DEVELOPMENT OF FARM MONITORING SYSTEM USING IoT

In the partial fulfilment of the requirement for the award of the degree

of

Bachelor of Engineering

in

Electronics and Communication Engineering

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Year 2021-2022

DECLARATION

We hereby declare that the project report entitled "**Development of Farm Monitoring System using IoT"** submitted to the department of Electronics and Communication Engineering (ECE), Chaitanya Bharathi Institute of Technology, Hyderabad, in fulfilment of degree for the award of **Bachelor of Engineering** is a bonafide work done by us, which was carried under the supervision of **Dr. Suman Kshirsagar**.

Also, we declare that the matter embedded in this report has not been submitted by us in full or partial for the award of any degree/diploma to any other institution or University previously.

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C E R T I F I C A T E

This is to certify that the Project work entitled ***"Development of Farm Monitoring System using IoT"*** is a bonafide work carried out by **Ashwitha K (160118735064), Manasvini N (160118735072), Sanjana M (160118735079)** in partial fulfilment of the requirements for the degree of Bachelor of Engineering in Electronics and Communication Engineering, Osmania University, Hyderabad during the academic year 2021 - 22. The results embodied in this report have not been submitted to any other University or Institution for the award of any diploma or degree.

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ABSTRACT

Agriculture is the primary source of income for approximately 58 percent of India's population. Agriculture supports more than 70% of rural families. Agriculture contributes to the Indian economy, accounting for nearly 17% of GDP. Productivity is one of the significant factors that influence the agriculture economy in India. Many factors influence productivity in agriculture, like temperature, humidity, soil moisture, Rainfall, and the seasons. These factors need to be considered for productive results. One of the significant factors that helps increase productivity is Rainfall.

This project aims to use climatic conditions to predict rainfall using machine learning techniques and monitor the farm conditions with different sensors. These predicted rainfall levels will be used to determine the productivity of the farm.

The proposed model consists of soil moisture, temperature, and humidity sensors to collect the data. This data is tested using various Machine Learning techniques like "Logistic Regression," "Random Forest Algorithm," and "Backpropagation Algorithm" to predict the Rainfall. Once the rainfall levels are predicted successfully, along with Rainfall, the values collected from different sensors help monitor the farm. These results will be displayed on the website created.

This project helps us keep track of weather conditions and soil moisture levels. These things are necessary for the high productivity of a farm. Finally, the total data collected will be analyzed, which can be used before harvesting crops and planting them.

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ABBREVIATIONS

IoT: Internet of Things

ML: Machine Learning

IDE: Integrated Development Environment

USB: Universal Serial Bus

TV: Television

SD Card: Secure Digital Card

HDMI: High Definition Multimedia Interface

RCA: Radio Corporation of America

AI: Artificial Intelligence

IT: Information Technology

AWS: Amazon Web Service

IBM: International Business Machines

GCP: Google Cloud Platform

NIST: National Institute of Standards and Technology

SaaS: Software as a service

PaaS: Platform as a service

IaaS: Interface as a service

MLR: Multiple Linear Regression

LED: Light Emitting Diode

PCB: Printed Circuit Board

IEEE: Institute of Electrical and Electronics Engineers

SMS: Short Message Service

SCM: Single Chip Microcomputer

OS: Operating System

HTML: Hyper Text Markup Language

CSS: Cascading Style Sheets

PHP: Hypertext Pre-Processor

RFID: Radio Frequency Identification

NFC: Near-field Communication

Wi-Fi: Wireless Fidelity

GSM: Global System for Mobile Communication

GPRS: General Packet Radio Service

LTE: Long Term Evolution

LAN: Local Area Network

AES: Advanced Encryption Standard

GPU: Graphic Processing Unit

DMA Infrastructure:

PAL: Programmable Array Logics

NTSC: National Television Standard Committee

GPIO: General Purpose Input Output

MIPI: Mobile Industry Processor Interface

DSI: Display Serial Interface

SDIO: Secure Digital Input Output

GFLOPS: Giga-Floating Point Operations

HDTV: High-Definition Television

BLE: Bluetooth Low Energy

UART: Universal Asynchronous Receiver Transmitter

I2C: Inter Integrated Circuit

SPI: Serial Peripheral Interface

SoC: System on Chip

ARM: Advanced RISC Machines

SMSC: Short Message Service Centre

CMOS: Complementary Metal Oxide Semiconductor

PWM: Pulse Width Modulation

MOSI: Master Output Slave Input

MISO: Master Input Slave Output

EEPROM: Electrically Erasable Programmable Read-Only Memory

Tx: Transmitter

Rx: Receiver

ADC: Analog to Digital Converter

DNL: Differential Nonlinearity

INL: Integral Nonlinearity

LSB: Least Significant Bit

SOIC: Small Outline Integrated Circuit

NTC: Negative Temperature Coefficient

MCU: Microcontroller Unit

API: Application Programming Interface

POP3: Post Office Protocol 3

IMAP: Internet Message Access Protocol

LDAP: Lightweight Directory Access Protocol

CORBA: Common Object Request Broker Architecture

SQL: Structured Query Language

OpenBSD: Open Berkeley Software Distribution

SAS: Statistical Analysis System

DFD: Data Flow Diagram

UML: Unified Modelling Language

SLA: Service-Level Agreement

CHAPTER 1

INTRODUCTION

Agriculture is derived from the Latin term ager, which means soil, and culture, which refers to cultivating that soil. In modern terminology, agriculture is defined as "the art and science of cultivating the soil, growing crops, and keeping livestock" in contemporary terminology.

Agriculture is the production of food and shelter for humans via the cultivation of plants and livestock. Agriculture was a crucial factor in the rise of the sedentary human lifestyle. Plant and food grain farming began many years ago to feed the city's inhabitants. Agriculture is the principal source of income for most people in rural areas.

Agriculture makes a considerable contribution to a country's GDP or Gross Domestic Production. Productivity is one of the significant factors driving India's agriculture sector. Agricultural productivity is influenced by temperature, humidity, soil moisture, rainfall, and the seasons. Several factors must be considered for successful outcomes. Rain is one of the essential variables in increasing output.

With the world's population growing (the UN Food and Agriculture Organization estimates that by 2050, (Food production will need to increase by 70%), shrinking agricultural lands, and the depletion of finite natural resources, the need to improve farm productivity has become critical. A scarcity of natural resources like fresh water and arable land and falling production patterns in critical staple crops have worsened the problem. Internet connectivity solutions have been utilized in farming operations to boost farm productivity due to dwindling agricultural resources.

Farmers can use IoT technologies to help close the supply-demand gap by maintaining high production, profitability, and environmental preservation. Smart farming uses IoT technology to enable the most efficient use of resources, increasing agricultural production while minimizing operating costs. The Internet of Things in agriculture includes specialized equipment, wireless connectivity, software, and IT services.

1.1 AIM

This project aims to monitor the farm using different sensors and Machine Learning Techniques to increase the productivity.

1.2 OBJECTIVES

To integrate soil moisture, temperature and humidity sensors to develop a prototype for data collection.

To transmit data collected from sensors to the ThingSpeak cloud.

To develop machine learning models using Logistic Regression, Random Forest Algorithm, and Backpropagation Algorithm for predicting rainfall.

To develop a webpage that displays the farm analysis that was done in the ThingSpeak cloud.

1.3 MOTIVATION

While international agriculture is becoming more industrialized, it is critical to collect farm data simultaneously. This data has become a leading indicator of global agricultural development and a determinant of farm productivity. Regarding India's agricultural growth, information about farms is a powerful driver for increasing farm productivity. The agricultural industry has witnessed significant gains after years of labor. However, there are still issues in India's agriculture sector. For example, we place a greater emphasis on hardware than software and cannot supply farmers with high-quality information to meet their production needs. Using modern technology such as machine learning and the Internet of Things, we can increase agricultural productivity.

1.4 METHODOLOGY

1.4.1 EXISTING SYSTEM

Many systems influence a farm's growth and development. Using existing techniques, individual factors can be measured, but significant factors like Rainfall is left off.

Need for a system that considers Rainfall and temperature, humidity, and moisture levels of soil are required.

1.4.2 IMPLEMENTED MODEL

The proposed system is an aggregate of several factors that influence a farm.

It uses temperature and humidity sensors for detecting climatic conditions.

It uses a soil moisture sensor to detect water levels of soil.

All of the sensors' data is transferred to the cloud.

Data from temperature and humidity sensors are used to predict Rainfall using Backpropagation Algorithm.

1.5 SCOPE OF THE PROJECT

In the coming years, IoT and ML techniques will play a significant role in removing the manual work for monitoring and predicting the factors influencing the productivity of farms.

Knowledge about newer agricultural technology is yet to spread extensively, especially in emerging countries.

The project's scope varies from small individual house gardens to large agricultural farms for monitoring the necessary conditions that can be reviewed by the guardian/owner of the farm.

1.6 ORGANIZATION OF THESIS

The first chapter outlines the project's goal, followed by the objectives, motivation, methodology, and the existing system, implementation model, and project scope.

The second chapter reviews other related works and shows how our work is distinguished from other works.

The third chapter contains a brief overview of the system requirements, which we will utilize to verify our thesis statement. It focuses on IoT as the critical technology and discusses the hardware and software tools and programming languages used to create user-friendly interfaces.

The fourth chapter uses a block diagram to highlight the design of the farm monitoring system and provides an overview of project module descriptions.

The fifth chapter uses several flow charts, such as data flow diagrams and UML diagrams, to show how the proposed system is implemented. It focuses mainly on the hardware setup, including various sensors connected to the Raspberry Pi.

The sixth chapter discusses data set, which includes rainfall, temperature, humidity, wind speed, and how the cloud was set up,.

The seventh chapter summarizes our project's overall outcome. The rainfall prediction results, a comparison of logistic regression, random forest classifier, backpropagation, and hardware setup and webpage are displayed.

The eighth chapter summarises the dissertation and outlines the directions for future scope.

CHAPTER 2

LITERATURE SURVEY

2.1 INTRODUCTION TO THE PROBLEM DOMAIN TECHNOLOGY

Put sensors in the power grid, railway, bridge, tunnel, road, building, water supply system, dam, oil and gas pipes, appliance, and so on, and connect them to the internet to run specific programs and enable the remote control to Wikipedia. Based on the internet, the central computer may recognize focused administration and management of machinery, equipment, and staff, improving output and living through more detailed and dynamic means. This is useful for integrating and harmonizing human civilization with the physical world, and it is considered the third wave of information industry development after computers and the internet. The four links of the IoT industrial chain, namely identification, sensing, processing, and information delivery, have all been affected by major IoT technologies such as radio frequency identification, sensor technology, sensor network technology, and internetwork communication.

The Internet of Things (IoT) is a trending technology for sensing and detection. IoT technology includes everything from life to life's intelligence. It's employed for information collecting and processing in pattern recognition fields like measurement and computing and computer and communication fields like sensing and communication. As Cloud computing becomes more common, the concept of IoT evolves. It's currently known as a "cloud computing," "ubiquitous," and intelligent sensing network. Relevant data is the "brain" of cloud computing, and the cloud computing management platform is the "brain." It entails controlling users' access to cloud computing customization applications, computing, arranging and coordinating the customization service, and organizing and coordinating service nodes in the data centre.

2.2 EXISTING SOLUTIONS

MAI Navid, et al[1] in their paper said that agricultural economy is largely based upon crop productivity and rainfall. A rainfall forecast is necessary for all farmers when analysing crop yield. Predicting the status of the atmosphere using science and technology is known as rainfall prediction. Rainfall must be precisely calculated for efficient use of water resources, crop productivity, and water structure development. Clustering, artificial neural networks, linear regression, and other techniques are commonly utilized for Rainfall. Rainfall is predicted using several linear regressions in this paper. We can compute Rainfall for future years using this equation if we know the precipitation, average temperature, cloud cover, and vapor pressure.

MULTIPLE LINEAR REGRESSION

Regression is a statistical method for determining the strength of a relationship between one dependent variable (typically denoted by Y) and a set of other variables (known as independent variables). The following is the relationship between independent and dependent variables. It is called the deterministic model.

$Y=A+BX$

Here , Y= Dependent variable

X=independent variable

A, B= Regression parameters

In Multiple regressions there are more than two variables among which one is the dependent variable and all others are independent variable and the equation looks like this:

$Yi =\beta 0 +\beta 1xi1+\beta 2\ xi\ 2+\beta 3xi\ 3....\beta px$

RAINFALL PREDICTION USING MLR

Data collection, data pre-processing and data selection, explanatory predictor reduction, model building using regression, and final validity check are all universal methods for estimating rainfall amounts. The most critical phase in data mining is data collection. The meteorological department of Bangladesh provided the weather data. On a monthly and yearly basis, the department keeps the dataset in the form of an excel file. The next difficult task in data mining is data pre-processing; the data has been noisy, with some missing values and undesirable data. The data must be cleaned by filling in missing values and deleting extraneous data. Following data pre-processing, we must pick the data relevant to our study and discard the rest. We use correlation to decide which data are correlated and which are not. The inclusion of several highly intercorrelated explanatory variables can significantly raise the sampling variation of the regression coefficients and weaken the predictive model capacity. Therefore, the predictors with high inter-correlation with others are eliminated. Following the reduction of explanatory predictors, the next step is to develop a model using training data. The linear regression technique was applied in this case.

Matti Satish Kumar et al[2] in their paper discussed about the persistent increase in population of the world is demanding more and more supply of food. Hence there is a significant need for advancement in cultivation to meet future food needs. It is essential to know moisture levels in the soil to maximize the output. But most farmers cannot afford high-cost devices to measure soil moisture. Our research work in this paper focuses on a homemade low-cost moisture sensor with accuracy. This paper presents a method for manufacturing soil moisture sensors to estimate moisture content, hence providing information about the necessary water supply for good cultivation. This sensor is tested with several soil samples and can meet considerable accuracy.

Soil moisture measurement is a helpful tool for determining the state of the soil and determining the amount of water that has to be given for agriculture. This paper shows two different approaches for determining soil moisture over a large area and at different depths.

They proposed two methods:

METHOD 1

The same soil sample is evaluated by varying the amount of water, and values at various amounts of water are tabulated in this procedure.

Three conductivity zones are defined based on the values.

The first zone is the dry zone, denoted by a red LED on the PCB, and requires additional water.

The second zone, shown by a green LED on the PCB, is where the soil does not require water.

The third zone is the wet zone when the earth has more water than it needs.

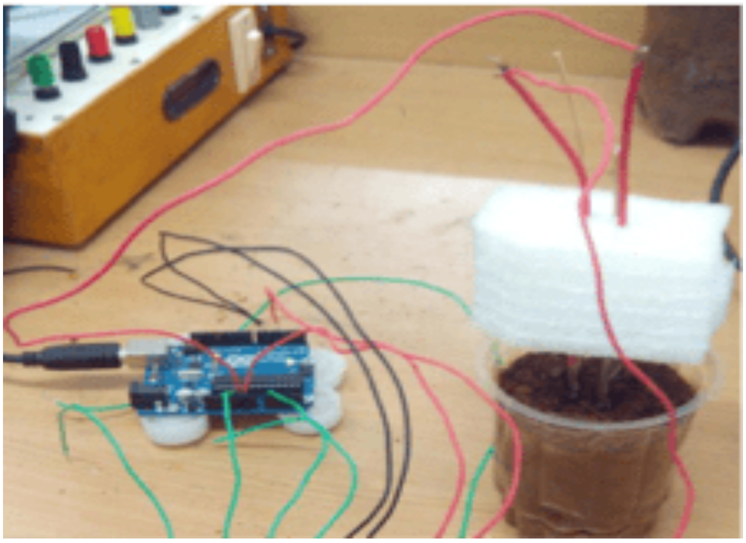


Figure 2.1 Hardware Set up

The above figure shows the hardware setup of how the same sample of soil is investigated by varying the amount of water, and the results are summarised for various amounts of water.

METHOD 2

This approach involves placing dirt in a bottle of a specific height. It is divided into three tiers based on depth, with three sensors put into the soil at varying depths. The values of the sensors are taken by pouring water on them. Moisture at various depths of the soil can be determined using this method.

