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Intelligent Irrigation System using Machine Learning

A MINOR PROJECT-18TE64 REPORT

Submitted by

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Submitted in partial fulfillment for the sixth-semester examination of

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RV COLLEGE OF ENGINEERING®, BENGALURU-59

(Autonomous Institution Affiliated to VTU, Belagavi)

DEPARTMENT OF ELECTRONICS AND TELECOMMUNICATION ENGINEERING

CERTIFICATE

Certified that the minor project work titled ***"Intelligent irrigation system using Machine learning"*** is carried out by **Riddhi Sharma (1RV19ET043), Samarth C (1RV19ET049), Aditi (1RV20ET002), CH Pujith (1RV20ET015)** who are bonafide students at RV College of Engineering, Bengaluru, submitted in partial fulfillment for the sixth-semester examination of **Bachelor of Engineering** in **Electronics and Telecommunication Engineering** of the Visvesvaraya Technological University, Belagavi during the year 2022-2023. It is certified that all corrections/suggestions indicated for the Internal Assessment have been incorporated in the minor project report deposited in the departmental library. The minor project report has been approved as it satisfies the academic requirements in respect of minor project work prescribed by the institution for the said degree.

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DECLARATION

We, **Riddhi Sharma, Samarth, Aditi Bardhan, Ch Pujith** students of sixth semester B.E., Department of Electronics and Telecommunication Engineering, RV College of Engineering, Bengaluru, hereby declare that the minor project titled ***"Intelligent irrigation system using machine learning"*** has been carried out by us and submitted in partial fulfillment for the sixth-semester examination of **Bachelor of Engineering** in **Electronics and Telecommunication Engineering** during the year 2022-2023.

Further, we declare that the content of the dissertation has not been submitted previously by anybody for the award of any degree or diploma to any other university.

We also declare that any Intellectual Property Rights generated out of this project carried out at RVCE will be the property of RV College of Engineering, Bengaluru and we will be one of the authors of the same.

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ABSTRACT

In recent years, there has been an increase in demand for efficient agricultural practices and sustainable water management. This has led to the development of smart agriculture systems that leverage IoT and machine learning. In this project, we propose an Intelligent Irrigation System that comprises of Crop Recommendation system. Predicting the most suitable crop to be grown on a particular soil has become very critical these days. Development of a smart irrigation system using IoT, sensors and Machine Learning have facilitated the prediction of the most suitable crop. The hardware architecture comprises of sensors such as the DHT11 sensor soil moisture sensor.

Soil moisture sensor measures moisture content in the soil. DHT11 sensor is used to measure both temperature and humidity. The data obtained from DHT11 and soil moisture sensor is collected and processed by the Node MCU microcontroller. Continuous monitoring of soil moisture levels is facilitated through the communication established between the soil moisture sensor (DHT11) and the Node MCU. Based on the data acquired regarding soil moisture levels, the Node MCU microcontroller initiates the irrigation system to dispense water to the plants. On the server side, python scripts implement machine learning algorithm to analyze the sensor data and provide personalized crop recommendation.

Relevant features from the collected dataset, such as soil moisture, humidity, and temperature are extracted. These features serve as input variables for the crop recommendation model. When new environmental data such as soil moisture, humidity, and temperature are received from the hardware model with Node MCU, the trained Random forest model predicts the most suitable crops based on the input features with 99% accuracy.

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List of Acronyms

AI	-	Artificial Intelligence
ANN	-	Artificial Neural Network
ADC	-	Analog to Digital Convertor
CYP	-	Crop Yield Prediction
DTH11	-	Digital temperature and humidity sensor
DC `	-	Direct Current
GUI	-	Graphical user interface
GSM	-	Global system for mobile communication
GPRS	-	General packet radio service
GUI	-	Graphic User Interface
GPIO	-	General Purpose Input - Output
HTTP	-	Hypertext Transfer Protocol
IDE	-	Integrated Development Environment
IOT	-	Internet of things
KNN	-	K-Nearest Neighbours Algorithm
LSTM	-	Long short-term memory networks
MPU	-	Microprocessor Unit
ML	-	Machine Learning
MLR	-	Multiple Linear Regression
USB	-	Universal serial Bus
Vcc	-	Voltage at common collector
Wi-fi	-	Wireless Fidelity

CHAPTER 1

INTRODUCTION TO INTELLIGENT IRRIGATION SYSTEM

CHAPTER-1

INTRODUCTION TO INTELLIGENT IRRIGATION SYSTEM

The major component comprising of India's Gross Domestic Product is agriculture. The cultivation of the most suitable crop on a particular soil holds a critical position within the realm of modern agriculture. The significance of this practice lies in its ability to address the prevalent issue of farmers being guided by intuition rather than optimizing total production. The selection of appropriate crops for specific soil types requires a comprehensive understanding of soil characteristics and crop requirements like soil moisture, temperature and humidity.

