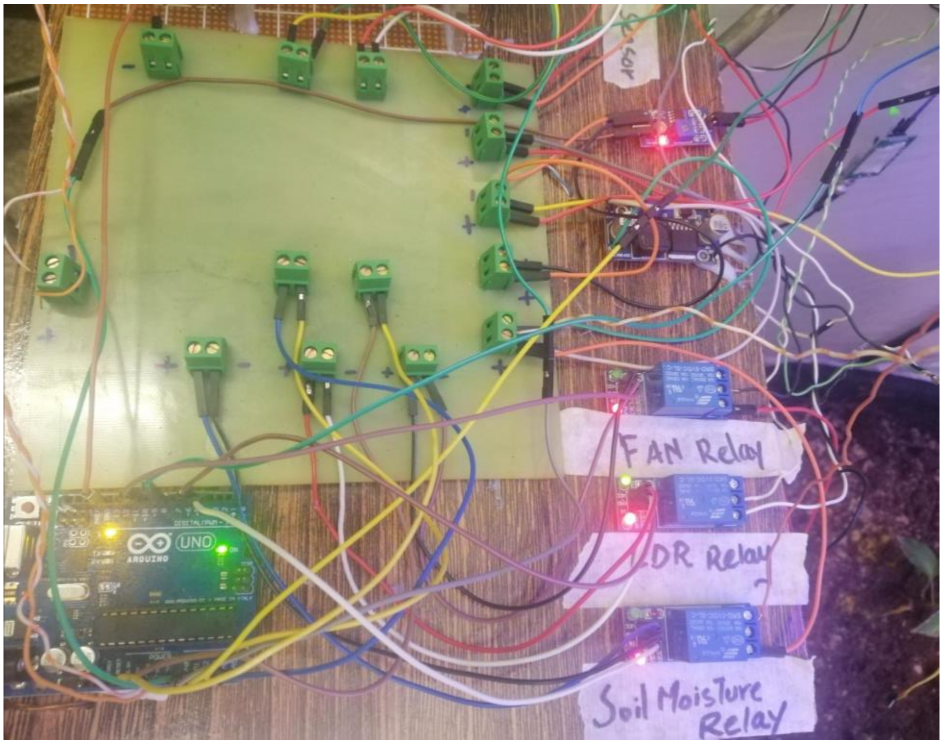


Figure 22: Final Circuit Look

3.The attached figure, figure 3 shows a complete example of the AI-based automated greenhouse system. It consists of a rectangular pyramid-shaped solid iron structure, about 3 feet wide, 4 feet. high, and 5 feet. These frames are covered with transparent sheet to form an enclosed structure. Inside the building, you can see a growing pocket with a plant room as seen in the previous photo. Plants are raised in this controlled environment, benefiting from the optimal conditions and sensor-driven automation provided by AI algorithms This diagram is a visual representation of the well-realized example, highlighting the combination of hardware components and greenhouse design It shows how an A-based automated greenhouse system has been successfully implemented to create optimal conditions for plant growth, for resource efficiency, and promote sustainable agricultural practices.

Figure 23: Greenhouse Final Look

4. The accompanying figure, figure 4 shows a 20x4 LCD display of the various parameters required to monitor the greenhouse effect. The LCD screen is divided into sections that display real-time measurements of temperature, humidity, soil moisture percentage humidity and soil pH.

Temperature readings provide an indication of the current internal temperature of the hot space, allowing for precise temperature control. Hygrometry measures the amount of moisture in the air, allowing for more efficient management of the moisture. Percentage of soil moisture provides information about water availability in the soil, and helps in irrigation decisions. Finally, soil pH readings help control soil acidity or alkalinity levels and help create optimal soil conditions for plant growth.

These figures highlight the importance of real-time monitoring and feedback in an AI-based automated greenhouse system. The LCD display is intuitive and informative for greenhouse operators, allowing them to make data-driven decisions and ensure optimal plant growing conditions.

Incorporating a 20x4 LCD display to display the vital components, the AI-based automated greenhouse system enhances monitoring capabilities, optimizing resource management and monitoring environmental conditions so accuracy is easy.

Figure 24: Sensors Values on LCD

4.2.1 Completion

Purpose of the content:

The completion of the AI-based automated greenhouse system demonstrates the successful achievement of the main objective of the project. The system was designed to provide an intelligent and automated environment for climate-friendly agriculture, improve resource efficiency, reduce human intervention and promote sustainable agricultural practices.

Hardware and Software:

The project included various hardware components such as Arduino, Raspberry Pi, sensors, actuators, network of interconnected modules etc. These components are seamlessly and accurately connected to enable data collection, analysis and decision-making. The software component includes the development and implementation of AI algorithms, visualization techniques, and real-time data analytics to ensure proper monitoring and maintenance of the greenhouse system.