A bottle is used for our method. A marking is done on the bottle dividing into three equal levels.

Three sensors are inserted into three levels.

The output of each sensor is given to different analog ports A0, A1, A2 respectively

A PCB consisting of Resistors and LEDs is designed for easy experimental set up.

The LEDs can be used as a warning to avoid large amount of water as well as less amount of water.

Rakiba Rayhana et al[3] in their paper studied the rapid change of climate, population explosion, and reduction of arable lands calling for new approaches to ensure sustainable agriculture and food supply for the future. Greenhouse agriculture is seen as a potential and long-term solution to the future food issue. It allows farmers to regulate their local environment and grow crops all year long, even in harsh outdoor conditions. However, greenhouse farms face numerous operational and management issues. Intelligent sensors, gadgets, network topologies, big data analytics, and smart decision-making answer the fundamental difficulties facing greenhouse farming, such as greenhouse local climate management, crop growth monitoring, and crop harvesting. This study examines existing greenhouse growing techniques and contemporary IoT technology for smart greenhouse farms. The study also identifies the significant issues that must be addressed.

PROPOSED MODEL

They used IoT-enabled gadgets in their concept. Sensors, actuators, cloud computing-based data facilities, drones, navigation, and analytical systems are among the IoT technologies that enable the architecture to make intelligent decisions to boost crop yield. IoT devices can collect data on ambient variables such as humidity, temperature, climatic conditions, and field variables such as soil and plant biomass. It can be used to predict and track crop quality for consumer benefit. In addition, IoT can be used to collect data and store it in cloud computing devices to create alerts and send SMS to farmers. The data in the cloud can also be utilized to develop predictive models that can anticipate the future.

IoT Implementation for Traditional Greenhouse Farming :

One of the key goals of using IoT in greenhouse farming is to provide farmers with a long-term sustainable solution.

The greenhouse has an IoT-based environmental monitoring system that integrates wireless networks, mobile networks, and the Internet to perform real-time remote monitoring of the plants.

CC2420 (ZigBee) radio frequency modules, temperature and humidity sensors, and a single-chip microcomputer (STC9051 SCM) with a wireless transmission module make up the architecture.

This architecture could assist farmers in receiving short notifications regarding plant conditions and give real-time plant information.

IoT Implementation for Hydroponic :

The term "hydroponic" describes how plants are grown in water rather than soil. Greenhouse farms benefit greatly from hydroponics. Lettuce is one of the most frequent hydroponic greenhouse vegetables. Broccoli and tomatoes are now grown in hydroponics as well.
Growing those plants, on the other hand, is quite challenging since they are susceptible to changes in pH and nutrient levels in the water. As a result, IoT architectures were investigated to automate plant monitoring in the Greenhouse. A smartphone application was developed to manage the pH of the water using an IoT-based mechanism, which could help to monitor the current state of the plants.

The humidity, temperature, pH, and pressure sensors are connected to a Raspberry Pi 3 board.

The Python programming language was used to create an android smartphone application that may inform farmers (users) about the present state of their plants.

IoT Implementation for Vertical Farming :

A vertically assembled farm, frequently built-in indoor greenhouse farms, is vertical farming (controlled environment). Vertical farming is both environmentally friendly and insecticide-free. However, to grow the plants, this farm form necessitates a significant amount of maintenance. LED lights are used to compensate for sunshine in vertical farming. Sensors for temperature, light intensity, humidity, and soil moisture are included in the IoT design. A wireless microcontroller module for data transfer and a Web-based application for monitoring sensor data.

The sensor data is analysed using an Intel Edison wireless module and an Arduino board connected to Linux OS, Eclipse, and Intel XDK.

ThingSpeak is the Web server that connects the data to the cloud, and the Virtuino Android app was used to send SMS from mobile devices.

CONCLUSION

We analysed a number of publications from different journals based on our base paper, which employs the Multiple Linear Regression technique, and tried to identify techniques that could increase the accuracy of our project and make it optimal.

CHAPTER 3
TOOLS AND TECHNOLOGIES

The tools and technologies used in this project are described in this chapter. It focuses over the project's system requirements, hardware tools like the Raspberry Pi, temperature and humidity sensors, and soil moisture sensors, as well as software tools like Raspbian OS, Cloud services, and PHP. It also includes programming languages like Python, HTML, CSS, and PHP that are used to construct user-friendly interfaces. IoT is the main technology employed in this project.

3.1 System Requirements

Hardware Requirements

- Raspberry Pi
- Temperature and humidity sensor
- Soil moisture sensor

Software Requirements

- Raspbian OS
- Cloud services

Languages Used

- Python
- HTML, CSS, and PHP

3.2 INTERNET OF THINGS (IoT)

In Internet of Things (IoT) every object or thing is provided a unique identifier and is connected to the Internet. It is estimated that over 150 billion IoT devices will be connected to the Internet by 2025. With such a widespread, IoT can enhance every individual's life and provide new business opportunities.

IoT for consumers can pave the way for automating the most routine tasks done every day. It also provides security solutions and has the potential to drive complete supply chain management. Enterprises can use IoT to reduce labour costs and improve production and development efficiency.

Recent advancements in networks and devices have opened the door to a far more comprehensive range of linked devices and Internet of Things (IoT) capabilities. The term "Internet of Things" now alludes to a world of intelligently linked objects and gadgets. The remote control has been replaced with an intelligent device that will do its work automatically depending on its study of user behaviour. All of this is made feasible by shrinking the electronic equipment, followed by a massive rise in internet access availability.

The Internet of Things represents real-world objects and sensors embedded in or attached to them connected to the Internet via wireless and cable connections. RFID, NFC, Wi-Fi, Bluetooth, and ZigBee are all examples of local area connectivity that these sensors can employ. Wide-area connections, such as GSM, GPRS, 3G, and LTE, can be used by the sensors.

Applications of IoT:

1. Cloud Computing
2. Smart Homes
3. Smart City
4. Self-driven Cars
5. Smart Supply-chain Management

3.3 RASPBERRY PI

Features of Raspberry Pi

Where the system's processing power is enormous, because most ARDUINO boards run at less than 100MHz, they can only perform functions that are within their capability. They cannot run complex programs for applications like weather stations, cloud servers, gaming consoles, and so forth. Raspberry Pi can execute these advanced functions with a 1.2GHz clock speed and 1 GB of RAM when you require wireless connectivity. The Raspberry Pi 3 features wireless LAN and Bluetooth capabilities, allowing you to create a WIFI HOTSPOT for internet access. This functionality is ideal for the Internet of Things. The Raspberry Pi also has a dedicated camera connection, making it easy to connect a camera to the PI board.

Raspberry Pi Specification

Processor

Broadcom's BCM2387 processor. 802/11/g/n Wireless LAN with Bluetooth 4.1 (Bluetooth Classic and LE) 802.11. 1.2GHz Quad-Core ARM Cortex-A53 (64Bit) WEP, WPA WPA2, AES-CCMP algorithms (maximum key length of 256 bits), full range of 100 meters. IEEE 802.15 Bluetooth, Advanced Encryption Standard (AES) symmetric encryption technique with a 128-bit key, a maximum capacity of 50 /meters.

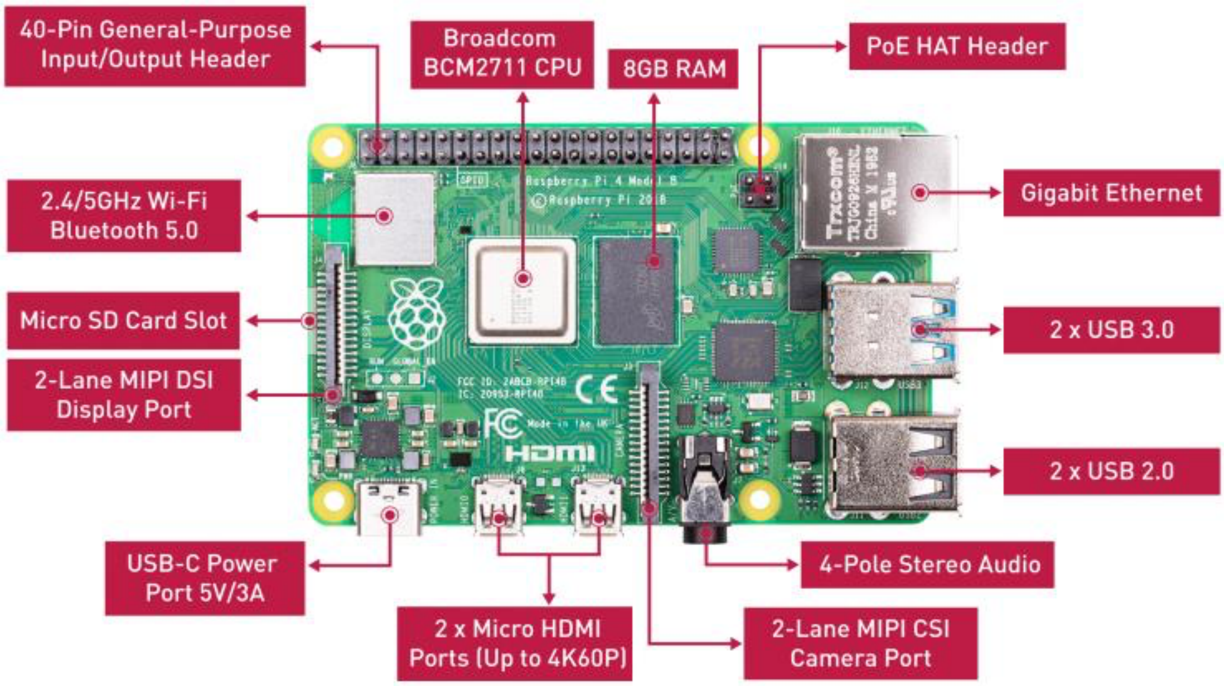


Figure 3.1 Raspberry Pi

The GPU provides Open GL ES 2.0, hardware-accelerated Open VG, and 1080p30 H.264 high-profile decode and is capable of 1Gpixel/s, 1.5Gtexel/s, or 24 GFLOPs of general-purpose compute. What's that all mean? If you plug the Raspberry Pi 3 into your HDTV, you can watch Blue Ray quality video using H.264 at 40MBits/s.

The Raspberry Pi 3's four built-in USB ports provide enough connectivity for a mouse, keyboard, or anything else that you feel the RPi needs, but you can still use a USB hub if you want to add even more. Keep in mind that it is recommended that you use a powered hub so as not to overtax the onboard voltage regulator. Powering the Raspberry Pi 3 is easy. Just plug any USB power supply into the micro-USB port. There's no power button, so the Pi will begin to boot as soon as power is applied. To turn it off, simply remove the power. The four built-in USB ports can even output up to 1.2A, enabling you to connect more power-hungry USB devices (This requires a 2Amp micro–USB Power Supply).

On top of all that, the low-level peripherals on the Pi make it great for hardware hacking. The 0.1" spaced 40-pin GPIO header on the Pi gives you access to 27 GPIO, UART, I 2C, SPI, and 3.3 and 5V sources. Each pin on the GPIO header is identical to its predecessor, the Model B+.

Power-on states

All GPIO pins revert to general-purpose inputs on power-on reset. The default pull states are also applied, which are detailed in the alternate function table in the ARM peripherals datasheet. Most GPIOs have a default pull applied.

Interrupts

Each GPIO pin, when configured as a general-purpose input, can be configured as an interrupt source to the ARM. Several interrupt generation sources are configurable:

- Level-sensitive (high/low)
- Rising/falling edge
- Asynchronous rising/falling edge

Level interrupts maintain the interrupt status until the level has been cleared by system software (e.g., by servicing the attached peripheral generating the interrupt).

The normal rising/falling edge detection has a small amount of synchronization built into the detection. At the system clock frequency, the pin is sampled with the criteria for generation of an interrupt being a stable transition within a three-cycle window, i.e., a record of '1 0 0' or '0 1 1'. Asynchronous detection bypasses this synchronization to enable the detection of very narrow events.

Outputs

A GPIO pin designated as an output pin can be set to high (3V3) or low (0V).

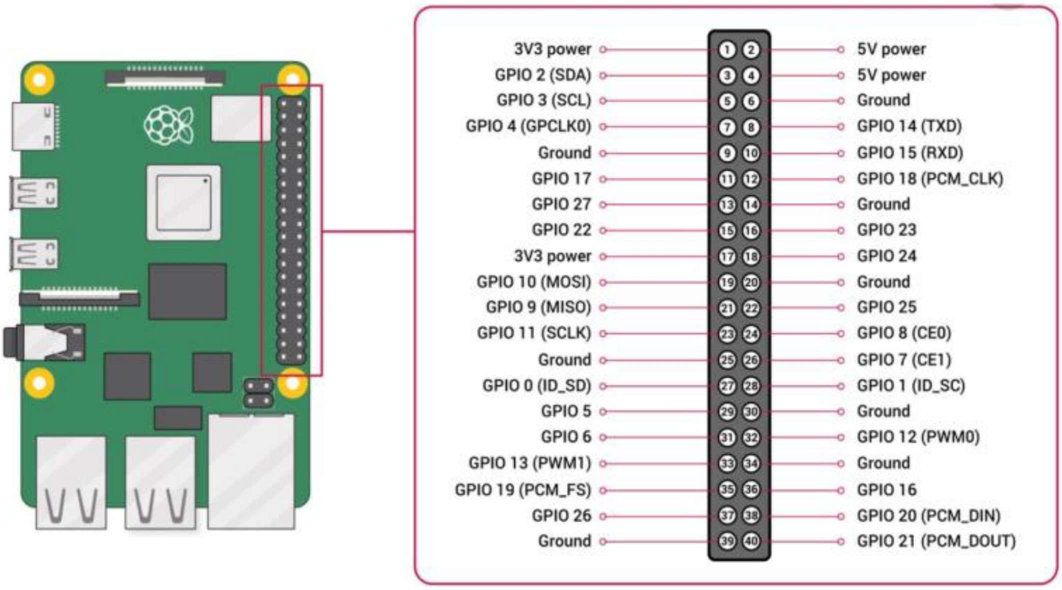


Figure 3.2 Raspberry Pi Pin Diagram

Inputs

A GPIO pin designated as an input pin can be read as high (3V3) or low (0V). This is made easier with the use of internal pull-up or pull-down resistors. Pins GPIO2 and GPIO3 have fixed pull-up resistors, but for other pins this can be configured in software.

3.4 SOIL MOISTURE SENSOR

The volumetric water content in the soil is measured by the soil moisture sensor. It consists of two probes inserted into the ground, as seen in the figure. The probes of the sensor are inserted 10 cm away from the plant. The controlling unit switches on the water pump when the water content is below the threshold value.

For better monitoring, sensors are put at three different layers in the soil. They're used to determine the moisture content of the soil at all levels.

The relation among the calculated property as well as moisture of soil should be adjusted & may change based on ecological factors like temperature, type of soil, otherwise electric conductivity. The microwave emission which is reflected can be influenced by the moisture of soil as well as mainly used in agriculture and remote sensing within hydrology.

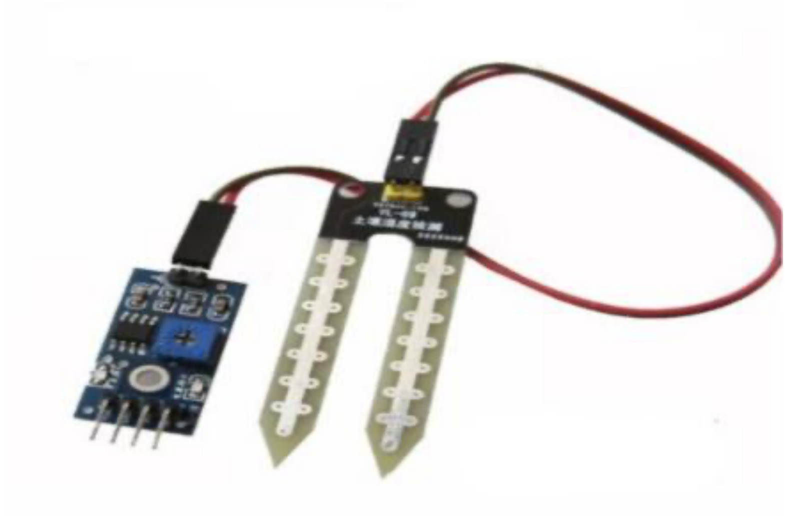


Figure 3.3 Soil moisture sensor

The capacitance between two soil-implanted electrodes can be used to see how soil moisture affects the dielectric constant. When soil moisture is mostly free water (as in sandy soils), the dielectric constant is proportional to the moisture content. The probe is frequently given a frequency stimulation to test the dielectric constant. The probe's reading is not proportional to water content and is impacted by soil type and temperature. As a result, thorough calibration is required, and the calibration's long-term durability is in doubt.