The integration of smart irrigation systems, equipped with sensors and Machine learning capabilities, propels a paradigm shift towards a more informed and scientific approach. Moreover, the predictive capabilities of these systems contribute to the efficient use of resources. Farmers can tailor their crop selection to match the soil's inherent properties, optimizing water usage and nutrient application. As a result, resource wastage is minimized, leading to cost savings and improved environmental sustainability.

In the prototype the moisture of the soil, temperature and humidity is measured using soil moisture sensor and DHT11. The water pump, being controlled is used to irrigate the soil. Then the data captured by the sensors is transmitted to the cloud for ongoing data monitoring and making suitable decisions.

The decision regarding which crop to grow is typically influenced by intuition and various irrelevant factors, such as making instant decisions, lacking awareness of market demand, overestimating a soil's ability to support a specific crop, and so forth. An ill-informed decision made by the farmer can exert substantial pressure on the overall yield, consequently diminishing the farmer's income.

A Crop Recommendation system is developed using Machine Learning takes into consideration the parameters of temperature, humidity and soil moisture. It gives the most suitable crop that can be grown on the tested soil as the prediction. This prediction is seen on the web interface.

1.2 Literature Review

Various research papers have been discussed about the design and implementation of smart irrigation system for crop recommendation.

Ashwini B V [1], proposed a Bluetooth based microcontroller system through which can a servo motor is operated remotely that is used in irrigation. The system consists of an Arduino Microcontroller along with low-cost temperature and humidity and soil moisture sensors which can keep track of change in temperature, humidity and soil moisture levels in real time, it also consists of an android application through which a user can view the status in real time. The user can set a threshold value for temperature, humidity and soil moisture below which a signal is sent from the user's phone to the microcontroller which in turn signals the servo motor to rotate in order to provide water for irrigation.

The decision to switch the motor on/off is automatic and does not involve the user however this can easily be converted to be manual. The values collected by the sensors can be stored and displayed to the user on his/her phone. The decision to switch the motor on/off is dependent on Naive Bayes Algorithm which makes decisions based on frequently occurring attributes not being zero.

Anitha, Sampath & Jerlin [2], proposed a WiFi enabled system through which Temperature, Humidity and Soil Moisture values are collected through Arduino. Node MCU (ESP8266) is connected to Arduino for networking purposes. The values gathered by the sensors are sent to a third analytics service Firebase which plots graphs in real time and is useful as a data storage platform. This system also makes use of a water level sensor which can be used to detect dampness in the soil. If soil moisture is low and water level sensor detects dampness then the Arduino module sends a signal through Node MCU to the motor.

Naik, Katti, Kumbi & Telkar [3], proposed an IoT system that collects temperature, humidity and soil moisture values with the help of DHT11 and Soil Moisture sensor and sends these values to an android application on the user's phone using Arduino microcontroller. When the Moisture level is less than some predetermined threshold value then the Arduino microcontroller sends a signal to the relay attached to it to switch the motor on. The user can view the motor status as well as temperature, humidity and soil moisture values in real time.

Mishra, Khan, Tiwari & Upadhyay [4], presented a system consisting of a soil moisture sensor and Arduino microcontroller. The soil moisture sensor measures humidity present in the soil and if it is found to be less than some predetermined value then the pump is turned on. The soil moisture value considered as threshold can be changed depending on the crop required to be produced.

Rawal [5], proposed an IoT system consisting of soil moisture sensor, Arduino microcontroller and GSM GPRS module for internet connectivity. In this system the soil moisture sensor collects soil moisture values in real time and posts this data on a webpage. If the soil moisture value recorded is less than some predetermined threshold value then the Arduino microcontroller sends a signal to the relay module to switch the motor on. If the moisture level has been the Arduino microcontroller sends a signal to turn the motor off. Soil moisture and motor status can be viewed on a webpage. Real time data is also transmitted to Firebase server, a third-party analytics service for plotting of real time graphs.

Vaishnavi, Shobana, Sabitha & Karthik [7], proposed a crop recommendation system that recommends a crop for a particular season or year based on historical data about crop production. In this system the authors analyzed the records of district wise production of crops and employed machine learning models to predict the best suitable crop for a particular year which may lead to maximum profit. For example it was found that in Coimbatore district of Tamil Nadu if the farmer decides to grow a banana the chances of him incurring a loss is minimal.