Prototyping and Physical Implementation:

The project was concluded with a successful design and a fully functional prototype. Involving building a greenhouse structure, assembling hardware components, and providing a controlled environment for plant growth the model demonstrated the ability to monitor environmental parameters such as temperature & humidity, moisture of the soil, and pH so to provide favorable conditions for plant cultivation.

System performance and optimization:

The AI-based automated greenhouse system was rigorously tested and optimized for robustness. The system was extensively reviewed and evaluated, assessing its ability to monitor the environment at predetermined locations, accurately forecast and meet plant needs, and provide real-time insights for consumables use it properly.

Easy to use interface and controls:

A user-friendly interface was designed to facilitate interaction with the system. This interface enabled greenhouse operators to monitor priorities, receive informational alerts, modify settings, and visualize data through an intuitive dashboard or display screen. The system's control mechanisms, which including remote access capabilities, provided convenience and flexibility for efficient greenhouse management.

Validation and comparison:

During the termination phase, the performance and results of the AI-based automated greenhouse system were compared with conventional greenhouse practices. Comparative studies were carried out to evaluate the efficiency, yield and quality of the processes. The results of these comparisons highlighted the effectiveness of AI-based systems in improving productivity and promoting sustainable agricultural practices.

Overall, the completion of the AI-based automated greenhouse system demonstrates the achievement of a sophisticated, intelligent, sustainable solution for greenhouse farming that combines hardware, software, and optimization techniques improve resource efficiency, environmental integrity, and crop yields. The completion of the project lays a solid foundation for future developments in AI-powered agricultural systems and contributes to further sustainable agricultural practices.

4.2.2 Accuracy

Sensor accuracy and calibration:

Accurate sensor measurements are crucial for the successful operation of the AI-based automated greenhouse system. The project includes an extensive calibration process to ensure the accuracy and reliability of sensor data. The measurements involve comparing sensor readings to standardized references and adjusting the system accordingly. This careful design helped to accurately measure environmental parameters such as temperature & humidity, moisture of the soil and pH.

AI Algorithm Performance:

The accuracy of the AI systems used in the program played a key role in making informed decisions about environmental management and resource management The project involves extensive training and strategic maintenance for it high accuracy to predict plant needs, anomalies and optimize control parameters and row level It was ensured accordingly. **Comparison with ground truth data:**

The accuracy of the AI-based automated greenhouse system was evaluated by comparing its predictions and control behaviors with ground truth data. Ground truth data refer to measurements obtained by manual surveys or traditional greenhouse effects. The performance of the system was compared with ground truth data and the accuracy of its predictions, decisions and control procedures was evaluated.

Validation by testing:

Experiments and field testing continued to confirm the validity of the system. Real-world scenarios were simulated, and system responses were compared to expected results. This validation process helped determine the system's ability to accurately adjust irrigation, ventilation and lighting based on sensor readings and predicted plant needs Continuous improvement and adaptation

Optimization:

The project emphasized continuous improvement and refining the system for accuracy. The experimental design, user feedback, and feedback from operational analysis guided the refinement of designs, control procedures, and sensor measurements This ongoing effort aims to it will increase the accuracy of system prediction, operation, and resource efficiency.

Focusing on precision, the project ensures that an AI-based automated greenhouse system provides precise and reliable control over the environment, leading to healthy plant growth and consumption efficiency occurs Specific continuous research and development contributes to the efficiency and effectiveness of the overall system.

4.2.3 Correctness

System validation and verification:

The correctness of the AI-based automated greenhouse system was verified through rigorous validation and validation procedures. The system was thoroughly tested to ensure that it conforms to predefined specifications and requirements. This process includes comparing the performance of the individual components, the accuracy of the data, and the performance of the system as a whole with the expected results.

Comparison of Standard Settings:

The correctness of the system was avaluated by comparing the results with established standards and best practices for greenhouse farming. The project included references to the scientific literature, industry guidelines, and expert opinion to validate the program's decision-making processes and implementation practices. This comparison helped ensure that the program adhered to accepted practices and produced the correct result.

Error detection and control measures:

The plan includes robust error identification and management procedures to reduce unethical consequences or actions. Real-time analysis and feedback loops allowed detection of anomalies or deviations from expected values. The system structure and control procedures were designed to handle such faults, ensuring a fully adequate response to maintain the desired environmental conditions.

Feedback and iterative improvement:

User feedback and performance evaluations played an important role in optimizing the system. Feedback from greenhouse operators, agricultural experts, and stakeholders provided valuable insights into system performance and efficiency. Continuous iterations and modifications were used to address any identified correction issues and to increase system reliability.

Data Integrity Protection:

The successful design of the system also included ensuring the accuracy and security of the data collected and processed. Steps were taken to prevent data corruption, loss, or unauthorized access. To ensure the precision and dependability of the system outcomes, measures such as data encryption, robust communication protocols, and effective data backup mechanisms were implemented.