Features

Adjustable sensitivity

Installation is simple due to the fixed bolt hole.

The threshold level can be set.

3.5 ANALOG TO DIGITAL CONVERTER

A digital to analog converter transforms digital data into numerical values of soil moisture readings, which are required to determine soil moisture levels.

The MCP3008 features a successive approximation register (SAR) architecture and an industry-standard SPI serial interface, allowing 10-bit ADC capability to be added to any PIC® microcontroller. The MCP3008 features 200k samples/second, 8 input channels, low power consumption (5nA typical standby, 425µA typical active), and is available in 16-pin PDIP and SOIC packages. Applications for the MCP3008 include data acquisition, instrumentation and measurement, multi-channel data loggers, industrial PCs, motor control, robotics, industrial automation, smart sensors, portable instrumentation and home medical appliances.

Figure 3.4 MCP3008

ADCs follow a sequence of stages while converting analog signals to digital. They sample the signal, quantify it to determine its resolution, and then establish binary values before sending it to the system to interpret the digital signal. The ADC's sample rate and resolution are two important properties.

The MCP3008 is a single-ended Analogue to Digital converter having eight channels and a 10-bit resolution. It has a four-wire serial SPI interface that allows digital output on all channels. It has circuits and an integrated sample. It contains analog and digital ground connectors for noise reduction. It's ideal for embedded system software.

The MCP3008 can be configured to provide eight single-ended inputs or four pairs of pseudo-differential inputs.

3.6 TEMPERATURE AND HUMIDITY SENSOR

This multipurpose sensor provides temperature and relative humidity data at the same time. The DHT22 digital temperature and humidity sensor is a composite sensor with a calibrated digital temperature and humidity signal output. The product's great dependability and long-term stability are ensured using dedicated digital modules collection technology, temperature, and humidity sensing technology. The sensor connects to a high-performance 8-bit microcontroller and incorporates a resistive sense of moist components and NTC temperature measurement devices.

The DHT22 is a low-cost digital temperature and humidity sensor with a single-wire digital interface. It monitors the ambient air with a capacitive humidity sensor and a thermistor and outputs a digital signal on the data pin (no analogue input pins are needed).

You may start measuring relative humidity and temperature because the sensor is calibrated and requires no extra components. Although it is simple to use, data collection requires careful planning. It can only provide you with new information every two seconds.

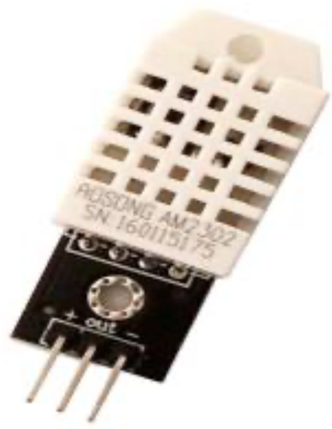


Figure 3.5 DHT22

DHT22 Specifications

3.5V to 5.5V operating voltage

Serial data is output.

-40°C to 80°C temperature range

The humidity ranges from 0% to 100%.

Temperature and humidity are both 16-bit resolution.

0.5°C and 1 percent accuracy

The DHT22 sensor comes factory calibrated and provides serial data, making setup a breeze. This sensor's connection diagram is shown below.

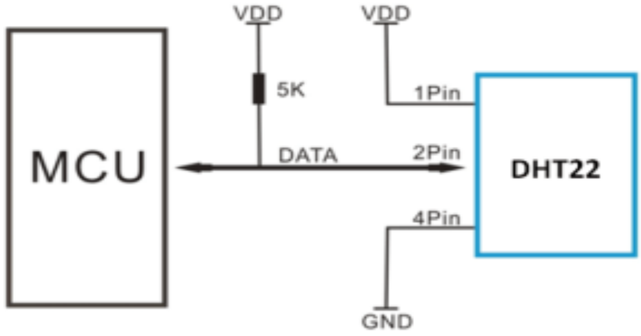


Figure 3.6 Connection diagram

As can be seen, the data pin is connected to an MCU I/O pin via a 5K pull-up resistor. As serial data, this data pin sends the temperature and humidity values. The data pin will output 8bit humidity integer data + 8bit humidity decimal data + 8bit temperature integer data + 8bit fractional temperature data +8 bit parity bit. The I/O pin must be made low and then kept high, as shown in the timing diagram below, to request the DHT22 module to provide these data.

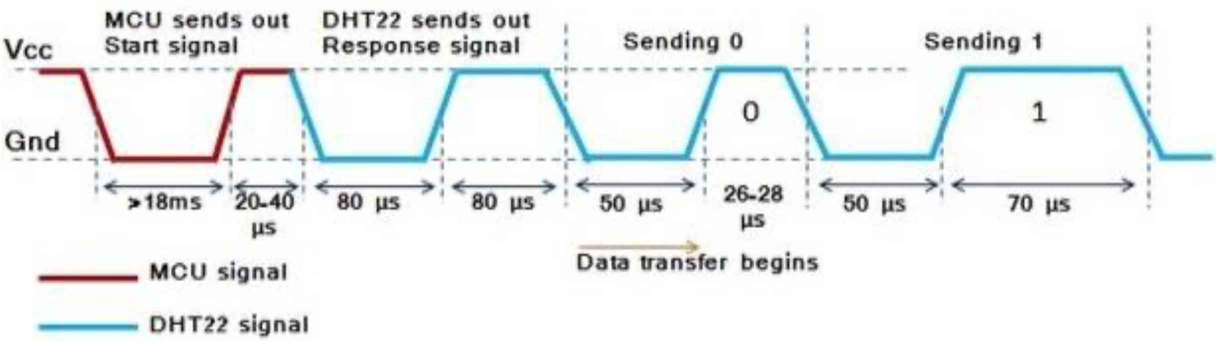


Figure 3.7 Timing diagram

The relative humidity of a gas is heavily influenced by its temperature. As a result, humidity measurement must verify that humidity sensors operate at the same temperature.

3.7 SOFTWARE REQUIREMENTS

Raspbian OS is installed on Raspberry pi.

Cloud platform services are used to store data from sensors connected to raspberry pi.

Backpropagation model is used for predicting the Rainfall.

A web page has been created to visualize the analysis of data and to get weather results using HTML, CSS, PHP.

Operating system for Raspberry Pi

For everyday use on a Raspberry Pi, Raspbian is the recommended operating system. Raspbian is a Debian-based free operating system optimized for the Raspberry Pi device. Over 35,000 packages are included in Raspbian, which are precompiled software bundles. Raspbian is a community-driven project that focuses on enhancing the reliability and performance of as many Debian packages as possible.

3.7.1 PYTHON

Python is a multi-purpose, high-level programming language which has gained momentum with the advent of IoT and machine learning. It is an object-oriented language which makes it more programmer friendly. The language needs less code and is indentation oriented which makes it more readable and understandable. Many technology-oriented companies now depend on python for implementing their services because of its huge collection of libraries.

Python, being an interpreted language, is not complied to run. Interpreter is a program that runs python code on any system. As an interpreter checks the code line by line, it takes more time to run the python code than other compiled languages. But the advantage of interpreted languages is that it directly processes the source code and allows programmers to modify the code quickly.

(i) Advantages of Python

The advantages of Python are specified below:

Extensive Libraries

Python contains huge amounts of extensive libraries which can be imported directly. A user can easily import libraries for regular expressions (RegEx), image manipulation, databases etc. These imported libraries can be directly used in any part of the code.

Embeddable

Python is embeddable, which adds to its extensibility. Because of its embeddable nature, it can be added in the source code of any other language which in turn adds scripting capabilities in the other language.

IoT Opportunities

Raspberry Pi has been the key platform of IoT applications, and python programming forms a base for its working. Thus, the Internet of Things applications need python for bridging the gap between the language and the real world.

Readable

Usage of python enhances the readability of a code. Use of indentation instead of curly braces to define blocks or functions increases the readability of a code.

Object-Oriented

Along with procedural programming, python also supports object-oriented programming. Its implementation of classes and objects enhances code reusability and the principles of inheritance, encapsulation, polymorphism and abstraction make it more usable in real-world applications.

Free and Open-Source

As python can be directly downloaded and its libraries and packages can be imported in a hassle-free way, it is considered as a best open-source programming language. Even its code can be directly used and modified easily making it much more user- friendly.

Portable

Many programming languages are platform-dependent where they need some changes to run on a different platform. Python makes the code more portable as it needs to be written only once and can be run anywhere.

(ii) Python Libraries

Libraries are a collection of functions that have pre-written codes which can be directly imported and used in a program. This saves time for the user and improves code-reusability. For example, a regular expression module can be imported and used to search for a pattern in a string. These are some libraries used for the implementation of our project in python.

a. Pandas
b. Matplotlib
c. Tkinter
d. Sklearn
e. Keras

a. Pandas

Pandas is considered to be a key data manipulation tool in python. Data Frame is one of the prominent data structures used in pandas, which is built on the NumPy package. The Data Frame function is used in our project for implementing the data storage in the form of a table containing user data.

Pandas Data Frame

The main components of Pandas Data Frame are the data, rows and columns. The data in the Data Frame is associated in the form of rows and columns. The variable and mutable size of the table makes it a good choice for usage in collecting data from a database.

Creating a Pandas Data Frame

The Pandas Data Frame is created using datasets loaded from a database. In our project, we implemented the Pandas Data Frame to load the datasets from an Excel file that is stored in the memory of Raspberry Pi.

b. Matplotlib

For 2D array charts, Matplotlib is an excellent Python visualization library. Matplotlib is a multi-platform data visualization package based on NumPy arrays designed to work with the entire SciPy stack. John Hunter was the first to launch it in 2002.

One of the essential benefits of visualization is that it allows us to see large amounts of data in easily understood images. Matplotlib includes graphs such as lines, bars, scatter, histograms, and more.

c. Tkinter

Python's standard GUI library is Tkinter. Designing graphical user interfaces is straightforward and rapid with Python and Tkinter. Tkinter is an object-oriented interface for the Tk GUI toolkit. Tkinter is a standard Python framework for creating desktop application graphical user interfaces.

Developing desktop applications using Python Tkinter is simple. To create an empty Tkinter top-level window, apply the approaches listed below.

Tkinter should be imported.

Create the application's primary window.

Add widgets to the window, such as labels, buttons, frames, and so on.

So that the actions can take place on the user's computer screen, call the main event loop.

d. Sklearn

In Python, Scikit-learn is the most helpful machine learning library. The Sklearn package for machine learning and statistical modelling includes several essential techniques, including classification, regression, clustering, and dimensionality reduction. Machine learning models are created with Sklearn. It should never be used to read, manipulate, or summarise data. There are better libraries for that (e.g., NumPy, Pandas, etc.)

e. Keras

Keras is a deep learning API that uses the TensorFlow machine learning framework. It was made to facilitate speedy experimentation. Keras is straightforward but not simplistic. Keras reduces developer cognitive load, allowing you to concentrate on the most critical components of the problem. Simple processes should be quick and straightforward, but more complicated workflows should be possible by following a clear route that builds on what you've already learned. Among others, NASA, YouTube, and Waymo use Keras as a robust platform with industry-leading performance and scalability.

3.7.2 HTML

Hyper Text Markup Language is the acronym for Hyper Text Markup Language. It's a markup language for creating web pages. The link between web pages is defined as hypertext. The markup language is used to describe the text material included within the tag that governs the structure of web pages.
HTML is a markup language that the browser uses to transform text, pictures, and other content so that it can be displayed in the desired format.

<html>: Every HTML code must be enclosed between basic HTML tags. It begins with **<html>** and ends with **</html>** tag.

< Head>: The head tag comes next which contains all the header information of the web page or document like the title of the page and other miscellaneous information. These information are enclosed within head tag which opens with **< Head>** and ends with **</Head>**. The contents will of this tag will be explained in the later sections of course.

<title>: We can mention the title of a web page using the **<title>** tag. This is a header information and hence mentioned within the header tags. The tag begins with **<title>** and ends with **</title>**

<body>: Next step is the most important of all the tags we have learned so far. The body tag contains the actual body of the page which will be visible to all the users. This opens with **<body>** and ends with **</body>**. Every content enclosed within this tag will be shown on the web page be it writings or images or audios or videos or even links. We will see later in the section how using various tags we may insert mentioned contents into our web pages.

3.7.3 CSS

CSS (Cascading Style Sheets) is a developed language that makes the process of making web pages presentable easier. CSS can be used to apply styles to web pages. More crucially, CSS allows you to do this for any web page independently of the HTML. Cascading Style Sheets (CSS) are used to define the style of HTML-based web pages. Inline CSS, Internal or Embedded CSS, and External CSS are the three types of CSS.

1. **Inline CSS:** Inline CSS is a CSS property that is attached to an element called inline CSS in the body section. The style attribute is used to provide this style within an HTML tag.
2. **Internal or Embedded CSS:** This is useful when only one HTML document needs to be styled. The CSS ruleset should be in the head section of the HTML file, i.e., the CSS is embedded in the HTML file.

3. **External CSS:** External CSS is a distinct CSS file that simply contains stylistic properties via tag attributes (such as class, id, heading, and so on). A separate file is used to write CSS properties. A link tag should be used to connect the CSS extension to the HTML text.

3.7.4 PHP

PHP started off as a small open-source project that gained in popularity as more people learned about its advantages. Rasmus Lerdorf delivered the first version of PHP in 1994. The abbreviation "PHP: Hypertext Pre-processor" is recursive. Dynamic content, databases, session tracking, and even whole e-commerce sites are all supported. It supports MySQL, PostgreSQL, Oracle, Sybase, Informix, and Microsoft SQL Server, among other databases. PHP is quite fast, especially when compiled as an Apache module on Unix. The MySQL server, once started, executes even the most complex queries with massive result sets in record time. POP3, IMAP, and LDAP are just a few of the prominent protocols that PHP supports.

CONCLUSION

We have discussed about the project's various system requirements, including hardware such as the Raspberry Pi, temperature and humidity sensors, and soil moisture sensors, as well as software such as Raspbian OS, Cloud services, and programming languages such as Python, HTML, CSS, and PHP for designing user-friendly interfaces.

CHAPTER 4
DESIGN OF FARM MONITORING SYSTEM

The design of the farm monitoring system provides a detailed explanation of the project's flow as well as different algorithms used to predict rainfall, such as Logistic Regression, Random Forest Algorithm, and Backpropagation.
It also provides an overview of the project's module descriptions. The project is split into several modules. The modular approach makes it simple to create and interpret.