Doshi, Agarwal, Nadkarni & Shah [6], proposed a crop suitability system based on machine learning that intends to solve the problem of accurate crop selection given by environmental parameters. This system also includes a rainfall prediction system that is based on linear regression which predicts the amount of rainfall falling in the farmers district in every month of the year. It makes use of Neural Networks as it was experimentally found to be the most accurate machine learning model for crop suitability.

It takes input parameters soil type, aquifer, soil pH, soil characteristics and season. Based on these parameters the model is trained and appropriate crop recommendations are made. This system makes 20 different types of crop recommendations. It also shows the geographical area that is most suitable for growing the recommended crop

Jadhav, Riswadkar, Jadhav & Gogawale [8], have proposed a crop recommendation system based on machine learning that takes in environmental and soil parameters in the dataset as input and recommends the most suitable for that particular climate and soil. The system makes use of the Random Forest algorithm as it was found to be the most accurate with respect to other machine learning algorithms. The authors have also developed a web interface for using this system.

Gosai, Raval, Nayak, Jayswal & Patel [9], a crop recommendation that takes soil and environmental factors as input is discussed. It recommends crop by applying a particular machine learning model. In this system the authors have utilized Decision Tree, naïve Bayes, SVM, Logistic Regression, RF and XGBoost..By training and testing the dataset on these algorithms it was found that the XGBoost algorithm gave the most accurate result.

Pande et.al., [11], explained the mechanism of a system providing information about the crops to farmers via a mobile application. The mobile application includes multiple features that users can leverage for the selection of a crop. The inbuilt predictor system helped the farmers to predict the yield of a given crop. The inbuilt recommender system allowed a user exploration of the possible crops and their yield to take more educated decisions. For yield to accuracy, various machine learning algorithms such as Random Forest, ANN, SVM, MLR, and KNN were implemented and tested on the given datasets from the Maharashtra and Karnataka states.

Reddy, D. J & Kumar, M. R [12], discussed the variety of features that are mainly dependent on the data availability and each of the research will investigate CYP using ML algorithms that differed from the features. The features were chosen based upon the geological position, scale, and crop features and these choices were mainly dependent upon the data-set availability, but the more features usage was not always giving better results. Therefore, finding the fewer best performing features were tested that also have been utilized for the studies.

Karpagam, J et.al., [13], explained the working procedure of a smart irrigation system which is used to reduce the wastage of water and to provide healthy plants and agriculture. In this project the motor is turned ON and OFF automatically by using a relay module which controls this operation. The plants get the required amount of water from the water tank or water storage that is connected to the motor. Proper monitoring of water level to the plants is done by this project. It Provides correct amount of water plants whenever it is necessary. The health and growth of the plants can be maintained.

Rawal [14], discussed a system to monitor the moisture levels in the soil. The proposed system can be used to switch on/off the water sprinkler according to soil moisture levels thereby automating the process of irrigation which is one of the most time-consuming activities in farming. The farm owner can monitor the process online through a website. Through this project it can be concluded that there can be considerable development in farming with the use of IOT and automation.

Rajak, R. K., Pawar et.al., [15], proposed an intelligent irrigation system that integrates a data fusion model and a long-rang (LoRa) network for optimizing the watering schedule. A data fusion model is proposed, which first adopts the long short-term memory (LSTM) network to simulate and predict the proper watering demands by integrating multi-source heterogeneous data, that is, historical weather data, user irrigation logs, weather forecasts, and online monitoring sensor data.

A self-powered wide-area network is implemented and deployed by using LoRa to facilitate multiple Internet of Things (IoT) application scenarios. It includes a gateway and two types of nodes: a valve node and a sensing node. The node is capable of energy

autonomy through the scheme of waterflow-based power generation. A cloud platform is designed to provide network management, intelligent irrigation control, and the interface of the mobile application. On average, the proposed system achieves a water-saving efficiency of 94.74% compared with the conventional manual setting solutions.

1.3 Literature Gap

The individual studies focus on specific aspects such as sensor-based data collection, machine learning algorithms for crop recommendation, and automated irrigation control, there is a lack of holistic approaches that combine these elements into a seamless and fully integrated system. Bridging this literature gap would involve implementation of a unified framework that effectively combines data collection, machine learning-based crop recommendation, such an integrated approach could provide a more effective and user-friendly solution for sustainable and efficient agricultural practices.