By emphasizing accuracy, the project highlights the system's ability to deliver accurate and reliable results in greenhouse control and management. Validation, verification and comparison systems ensure compliance with established standards, while error detection and continuous improvement methods enhance system correctness and reliability If the focus is on the project internal discipline, strengthening the reliability of the system and its ability to be widely adopted in the agricultural industry.

Chapter 5

Conclusion and Future Recommendations

5.1 Conclusion

In this project, our team has successfully developed and implemented an AI-based greenhouse system that is changing the way we farm plants. Using Arduino for sensor automation, Raspberry Pi for intelligent plant growth management, and integrating IoT for remote monitoring, we have created a comprehensive solution that combines sophisticated technology with the human touch.

Our main focus throughout the project was to design a system that not only maximizes plant growth but also considers the well-being of the people interacting with it. We wanted to create an environment where technology and human presence merge seamlessly and contribute to a sustainable, well-managed ecosystem.

The first part of our project involves collecting data from sensors connected to the Arduino. The DHT11 sensor provided accurate temperature and humidity readings, enabling us to closely monitor environmental greenhouse effects. Soil moisture detectors were used to measure irrigation water, allowing for precise control of irrigation. Additionally, we have added relays for controlling devices such as fans and LED lighting to control ventilation and optimize lighting conditions. The addition of LDR allowed us to measure the light intensity and adjust accordingly.

With the dataset we collected from the Arduino sensors, we set out to train the AI algorithm. This algorithm was developed to analyze data, identify patterns, and determine the optimal conditions for plant growth. By providing the algorithm with labeled data, we enabled it to make appropriate decisions and make adjustments to maintain optimal conditions for plant growth.

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Once the AI algorithm was trained, we implemented it on the Raspberry Pi. This powerful microcomputer served as the main processing unit of our system. It seamlessly integrated with Arduino sensors, capturing real-time data and processing it using a trained AI algorithm. The Raspberry Pi was responsible for controlling the environmental climate, making intelligent decisions based on sensor readings, and controlling various features like fans and LED lights to create an optimal environment if it grows, We recognize the importance of human interaction and the importance of creating an accessible and user-friendly system. To overcome this, we focused on humanizing the greenhouse system.

We ensured that the system interface was intuitive and accessible, allowing users to interact with it effortlessly. By providing an intuitive experience, we aimed to bridge the gap between technology and people, enabling individuals to actively participate in the nutrition process. We incorporated IoT capabilities into the system to enhance the overall experience and facilitate remote monitoring. By connecting the Arduino sensors to the ThingSpeak IoT server, we enabled the real-time display of sensors. And users can access this information remotely through a web-based interface or mobile application, allowing them to monitor the greenhouse environment from anywhere

5.2 Future Recommendations:

As we reflect on the success of our AI based Greenhouse system, it is important to consider possible future proposals that could further increase its impact on sustainable agriculture. While our business already incorporates cutting-edge technologies, we believe there is plenty of room for improvement and expansion to deliver a greener and more harmonious future. Both human priority and approach to plant breeding, these recommendations aim to have a profound and sustainable impact on the environment and human well-being

Education and Community Engagement:

Prioritize education and community engagement to ensure adoption and understanding of smart greenhouse systems. Workshops, seminars and outreach programs can be conducted to empower individuals to develop the knowledge and skills needed to effectively implement and manage such programs. By partnering with educational institutions, garden clubs and communities, we can inspire a new generation of environmentally conscious individuals who are passionate about sustainable agricultural practices.

Farmers in partnership with communities:

Partnering farmers with local communities is essential to blend traditional agricultural wisdom with advanced technology. Connecting with farmers allows us to tap into their vast knowledge and experience, and make them aware of the benefits of smart greenhouse systems By collaborating on research projects or providing training and support, we can help farmers for integrating technology into their existing practices, promoting efficiencies management systems and increasing productivity.

Renewable Energy Integration:

By integrating sustainable energy sources like solar panels and wind turbines, smart greenhouse systems can enhance their sustainability quotient. By using clean energy, we reduce our dependence on conventional energy sources and reduce the environmental impact of the system. The integration of energy storage solutions can ensure a continuous supply of electricity, even during periods of low renewable energy.

Propagation of crop varieties:

Although our work focused on specific plants, expanding the range of crops that can be grown in smart greenhouse systems increases its versatility and impact. By including a wide variety of fruits, vegetables, herbs and even ornamental plants, we can meet market demands and help ensure food security in addition as native and endemic plant species finding them can help to conserve biodiversity and support local ecosystems.

Water conservation and recycling:

Water scarcity is a major global concern, such that water conservation and recycling are prioritized in smart climate change policies. The use of improved water management systems, such as irrigation and rainwater harvesting, can reduce water wastage and ensure efficient use Water filtration and transportation the addition of purification measures can enable water reuse, reducing overall freshwater demand.

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