4.1 BLOCK DIAGRAM

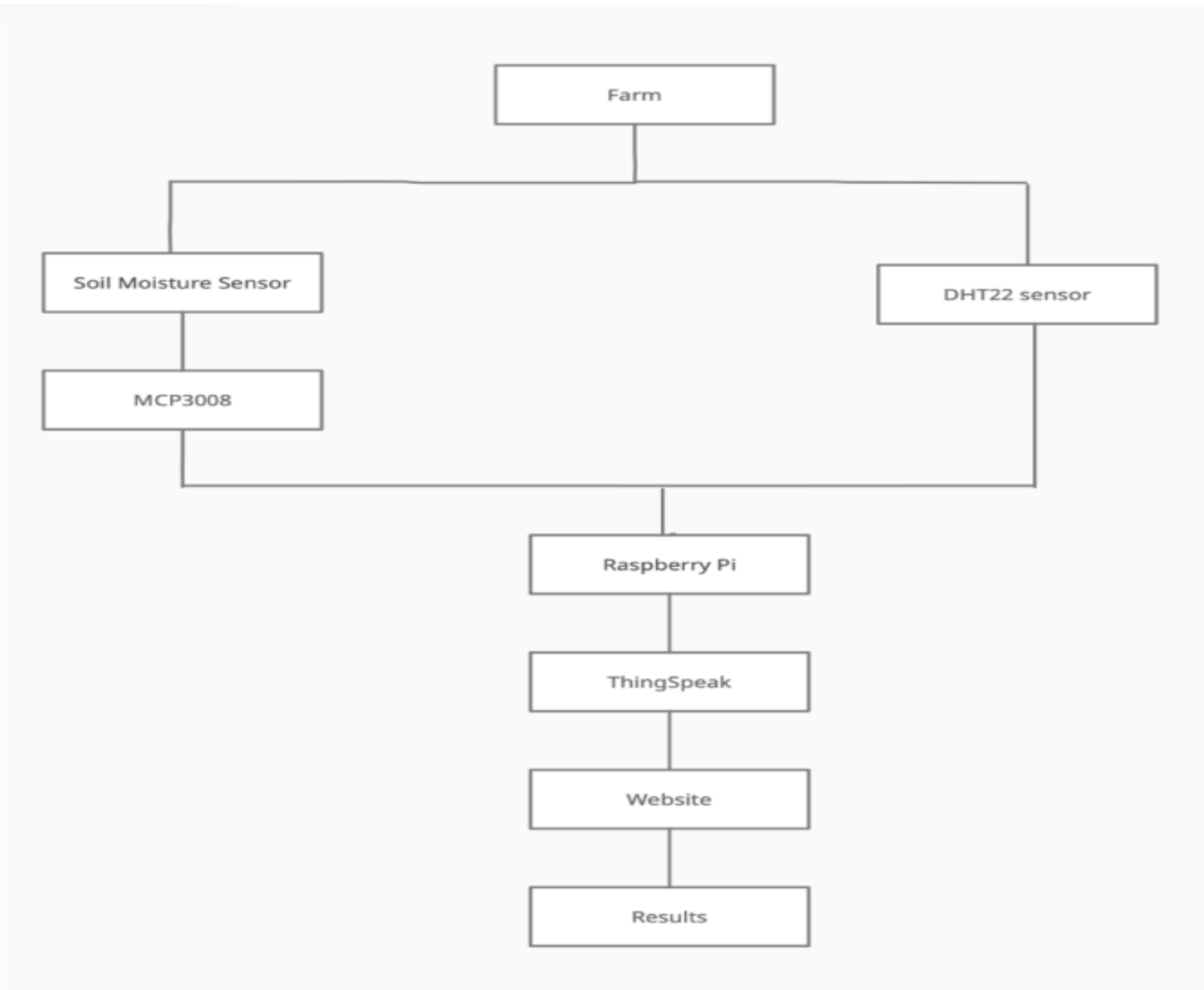


Figure 4.1 Block Diagram

All the sensors connected to the node Raspberry Pi are inserted into the farm. The sensors used in the project are soil moisture sensor and temperature and humidity sensor (DHT22). Raspberry PI retrieves data from sensors and sends that data to the cloud.
The data from sensors is measured against standard conditions for plant growth. Later live values are retrieved from the cloud through a web application. Once the Back Propagation algorithm is trained, the rain occurrence is predicted using the data collected from the temperature and humidity sensor, and results are displayed.

4.2 MODULE DESCRIPTION

The project is divided into multiple modules. The modular approach makes it convenient to develop and understand .
The different modules present in this project are :
The **first** module consists of the sensors. Different sensors, such as temperature and humidity and soil moisture sensors, are connected to Raspberry Pi through wires. Raspberry Pi is connected to the system through an HDMI cable. After the connection, the data is collected from sensors.
The **second** module consists of sending data from Raspberry Pi to the cloud, retrieving the information whenever needed, and analysing it.
The **third** module consists of training the model using Logistic Regression Algorithm, Random Forest Algorithm, and Back Propagation Algorithm with the help of historical rainfall data available. Comparing all these algorithms, Back Propagation is found to have the best accuracy and is used to predict the rainfall.
The **final** model includes creating a web page and displaying data analysis.

4.3 ALGORITHMS

An algorithm is a set of instructions for solving a problem or accomplishing a task.

In this project Logistic Regression, Random Forest Algorithm, and Backpropagation are compared for predicting the Rainfall.

4.3.1 LOGISTIC REGRESSION

A supervised classification approach is a logistic regression. For a given collection of features (or inputs), X, the target variable (or output), y, can only take discrete values in a classification issue.

Logistic regression, contrary to widespread assumption, is a regression model. The model creates a regression model to predict the likelihood that a given data entry falls into the "1" category. Logistic regression models the data using the sigmoid function, similar to how linear regression assumes the data follow a linear distribution.

When a decision criterion is introduced, logistic regression transforms into a classification procedure. The threshold value is an essential part of logistic regression and is determined by the classification problem.

The precision and recall levels have a significant influence on the threshold value determination. Precision and Recall should ideally be 1. However, this is rarely the case. We utilize the following reasoning to determine the threshold in the case of a Precision-Recall trade-off:-

1. **Low Precision/High Recall:** We use a decision value with low precision or a high recall in applications where we wish to lower the number of false negatives without necessarily reducing the number of false positives. In a cancer diagnosis application, for example, we don't want any affected patients to be labelled as unaffected without considering whether or not they are being unjustly diagnosed with cancer. This is because other medical tests can detect the absence of cancer, but not the existence of cancer in a candidate who has previously been rejected.

2. **High Precision/Low Recall:** We choose a judgement value with a high precision or a low Recall in applications where we wish to reduce the number of false positives without necessarily reducing the number of false negatives. Consider how we might categorise customers in terms of whether they will respond positively or adversely to a customised advertisement. In that situation, we want to be certain that the customer will

respond positively to the advertisement because a negative response could result in a loss of prospective sales.

4.3.2 RANDOM FOREST ALGORITHM

A random forest is a decision tree-based supervised machine learning technique. A random forest is a problem-prediction and classification machine learning technique. It uses ensemble learning, which is a method for merging several classifiers to solve complex problems.

A random forest algorithm is made up of many decision trees. The 'forest' of the random forest algorithm is trained by bagging or bootstrap aggregation. Bagging is a machine learning technique that improves accuracy by using an ensemble meta-algorithm.

A random forest algorithm is built on decision trees. A decision tree is used for making decisions. A basic understanding of decision trees will aid our comprehension of random forest algorithms.

A decision tree comprises three parts: decision nodes, leaf nodes, and the root node. A decision tree approach divides a training dataset into branches, which are then divided further. This pattern continues until you reach a leaf node. The leaf node cannot be separated anymore.

The main difference between decision tree and random forest methods is that the latter establishes root nodes and separates nodes randomly. Random forest uses the bagging method to make predictions.

To obtain the required outcome, random forest classification employs an ensemble methodology. The training data is used to train various decision trees. The observations and features in this dataset will be chosen at random during node splitting.

Regression is another function of a random forest algorithm. The dependent (features) values and independent variables are sent via the random forest model.

In a random forest regression, each tree produces a unique forecast. The average prediction of the individual trees is the output of the regression. The decision trees' class mode, on the other hand, prescribes random forest classification outcomes.

Their functions differ, although they operate on the same premise. The formula for linear regression is $y=bx + c$, where y represents the dependent variable, x represents the independent variable, b represents the estimation parameter, and c represents a constant.

4.3.3 BACKPROPAGATION ALGORITHM

Eventually, after comparing accuracy, Backpropagation is utilized to predict Rainfall in this project.

A neural network consists of I/O devices which are interconnected with weighted links. It facilitates the creation of prediction models from large databases. This idea is based on the human neurological system. It helps with image perception, human learning, computer speech, and various other tasks.

Backpropagation is the foundation of neural network training. It's a method for fine-tuning the weights of a neural network based on the error rate of the previous epoch (i.e., iteration). You can lower error rates and increase the model's generalization by fine-tuning the weights, making it more trustworthy.

In neural networks, backpropagation is a short form meaning "backward propagation of faults." This method aids in calculating a loss function's gradient concerning all network weights.

The Backpropagation algorithm uses the chain rule in a neural network to compute the gradient of the loss function for a single weight. Unlike native direct computation, it efficiently adds one layer at a time. It calculates the gradient but does not specify how it should be used. It generalizes the delta rule calculation. Backpropagation reduces the network's complexity by including weighted links that have a minor influence on the training network. You must examine a collection of input and activation values to establish the relationship between the input and hidden unit layers. It assists in determining the impact of a specific input variable on the output of a network. The outcomes of this investigation should be reflected in the rules. Backpropagation is beneficial to deep neural networks working on error-prone projects like image or speech recognition. The chain is used in backpropagation, and power rules allow it to work with any number of outputs.

CONCLUSION

The design of the farm monitoring system is addressed, as well as the algorithms used to predict rainfall, such as Logistic Regression, Random Forest Algorithm, and Backpropagation are discussed.

CHAPTER 5

IMPLEMENTATION OF PROPOSED SYSTEM

A flowchart illustrates a method, system, or computer algorithm. The suggested system is implemented using flowcharts such as data flow diagrams and UML diagrams. A data flow diagram describes how data "flows" through the various process units of an information system. The Unified Modelling Language is referred to as UML.

The proposed system which includes the hardware part consists of a Raspberry pi connected to a temperature and humidity sensor (DHT22) and soil moisture sensor. The values are read from sensors at different intervals of time.

5.1 FLOWCHARTS

5.1.1 DATA FLOW DIAGRAMS

A DFD is frequently used as a first stage to provide an overview of the system without going into great depth, which can then be expanded upon afterward. The visualization of data processing can be done with DFDs. Data flow diagrams are often known as bubble charts. DFD is a system design tool that is used in a top-down approach. The context-level DFD is then "exploded" to produce a level-1 DFD that depicts some of the system's details. The Level-1 DFD depicts how the system is divided into subsystems, each of which handles one or more data flows from an external agent while also providing all of the system's functionality. It also displays the flow of data between the various sections of the system and indicates internal data stores that must be present for the system to function.

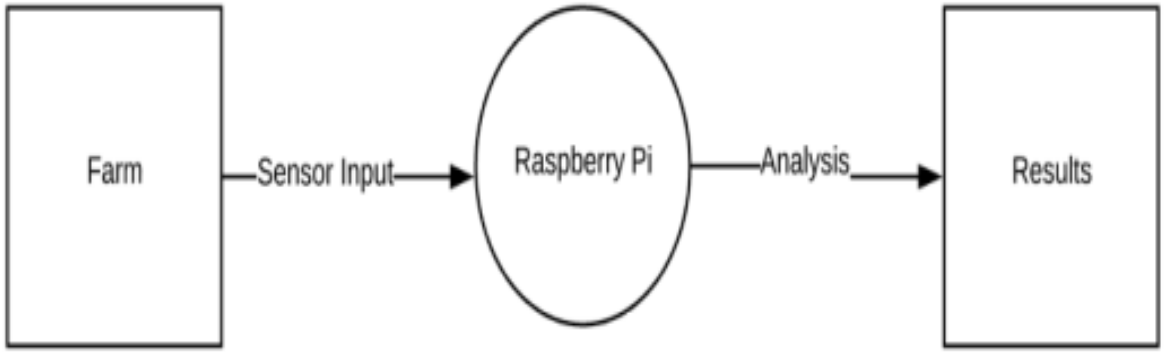


Figure 5.1 Data flow diagram

The DFD level 0 illustrates the flow of data from soil through sensors onto a Raspberry Pi which are further analysed to visualize output.

The DFD level 1 is the elaboration of DFD level 0 where the pre-processed data is uploaded on to a database which is analysed using comparison algorithm and the data is shown on a web-app.

UML Diagrams

The acronym UML refers to the Unified Modelling Language. In object-oriented software engineering, UML is a standardized general-purpose modelling language. The Object Management Group managed and established the standard.

UML is an essential aspect of the software development process and the development of object-oriented software. To describe software project design, the UML essentially uses graphical notations.

The UML's building blocks. The UML vocabulary includes three types of building blocks. Things, relationships, and diagrams

Things in the UML:

Things in a model are abstractions that are treated as first-class citizens. There are four examples of this.

1. Structural Elements

2. Sorting Items

3. Behavioural aspects

These are UML's fundamental object-oriented building components. You write well-formed models using them.

Relationships in the UML

With the use of relationships in object oriented modelling, things can be related logically and physically. There are four types of relationships. Dependency, Association, Generalization and Acceptance

5.1.2 CLASS DIAGRAM

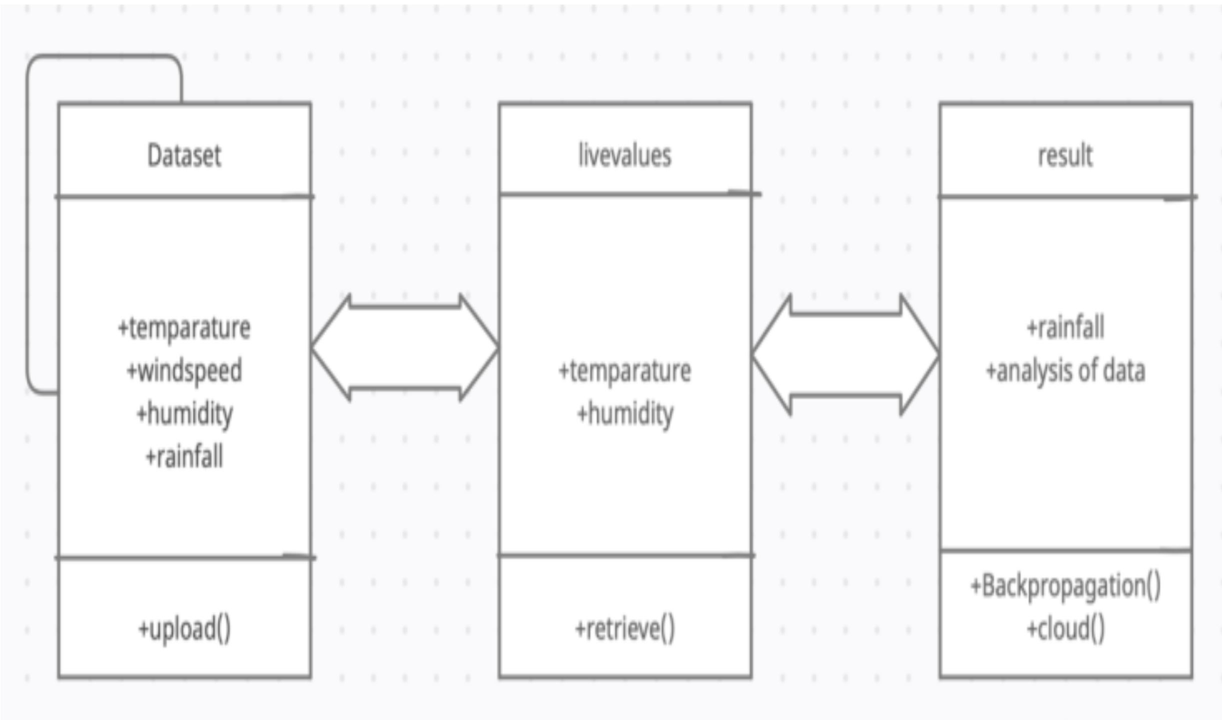


Figure 5.2 Class diagram

The above class diagram shows how live values from sensors are collected and sent to cloud for analysis and sent to logistic regression algorithm for rain fall prediction. The blueprints of your system or subsystem are class diagrams. Class diagrams can be used to model the items that make up the system, depict their relationships, and define what those objects perform and what services they provide. Many stages of system design benefit from class diagrams. A class diagram can assist you comprehend the requirements of your issue domain and identify its components during the analysis stage. The class diagrams you build during the early stages of an object-oriented software project contain classes that often translate into actual software classes and objects when you write code.

5.1.3 USE CASE DIAGRAM

A use case diagram can describe the details of your system's users (also known as actors) and their interactions with the system using the Unified Modelling Language (UML). A set of specialised symbols and connectors will be used to construct one.