1.4 Motivation

As India is a developing country, the yield from agriculture is one of the deciding factors to increase economy. Maximising agricultural produce therefore is crucial.

In our country, farmers are unaware of the most suitable crop that can be grown on a particular soil taking into account the environmental parameters such as soil moisture, temperature and humidity. Most number of times they go by their intuition thus not being able to maximise their yield. This issue is addressed by the prototype of an Intelligent Irrigation system that recommends the most relevant crop that can be grown on a tested soil, measuring soil moisture, temperature and humidity.

1.5 Problem Statement

Implementation of an Intelligent Irrigation System using Machine Learning for predicting the most suitable crop that can be grown by measuring soil moisture, temperature and humidity using sensors.

1.6 Objectives

The objectives of Intelligent Irrigation System are:

- To understand the working of IoT and Random Forest Algorithm of machine learning.
- To develop a prototype for determining and maintaining the optimum moisture content in the soil.
- To implement Random Forest algorithm for crop recommendation.
- To suggest the most suitable crop to be grown on the tested soil.
- To Create a user-friendly interface for web application.

1.7 Methodology

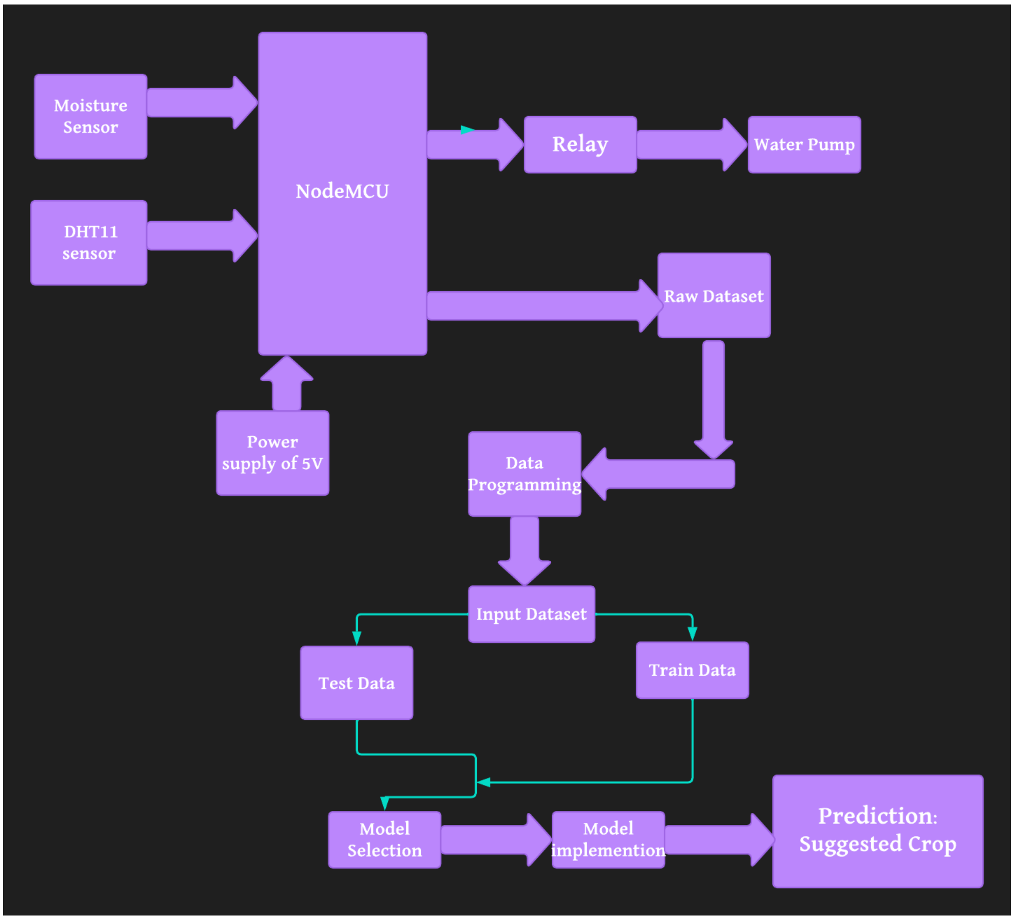

Figure 1.1: General block diagram of intelligent Irrigation system

General block diagram of Smart Irrigation System is depicted is figure 1.1. The system consists of Soil moisture sensor, DHT11 sensor and Node MCU, relay, and water pump Data is collected from soil moisture sensors. Soil moisture levels are sensed by the soil moisture sensor, and the data is collected. The temperature and humidity conditions are detected by the DHT11 sensor.The Node MCU microcontroller is employed to process the data obtained from the soil moisture sensor and the DHT11 sensor.