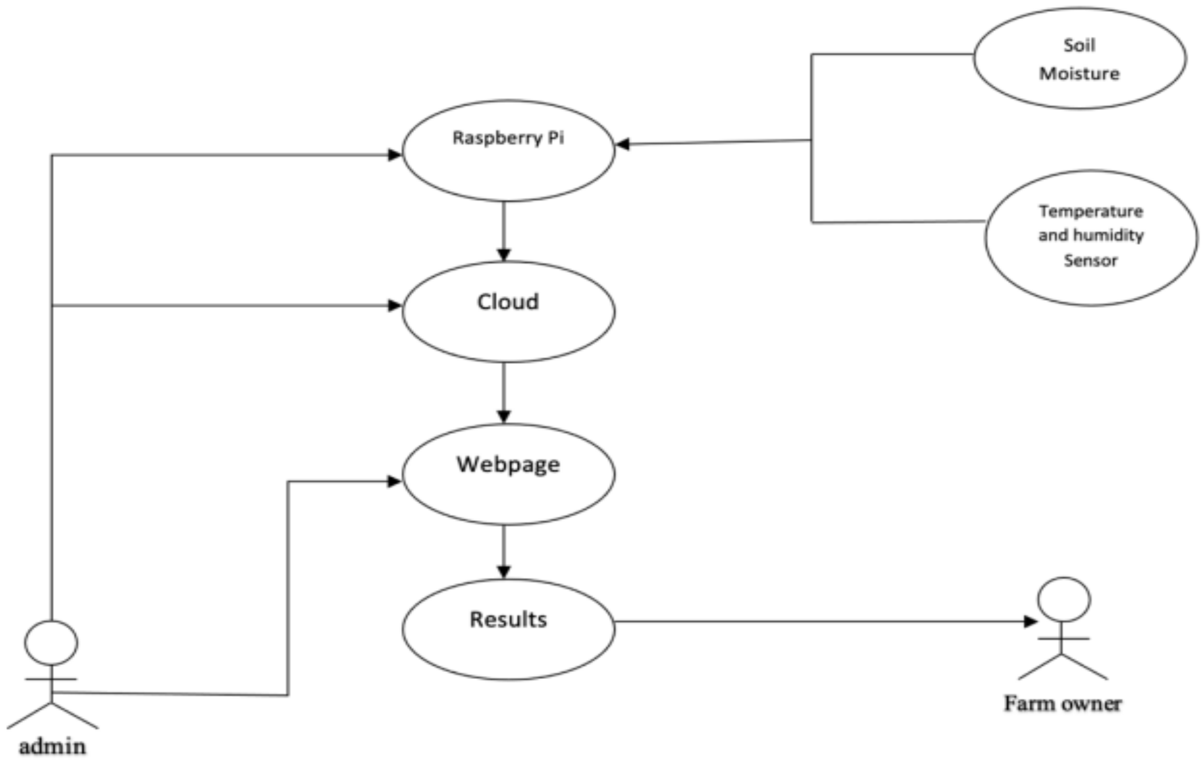


Figure 5.3 Use Case Diagram

The following Use Case diagram depicts how sensors collect data and send it to the Raspberry Pi, as well as how the admin controls the cloud platform. Following the analysis, the admin will send the results to a webpage that the farmer can access via email.

5.1.4 STATE CHART DIAGRAM

A State chart diagram is used to represent a state machine. A state machine is a machine that defines and controls many states of an entity via external or internal events. A state chart graphic depicts the transition of control from one state to another. A state is a state in which an item exists and changes due to an event. A State chart diagram's primary purpose is to depict an object's life cycle from creation to end.

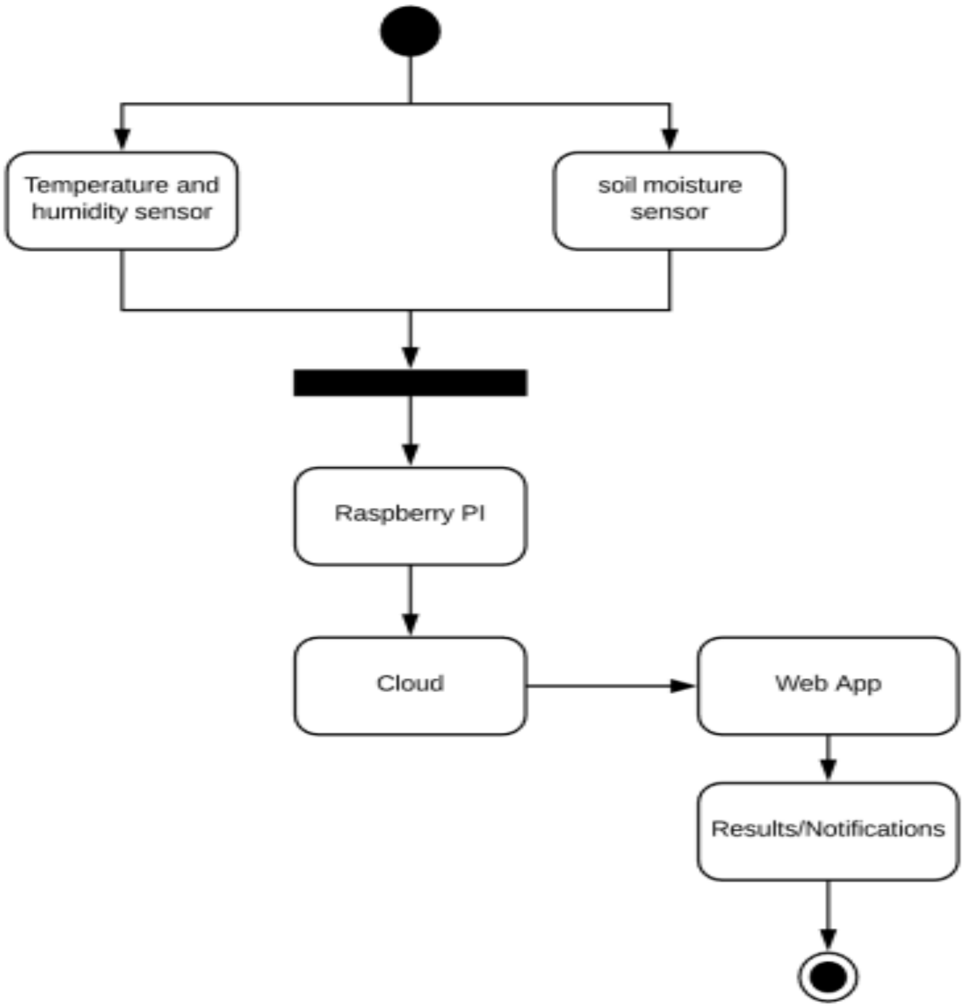


Figure 5.4 State Diagram

5.2 DESIGN AND TEST STEPS

The proposed system comprises two parts the hardware part and the software part.

The hardware part consists of a Raspberry pi connected to a temperature and humidity sensor (DHT22) and soil moisture sensor. The values are read from sensors at different intervals of time.

The software part consists of a cloud in which data from raspberry pi is stored. The accuracy of machine learning techniques (logistic regression, Random Forest Classifier) and neural network algorithms (Backpropagation) for predicting Rainfall is compared. The approach with the best accuracy is adopted, and HTML, CSS, and PHP are used for creating a web page to show analysis and weather conditions.

5.2.1 CONNECTING DHT22 WITH RASPBERRY PI

The 3 pins should be connected to the Pi as shown in the table 5.1 below :

Table 5.1 Connection of DHT22 to Raspberry Pi

DHT Pin	Signal	Pi Pin
1	V_{cc}	2 (5V)
2	GND	14 (Ground)
3	DATA	7 (GPIO 4)

The DHT22 sensor's power supply pin (Vcc) is linked to the Raspberry Pi's 5V pin (Pin 2). The GND (ground) pin is connected to the Raspberry Pi's ground pin (Pin 14). Pin 7 is connected to the DATA pin (GPIO 4).

The connection of a DHT22 sensor to a Raspberry Pi is shown in the figure 5.5 below.

Figure 5.5 DHT22 Setup

5.2.2 CONNECTING SOIL MOISTURE SENSOR WITH PI

To get analog values from the soil moisture sensor connected to the Raspberry Pi, we use an ADC (MCP3008).

The connections are as followed:

Table 5.2 Connection of Soil Moisture Sensor to Pi

MCP3008	Raspberry Pi	FC-28 Soil Moisture Sensor
V_{DD}	1 (3.3 V)	-
V_{REF}	1 (3.3 V)	-
A_{GND}	9 (GROUND)	-
CLK	23 (GPIO 11)	-
D_{OUT}	21 (GPIO 9)	-
D_{IN}	22 (GPIO 10)	-
CS	24 (GPIO 8)	-
D_{GND}	9 (GROUND)	-
-	2 (5 V)	V_{CC}

CH0	-	A0
-	14 (GROUND)	GND

The MCP3008's VDD and VREF pins are linked to the Raspberry Pi's 3.3 V pin (Pin 1). The GROUND pin is linked to the AGND pin (Pin 9). PIN 23 is connected to the CLK pin (GPIO 11). Pin 21 (GPIO 9) is connected to DOUT, while pin 22 is connected to DIN (GPIO 10). Pin 24 (GPIO 8) is connected to CS/SHDN, and pin nine is connected to DGND (GND). The soil moisture sensor's Vcc pin is linked to the Pi's 5V pin, and the GROUND pin is connected to the Pi's GND pin. The soil moisture sensor's A0 is connected to MCP3008's CH0.

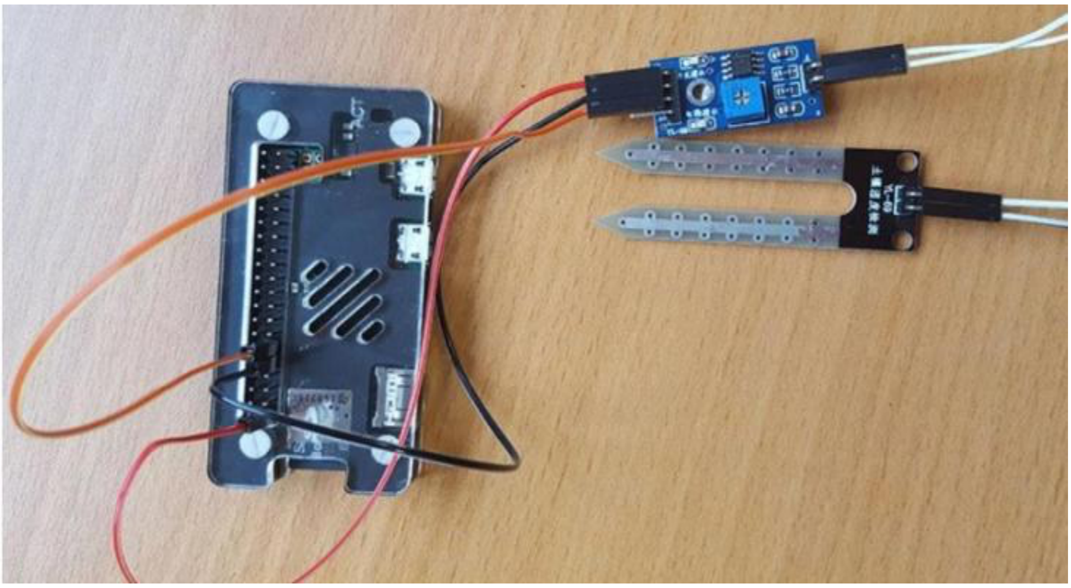


Figure 5.6 Soil Moisture Sensor Setup

CONCLUSION

The implementation of the proposed system is discussed using flowcharts such as data flow diagrams and UML diagrams. It also covers the hardware, which includes a Raspberry Pi connected to a temperature and humidity sensor (DHT22) as well as a soil moisture sensor.

CHAPTER 6

DATA SET DESCRIPTION AND CLOUD

To train machine learning algorithms how to execute various tasks, training datasets must be given into the algorithm first, followed by validation datasets (or testing datasets) to check that the model is correctly understanding the data.

Following the input of these training and validation sets into the system, you can use successive datasets to shape your machine learning model. The more data you give the machine learning system, the faster it can learn and improve.

6.1 DATA SET DESCRIPTION

The data set consists of 4 parameters.

- Rainfall
- Temperature
- Humidity
- Wind speed

Temperature, humidity, and windspeed place a significant role in determining the chances of Rainfall.

Rainfall is more likely when the temperature is low and the humidity is high, and it is less likely when the temperature is high, and the humidity is low. As a result, early Rainfall detection is critical.

The dataset utilised in the project is depicted in the figure 6.1 below. This information was obtained from the Telangana Open Data website. This data set contains over 2,00,000 lac values, which were employed to train machine learning models. Temperature, Humidity, Windspeed, and Rainfall are the four columns in this dataset. This data was gathered for the year 2020 in the state of Telangana.

Temparature	Humidity	Windspeed	Rainfall
20.85	46.2	0.55	0
23.15	48.25	0.7	0
24.85	49.75	0.25	0
25	53.5	3.4	0
24.6	52.9	1.15	0
25.55	55.4	0.8	0
24.25	60.3	1	0
26.95	53.8	0.9	0
24.75	52.35	0.15	0
24.9	38.6	0.25	0
25.3	54.45	0.3	0
26.2	60.9	1.75	0
25	62.25	0.05	0
24.7	52.85	0.05	0
25.2	49.45	4.5	0
25.4	49.45	0.15	0
24.05	46.9	0.55	0
26.95	55.35	0.55	0
26.6	60.4	0.75	0
25.1	58.6	1.2	0
26.15	58.35	3.5	0
26.25	54.3	2.55	0
27.6	56.15	1.9	0
26.95	71.25	2.15	0
26.4	71.55	0.8	0
27.45	66.85	3.95	0
24.6	83.3	2.55	1
22	90.7	2.6	1
20.4	78.95	1.7	0

Figure 6.1 Dataset

6.2 CLOUD

Cloud computing is Internet-based computing that makes a shared pool of resources accessible over a vast network. With minimal administrative effort and service provider involvement, these resources can be deployed or withdrawn.

Third parties manage **public clouds**, which offer cloud services to the general public over the internet. Pay-as-you-go billing is available for these services.

Private clouds are distributed systems that run on private infrastructure and offer consumers dynamic computing resource provisioning. Other techniques that analyse cloud usage and proportionally bill different departments or areas of a company could be used instead of the pay-as-you-go model used in public clouds.

A hybrid cloud is a distributed heterogeneous system that combines public and private cloud resources. As a result, they are also known as heterogeneous.

Community clouds are distributed systems that combine the services of multiple clouds to meet the demands of a certain industry, community, or enterprise. The cloud might be managed by an organisation or a third party.

Cloud platform used in the project

The ThingSpeak cloud platform is used in this project for data storage and analysis. A channel is created which contains fields to store data from Raspberry pi. The cloud platform generates an API key once channel setup is done, which is used to access the cloud from raspberry pi and read or write data from the cloud.

6.2.1 CHANNEL SETUP

ThingSpeak is a platform for Internet of Things applications. ThingSpeak allows users to construct a sensor-based application. ThingSpeak has capabilities such as real-time data collection, data processing, visualisations, apps, and plugins.

A ThingSpeak Channel is at the heart of ThingSpeak. You send your data to be stored through a channel. Each channel has eight data fields, three location fields, and one status field. Once you've created a ThingSpeak Channel, you may publish data to it, have it processed by ThingSpeak, and then have your application retrieve the data.

ThingSpeak is bought in units, where one unit allows 33 million messages to be processed and stored in a one-year period (~90,000 messages/day). One unit (home license type) also provides the ability to create **up to 10 channels** on ThingSpeak.

Updating a ThingSpeak Channel

You put data into a ThingSpeak Channel by using HTTP POST. For testing purposes, you can use a Firefox Add-on called Poster. This tool is great for testing web services.

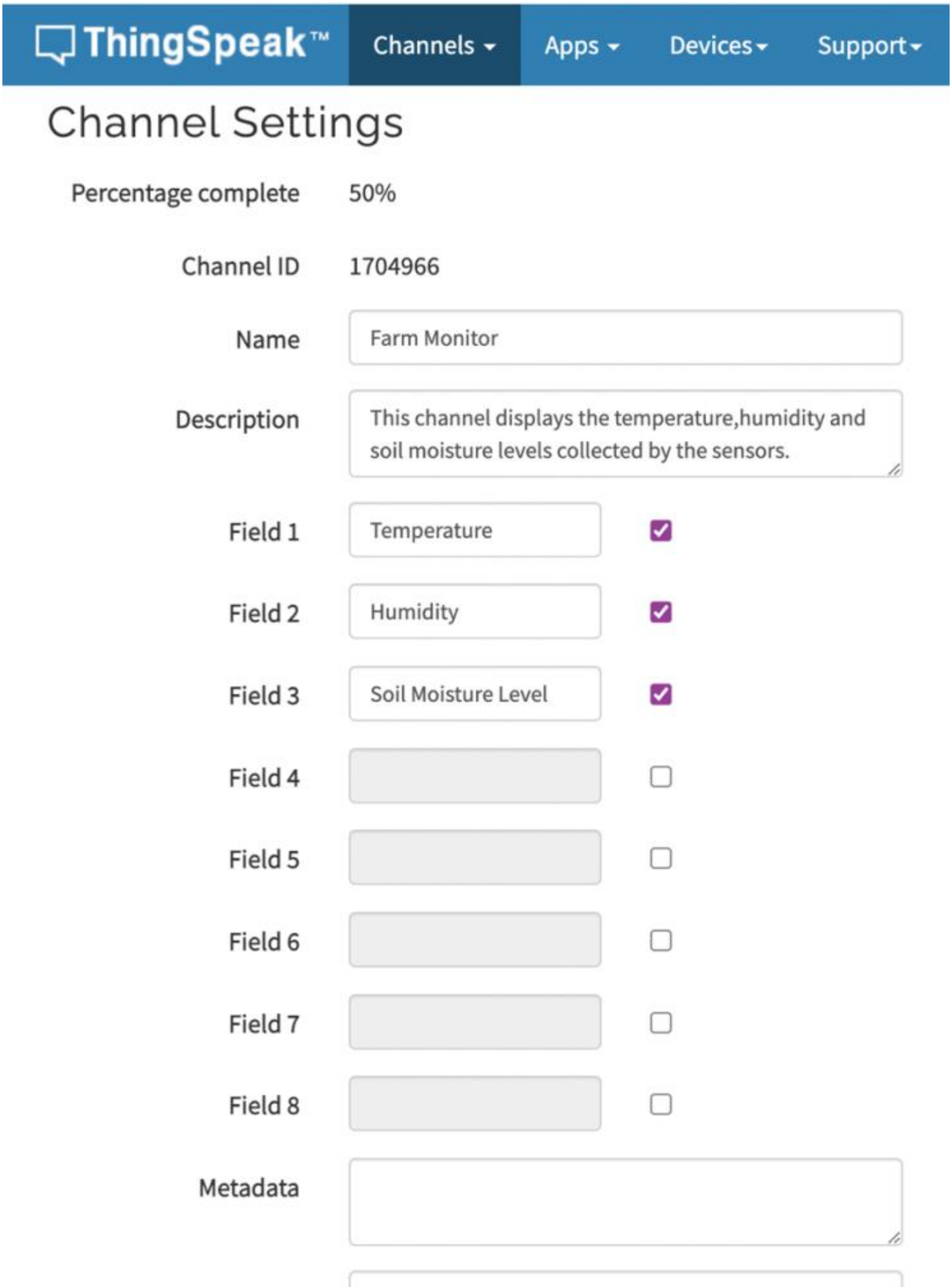


Figure 6.2 Channel Setup

6.2.2 API KEY GENERATION

A screen similar to this one should appear. The write API key is used to transmit data to the channel, while the read API key(s) are used to read data from the channel. A write API key is produced by default when a channel is created. The 'Generate New Read API Key' button beneath this tab is used to create read API keys. Each read API key can have its note.

The previous key will be overwritten if you use the 'Generate New Write API Key' option. At any given time, you will have just one Write API key. If your channel is private, others can only see the feed and charts using the Read API.

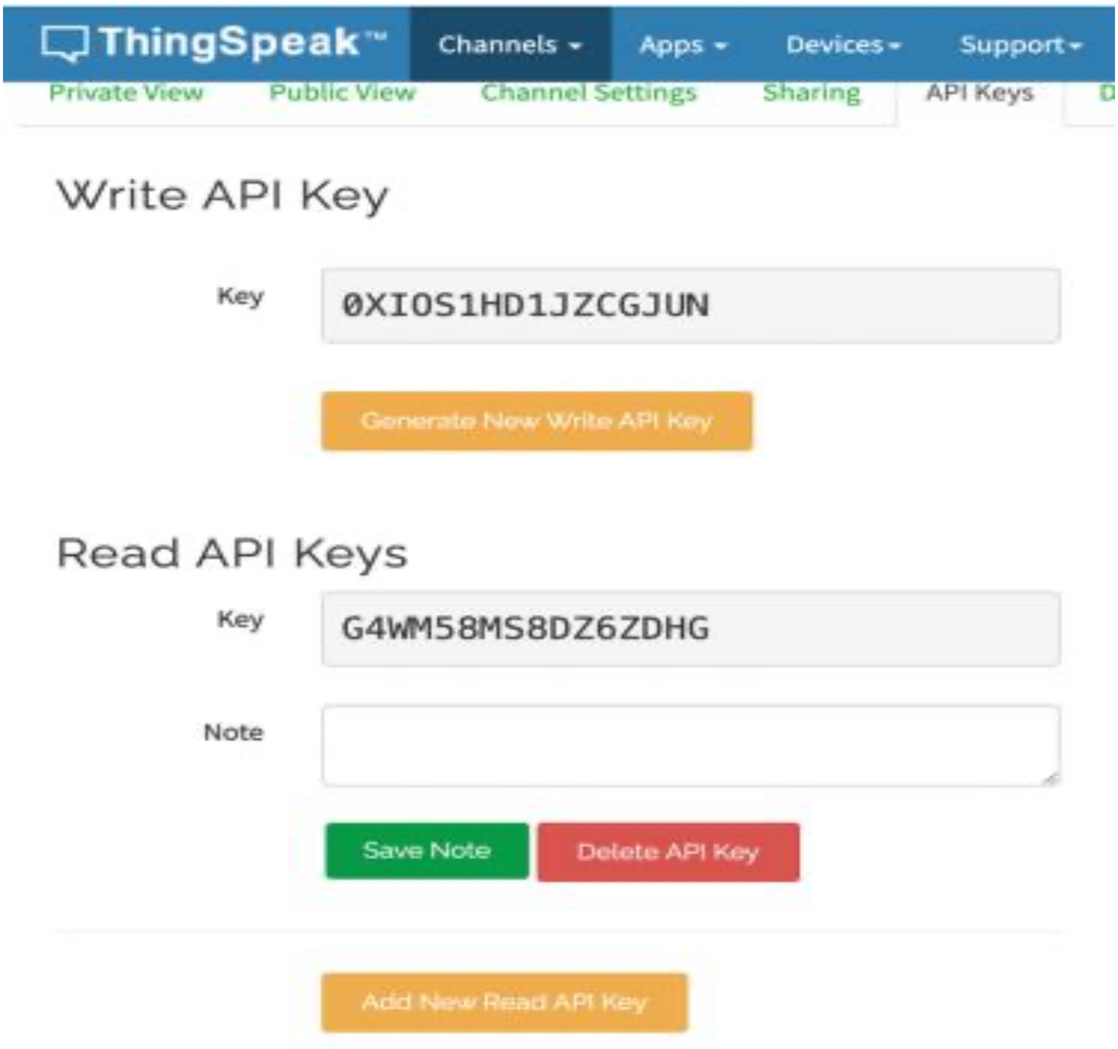


Figure 6.3 API Key Generation

6.3 TESTING PROCESS

One of the most crucial stages in evaluating a developed system is testing. The testing procedure in this project focuses on a few key areas that are strongly related to the objective of the data set being used. Identifying the areas that must be tested, the criteria for a positive test and the testing method used are all part of the project's testing phase. In this section, the many aspects of testing are described.

1. The first step - validate the data collected from sensors and determine whether it is accurate.
2. The second step - the data is sent to the cloud, allowing data import and export.
3. Finally, the algorithm (Backpropagation) is tested and the rainfall is predicted as it has better accuracy when compared to other algorithms.
4. Finally, the data collected from various sensors is sent to the webpage.

CONCLUSION

The dataset is studied and cloud setup is done.

CHAPTER 7

RESULTS

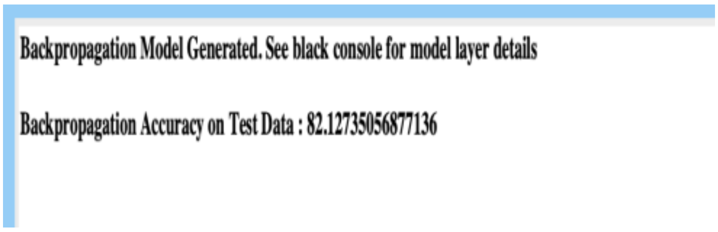
All of the project's outputs are covered in detail in the results section. The results for rainfall prediction, comparison of Logistic Regression, Random Forest Classifier and Backpropagation Algorithm, hardware setup, and the webpage are all discussed in detail in farm monitoring system project.

7.1 COMPARING ACCURACY OF DIFFERENT ALGORITHMS

The accuracy of the Logistic Regression, Random Forest Classifier, and Backpropagation Algorithm is determined using previously gathered data. The comparison of the Logistic Regression, Random Forest Classifier, and Backpropagation Algorithms is shown in Table 7.1.

Table 7.1 Comparison of accuracies

Algorithm	**Accuracy**
Logistic Regression	**Prediction Results** **logistic Accuracy** **Accuracy : 81.98231001471636**
Random Forest Classifier	**Prediction Results** **Random Forest Accuracy** **Accuracy : 79.5912794137727**

Backpropagation Algorithm	 Backpropagation Model Generated. See black console for model layer details Backpropagation Accuracy on Test Data : 82.12735056877136

The accuracies of the Logistic Regression, Random Forest Classifier, and Backpropagation Algorithm are compared and shown in a bar graph for easy understanding as shown in below figure7.1.As we can see Logistic Regression gives an accuracy of 81.9%, Random Forest Classifier gives an accuracy of 79.59% and Backpropagation Algorithm gives an accuracy of 82.127%. The rainfall is predicted with Backpropagation algorithm as it has better accuracy when compared to other algorithms.

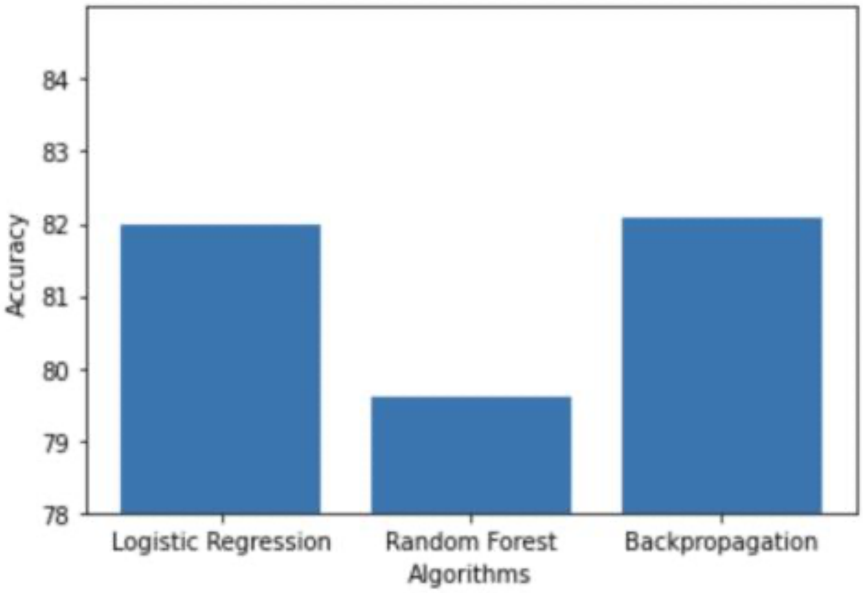


Figure 7.1 Comparison between algorithms

7.2 COMPARING BASE PAPER WITH BACKPROPAGATION

The Multiple Linear Regression algorithm is compared with the Back Propagation algorithm and is shown in table 7.2.

Table 7.2 Comparison of Multiple Linear Regression and Back Propagation algorithm

Algorithm	**Accuracy**
Multiple Linear Regression	Accuracy: 0.7115
Backpropagation	Backpropagation Model Generated. See black console for model layer details Backpropagation Accuracy on Test Data : 82.12735056877136

The Multiple Linear Regression algorithm and Backpropagation Algorithm are trained using previously obtained data, and their accuracy is determined .The accuracies of Multiple Linear Regression algorithm and Backpropagation Algorithm are compared and shown in a bar graph for easy understanding as shown in below figure7.1.As we can see Multiple Linear Regression algorithm gives an accuracy of 71.1% and Backpropagation Algorithm gives an accuracy of 82.127%.

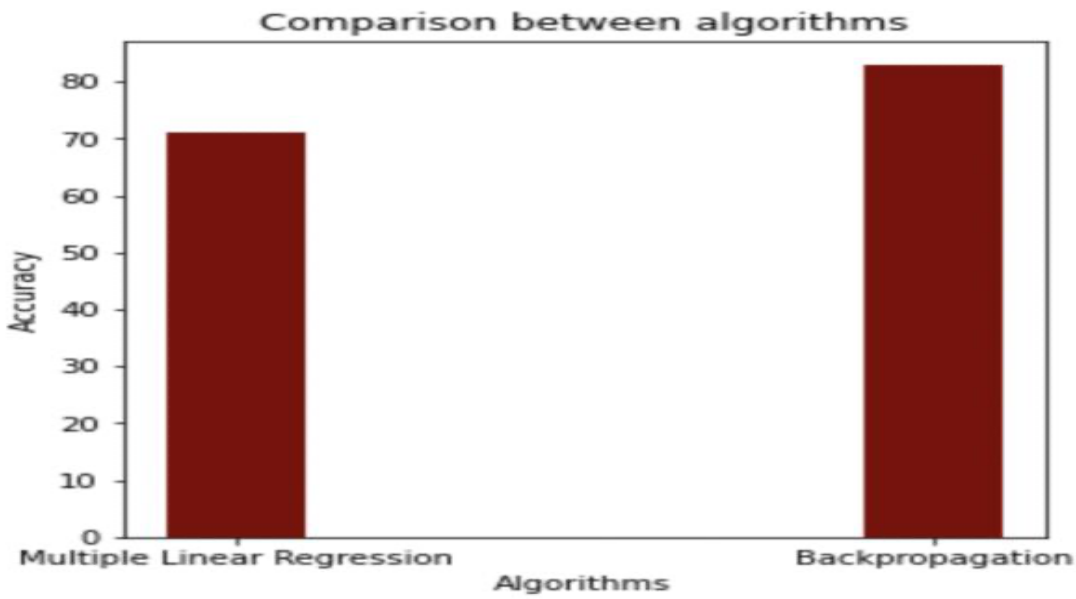


Figure 7.2 Comparison of Multiple Linear Regression and Back Propagation algorithm

7.3 DATA FROM SENSORS

The data comes from a soil moisture sensor attached to a Raspberry Pi, as well as temperature and humidity sensors. The Raspberry Pi board is controlled by the Raspbian operating system, and information of soil moisture levels, temperature, and humidity may be obtained in the output shell, as indicated in the figure 7.3 below.

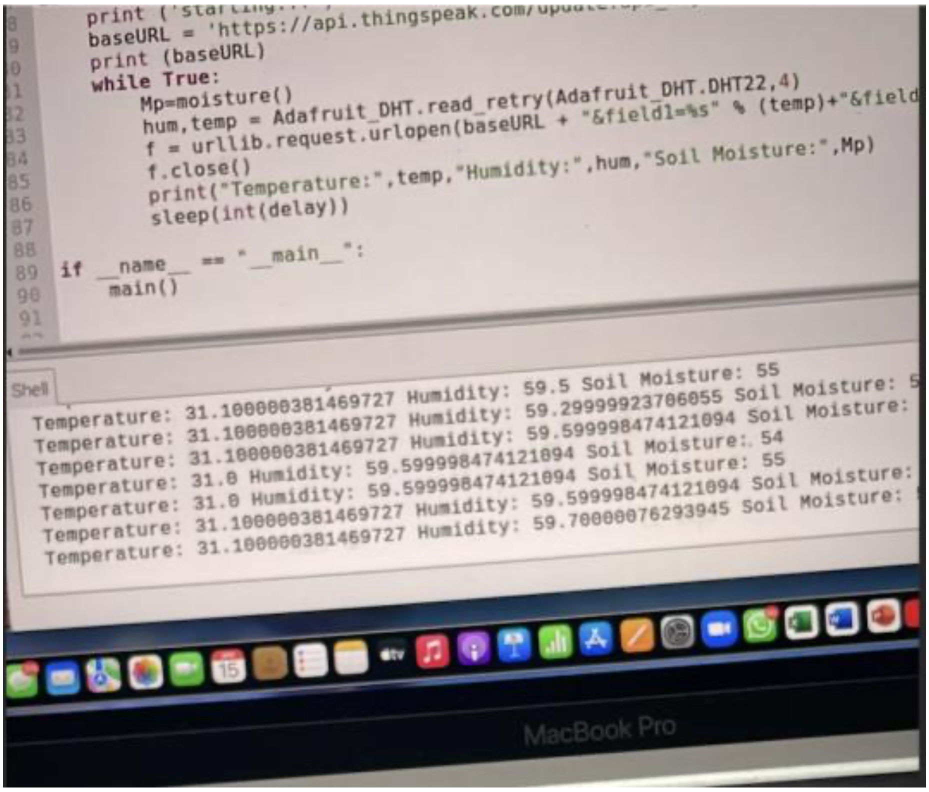


Figure 7.3 Data from sensors

7.4 WEBPAGE

For farmers, a website is a valuable tool. Farmers may easily monitor their farms by logging in with their registered accounts. This webpage is constantly updated with new information. The analysis done on the cloud is also updated on the internet. This website is also incredibly user-friendly, which is beneficial for farmers.

Since the information is confidential, a webpage is created using HTML, CSS, and PHP to allow farmers to examine the analysis of their farm anytime they log in. The layout of the login page is shown in below figure 7.4

7.4.1 LOGIN AND REGISTRATION PAGE OF WEBSITE

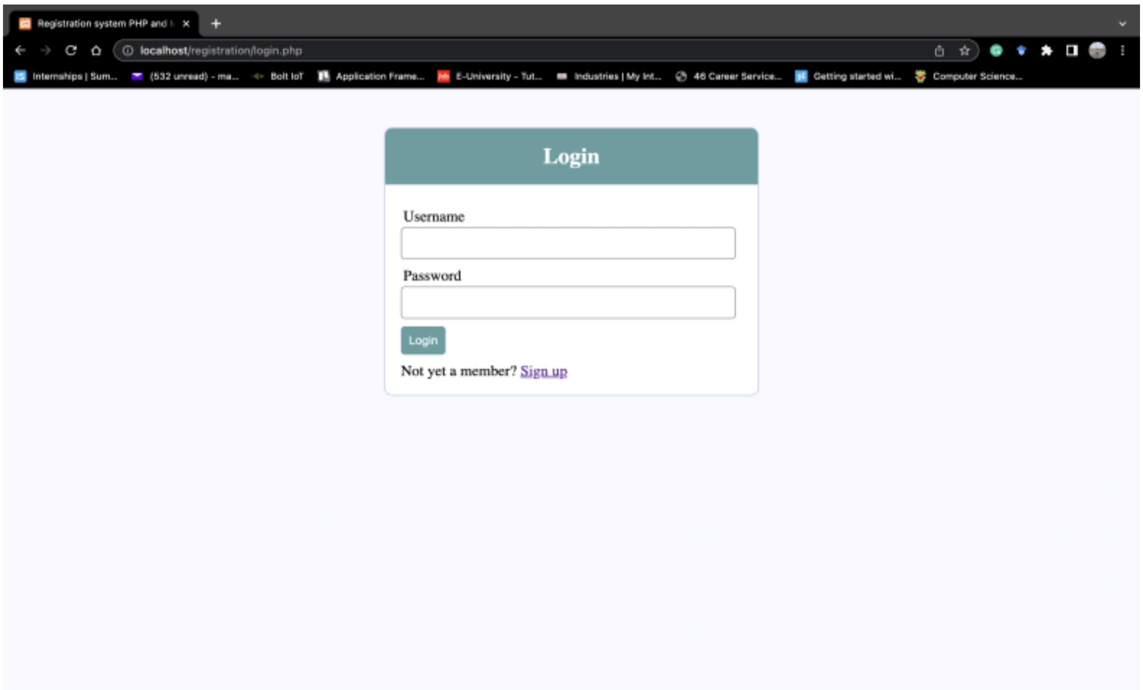


Figure 7.4 Login Page of website

If the farmer does not have an account, he can create one to access the farm's real-time analysis delivered from the cloud via the sensors. The layout of the login page is shown in below figure 7.5

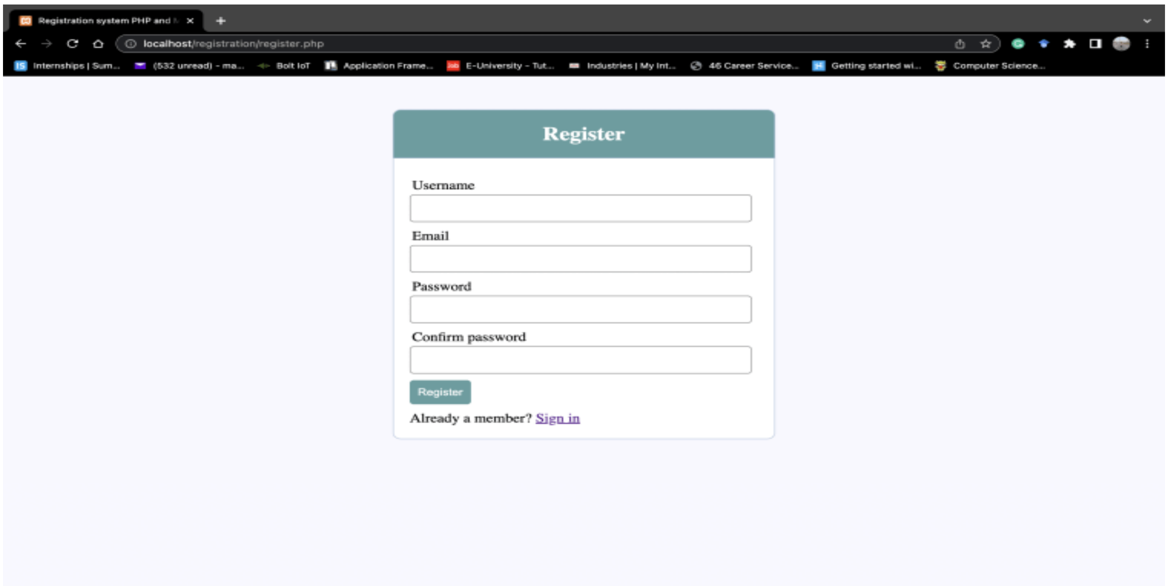


Figure 7.5 Registration Page of website

A web page shown above is created using html, CSS, PHP and it provides user an interface to visualize data from the cloud which is sent using sensors.

7.4.2 HOME PAGE OF WEBSITE

The below figure 7.6 shows how the user is redirected to the home page after registering, which is created with HTML, CSS, and PHP. The user may find all the information about the website on the home page, as well as a tab that takes him to the detailed farm analysis.

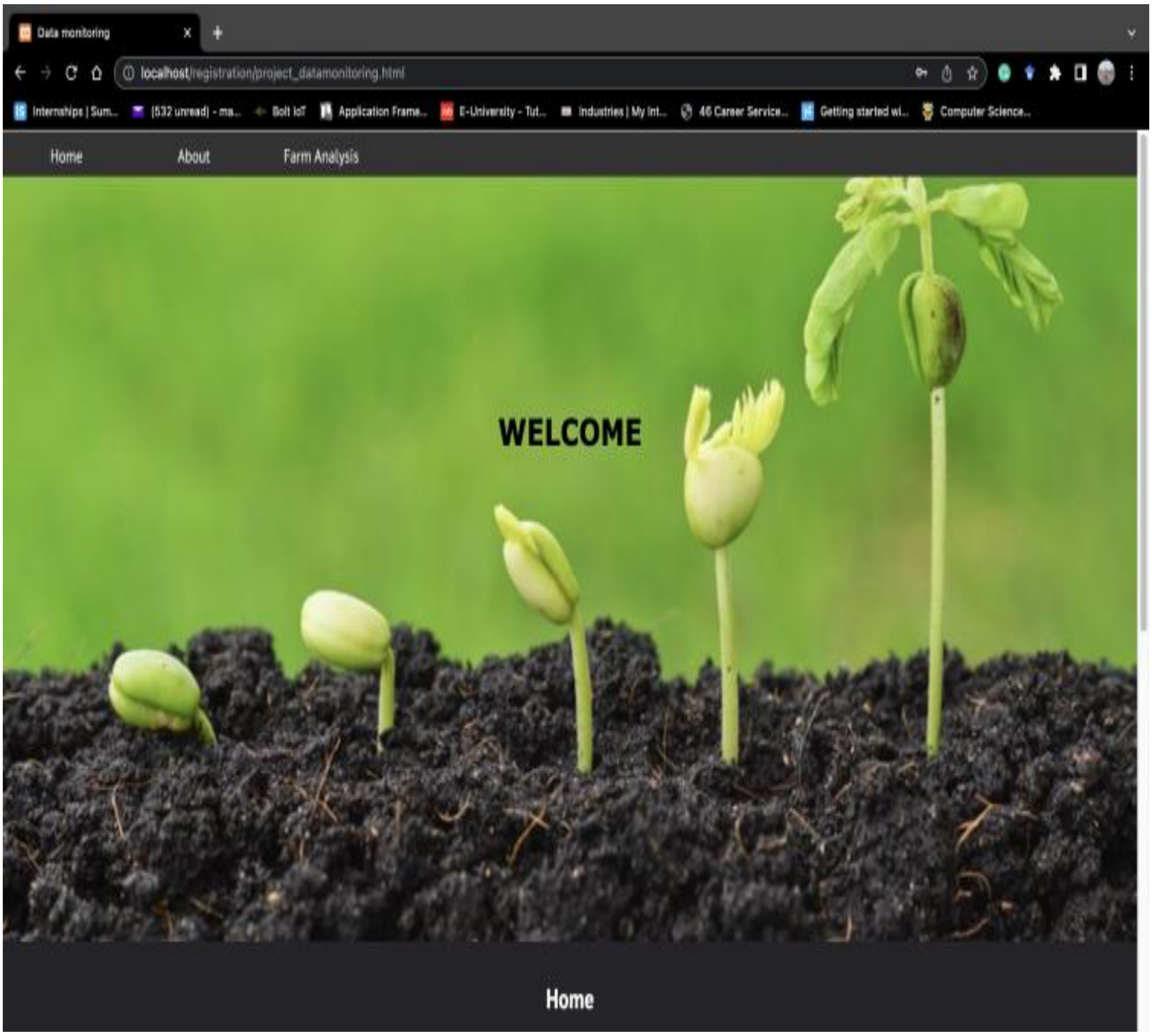


Figure 7.6 Home Page of website

After registering, the user is redirected to the home page.

7.4.3 ABOUT PAGE OF WEBSITE

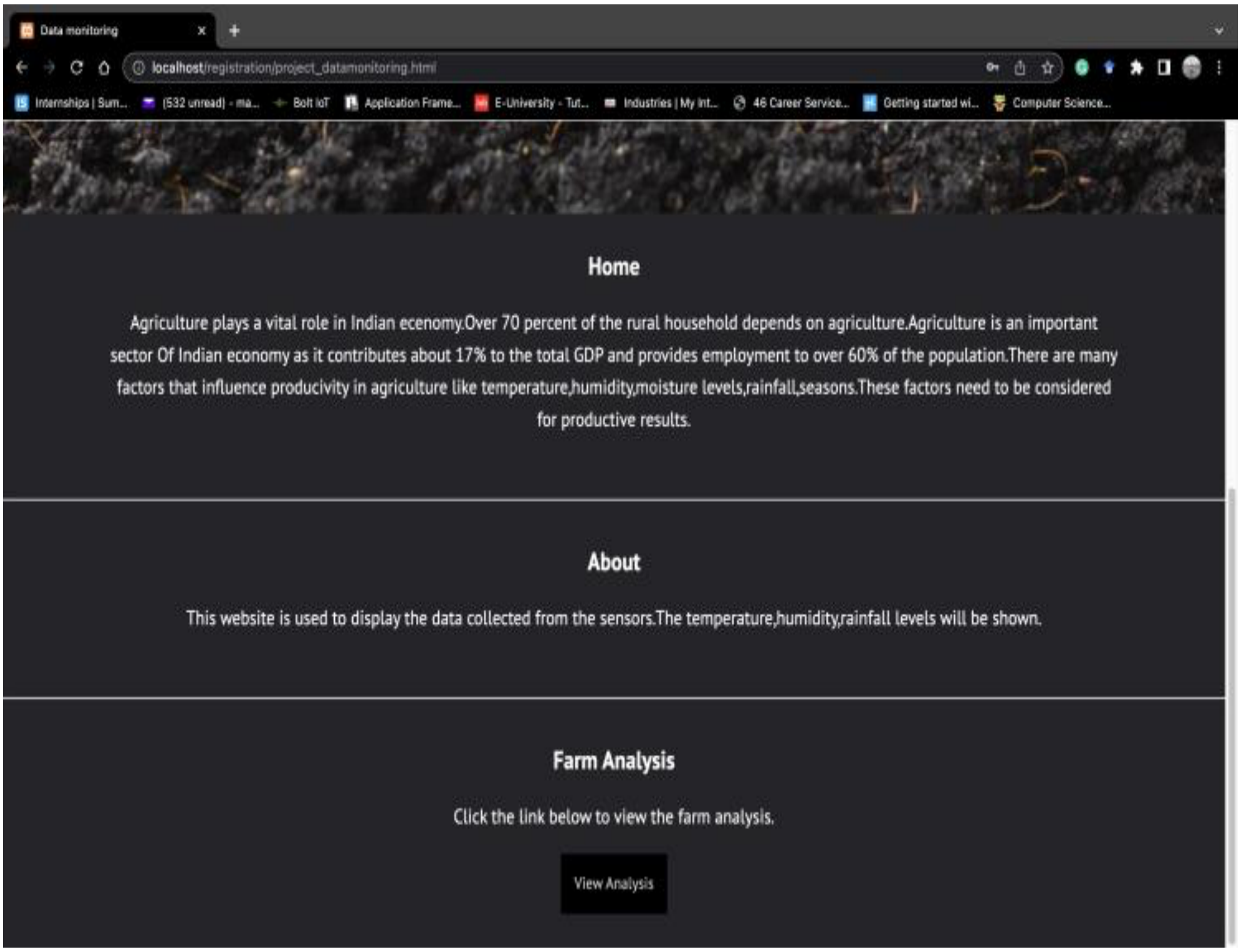


Figure 7.7 About Page of website

The user can see the about page in the home page of the website made with HTML, CSS, and PHP, as shown in Figure 7.7 On the about page, the user will find all the website's information, as well as a tab to the complete farm analysis.

7.5 TEMPERATURE ANALYSIS

The temperature analysis is done in the cloud and the graph is drawn across Time v/s Temperature values. The temperature can be noted down at each time interval accurately. All the detailed information about the temperature analysis is shown in the figure 7.8 below.

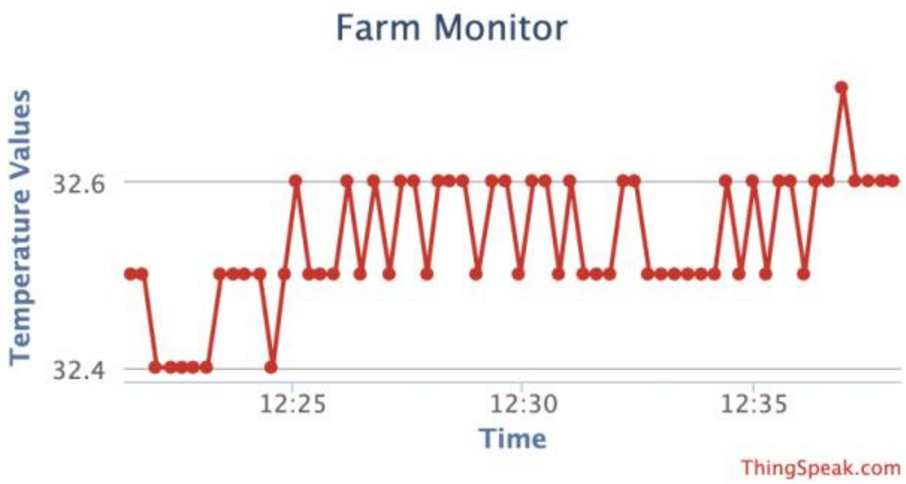


Figure 7.8 Temperature Analysis

7.6 HUMIDITY ANALYSIS

The humidity analysis is done in the cloud and the graph is drawn across Time v/s Humidity values. The humidity values can be noted down at each time interval accurately. All the detailed information about the humidity analysis is shown in the figure 7.9 below.

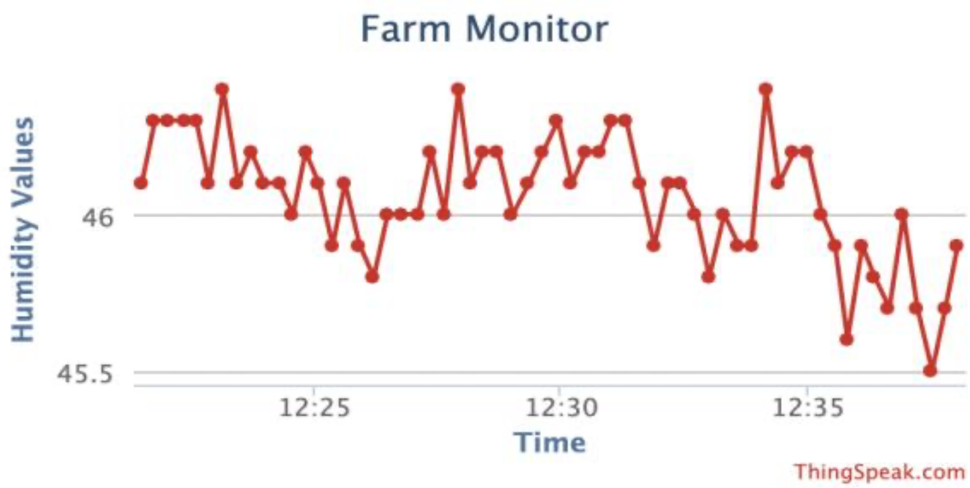


Figure 7.9 Humidity Analysis

7.7 SOIL MOISTURE ANALYSIS

The soil moisture analysis is done in the cloud and the graph is drawn across Time v/s soil moisture levels. The soil moisture levels can be noted down at each time interval accurately. All the detailed information about the soil moisture levels is shown in the figure 7.10 below.

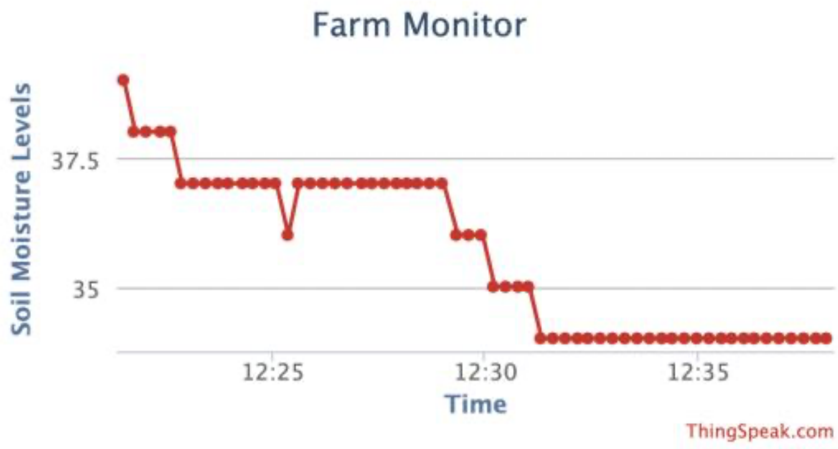


Figure 7.10 Soil moisture Analysis

7.8 FARM ANALYSIS ON WEBSITE

When a user selects the farm analysis tab from the about page, a screen displaying temperature, humidity, and soil moisture variations over time appears, as shown in figure 7.11. The values from the cloud are represented graphically at each interval. When the user selects a point on the graph's curve, detailed information about the temperature value in temperature graph, humidity value in humidity graph and soil moisture levels in soil moisture level graph are displayed.

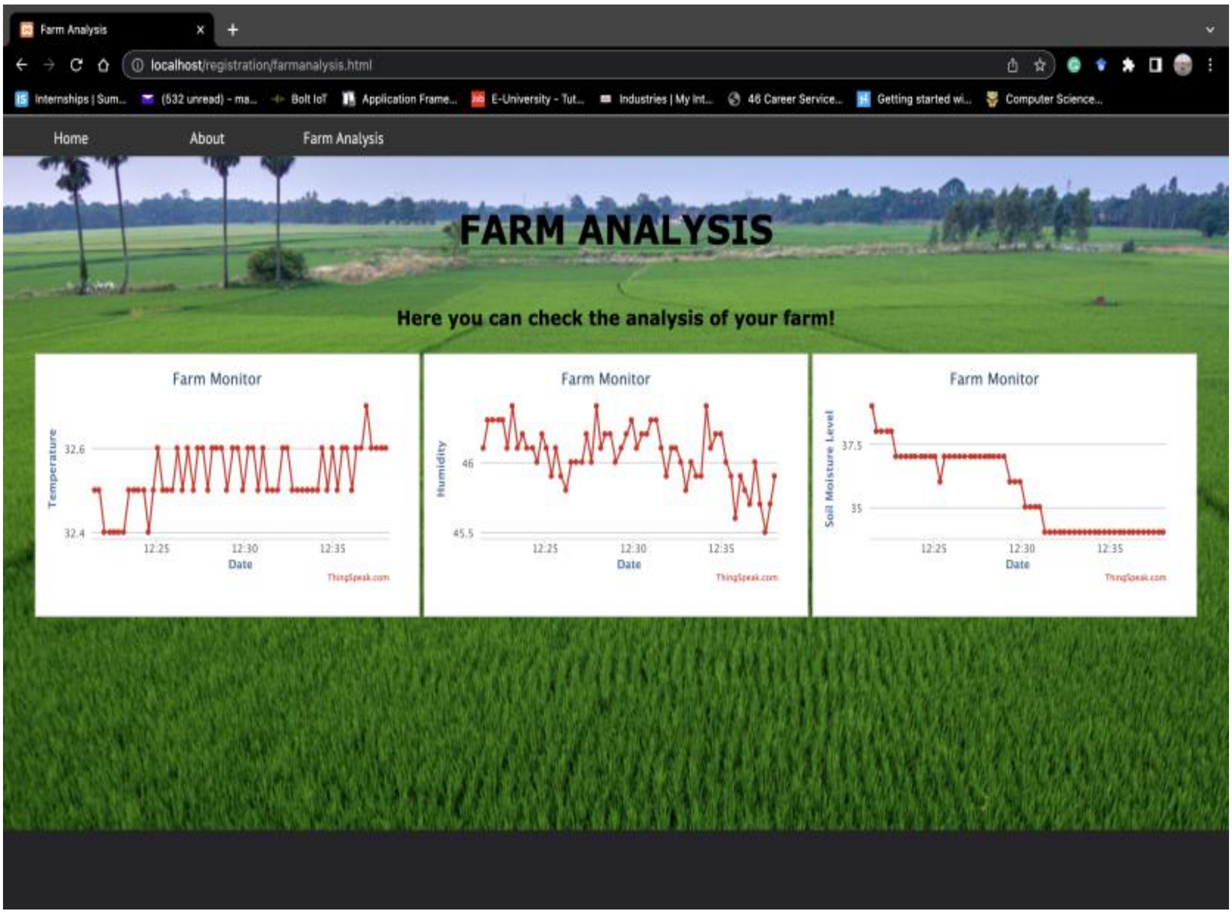


Figure 7.11 Farm Analysis displayed on website

A screen indicating temperature, humidity, and soil moisture variations over time shows after the user clicks on farm analysis on the webpage, as seen above.

7.9 PREDICTING RAINFALL

The Logistic Regression, Random Forest Classifier, and Backpropagation Algorithm are trained using previously obtained data and their accuracy is determined, as discussed in earlier chapters. After determining their accuracies, the Backpropagation algorithm was found to be the most accurate and is chosen to predict rainfall. The Backpropagation algorithm predicts Rainfall using live sensor data after training, as shown in Figure 7.12, and the results are displayed on a separate Tkinter GUI. Tkinter is a Python standard library for developing graphical user interfaces (GUIs) for desktop applications. Developing desktop apps with Tkinter is not a difficult effort. Tk, which is Python's default GUI library, will be our primary GUI toolkit. Tk will be accessed through Tkinter, a Python interface.

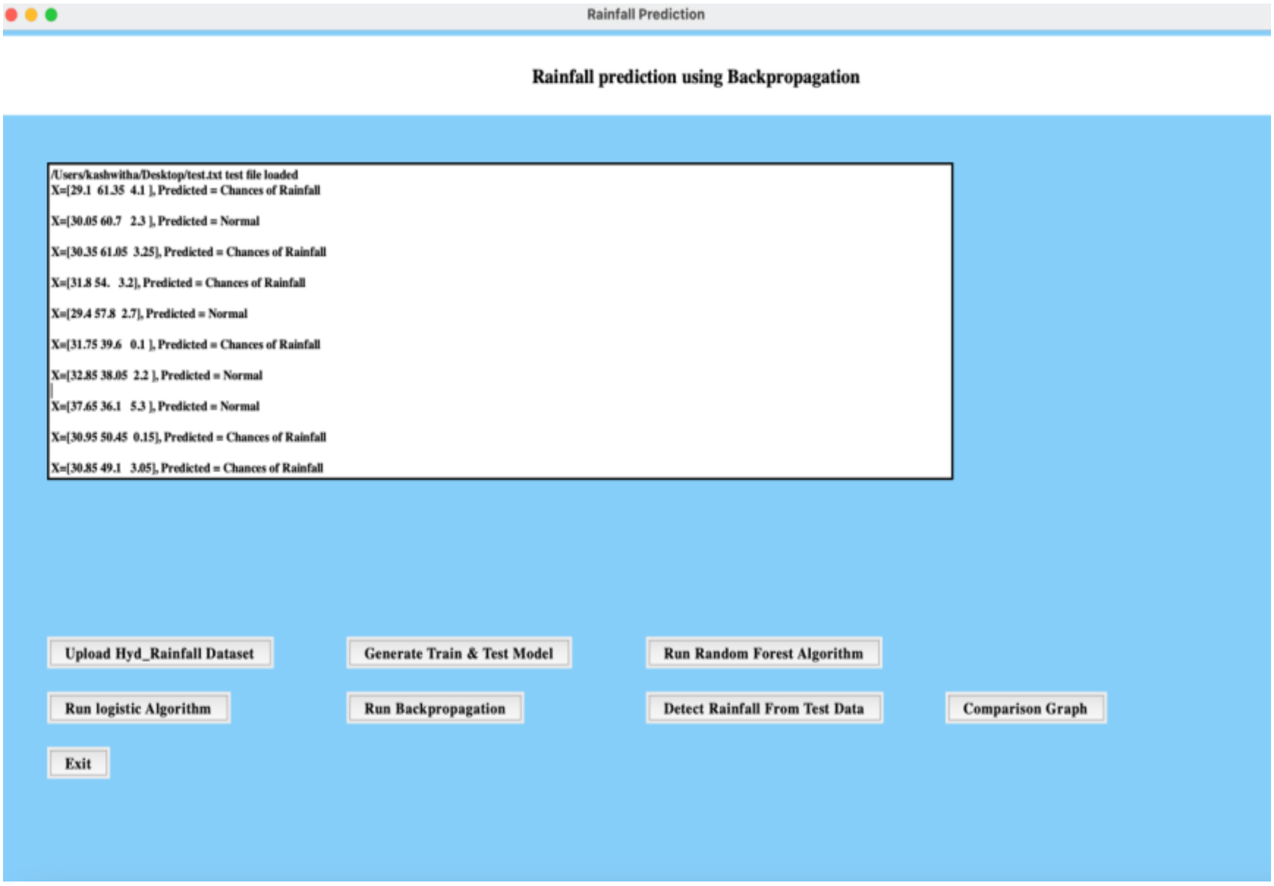


Figure 7.12 Prediction on data from cloud

The Backpropagation algorithm predicts Rainfall using live sensor data after training, and the results are displayed on a separate Tkinter GUI.

CONCLUSION

All the algorithms are compared for their accuracies and it was found that Back Propagation algorithm has the best accuracy and the webpage is also designed. The temperature, humidity and soil moisture analysis is done and the rainfall is predicted from the data available on the cloud.

CHAPTER 8

CONCLUSIONS AND FUTURE WORK

8.1 CONCLUSIONS

This project allows us to track soil moisture, temperature and humidity levels and predict rainfall. A prototype is developed and data collected from the sensors is transmitted to the ThingSpeak cloud. Machine learning models using Logistic Regression, Random Forest Algorithm, and Backpropagation Algorithm for predicting rainfall are developed. A webpage that displays the farm analysis that was done in the ThingSpeak cloud is also developed to predict the rainfall.

The data is analysed and posted on the webpage. This data is used to plan the harvesting and sowing the seeds. The collected data is stored in the cloud and can be used by the farmers in the future also. This can aid in reducing the losses that farmers have suffered due to poor crop choices and forecasting unfavourable conditions that have existed for many years. The system demonstrates the capacity to focus on many farm factors. Thus the farmer can utilize the farm analysis to increase the productivity of the farm.

8.2 FUTURE WORK

Additional sensors, such as wind speed, pH, and air quality sensors, could be added to this model. These sensors will assist in the overall management of the farm.

A camera and fiber optic sensor can relate to the nodes. The camera captures images periodically, and image processing is done on these images to determine the growth of the crop and the diseases; these images can also help in identifying the pests on the observation of any abnormalities.

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Common guidelines for uniform evaluation of BE Projects, AY 2021-22

Course: Project: Part 2 (18EC C34)

Course Outcomes: Upon completion of this course, students will be able to:

1. Recall the details of the approach for the selected problem.
2. Interpret the approach to the problem relating to the assigned topic.
3. Determine the action plan to conduct investigation.
4. Analyse and present the model / simulation /design as needed.
5. Evaluate, present and report the results of the analysis and justify the same.

S.No	Project Outcome	CO	PO	Blooms Taxonomy Levels
1	Studied and analysed the literature survey to identify and formulate the difficulties encountered when using IoT enabled gadgets and various Machine Learning techniques to predict rainfall.	CO1	PO1, PO2, PO7, PO8,PO12	Remember, Understand
2	Identified the essential sensors for weather monitoring, a Machine Learning Algorithm for accurately predicting rainfall, and an IoT prototype for hardware requirements.	CO2	PO1,PO2,PO5,PO11	Analyse, Apply, Evaluate

3	Interfacing sensors with Raspberry pi and stored data in the cloud to implement the prototype for the farm monitoring system and Backpropagation algorithm to predict the rainfall.	CO3	PO3,PO4,PO9	Apply, Analyse, Create
4	Prepared presentations that describe and communicate the topic effectively and documented a clear and precise project report.	CO4	PO6,PO9,PO10	Create
5	Exhibited technical knowledge, teamwork, communication skills, and organisational skills by proposing an effective solution to the current system's challenges.	CO5	PO9,PO10,PO12	Apply, Create

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