Based on the processed data, the relay is activated, allowing control over the water pump. The water pump, under the control of the relay, provides water to the plants. The measures of soil moisture, temperature and humidity are fed into a crop recommendation system predicts the most relevant crop.

1.8 Hardware and Software requirements

1.8.1 Hardware Requirement

- Node MCU ESP8266
- Soil Moisture Sensor Module
- Submersible DC motor
- DTH11 sensor
- Relay module
- Water pump

1.8.2 Software Requirement

- Arduino IDE
- Firebase
- Co-Laboratory

1.9 Organization of Report

Chapter 1 discusses the issues farmers face in cultivating crops due to unawareness. It also explains how a Smart Irrigation system resolves these issues by predicting the most suitable crop along with a detailed description of its objectives and methodologies.

Chapter 2 explains the principle of NodeMCU, its comparison with Arduino UNO, its advantages and applications. It also explains the working principles of DHT11 sensor, Soil Moisture sensor and Motor Driver Circuit.

Chapter 3: This chapter delves into the design and implementation aspects of the intelligent irrigation system. It outlines the specific design specifications and features, elaborates on the chosen design methodology, and discusses experimental techniques employed during the system's development. The chapter provides a detailed insight into the implementation process, including the integration of hardware and software components. The software details are also explained.

Chapter 4 is dedicated to presenting the results obtained from the intelligent irrigation system's operation. It provides an analysis of these results, shedding light on the system's performance, efficiency, and effectiveness. Data collected during the experimentation phase is discussed, and meaningful insights are drawn to assess the system's functionality.

Chapter 5 gives a brief overview of the work that has been completed and provides with the further
improvements that can be included. It also provides learning outcomes of the project.

Summary

Various literatures in Smart Irrigation System have been discussed. The hardware architecture is integrated with a software based crop recommendation system trained using Random Forest Algorithm of Machine Learning. This chapter also provides problem statement, motivation, objectives, methodology and hardware and software requirements

CHAPTER 2

THEORY OF INTELLIGENT IRRIGATION SYSTEM

CHAPTER-2

THEORY OF INTELLIGENT IRRIGATION SYSTEM

This chapter provides a brief summary of the intelligent irrigation system. The principles of the microcontroller and the NodeMCU are discussed. It offers comparison information for the various Microcontrollers and Sensors used in the project.

2.1 Microcontroller

Microcontroller is a small integrated circuit that controls a single operation in an embedded system. A typical microcontroller includes a processor, memory and input/output peripherals on a single chip.

Microcontrollers are also known as embedded controllers or MCU, can be found in a variety of devices, including vehicles, robots, office machines, medical devices, mobile radio transceivers, vending machines and home appliances. They are essentially simple miniature PCs designed to control minor aspects of a larger component without requiring a complex front-end operating system.

2.1.1 NodeMCU

NodeMCU is a widely used platform that simplifies the development of IoT applications. It is an open-source firmware and development board based on the ESP8266 Wi-Fi chip. It combines the ease of Arduino programming with the power of the ESP8266 module. It supports the Lua scripting language, allowing developers to quickly deploy IoT applications without extensive hardware or software knowledge. The block diagram of NodeMCU is shown in figure 2.1

These applications are supported by the Real Time Operating System inbuilt in NodeMCU. The NodeMCU operates at 80MHz to 160MHz clock frequency.

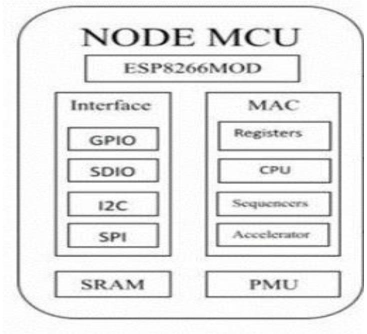

Figure 2.1 Block diagram of Node MCU

The comparison between NodeMCU and Arduino uno is discussed in table 2.1.

Table 2.1: Comparison between NodeMCU and Arduino Uno

Feature	NodeMCU ESP8266	Arduino Uno
Processor	ESP8266	ATmega328P
Clock Speed	80 MHz	16 MHz
Flash Memory	4 MB	32 KB
RAM	512 KB	2 KB
Analog Inputs	1	6
Digital I/O Pins	9	14
PWM Pins	10	6
Serial Ports	1	1
Wi Fi	Yes	No

2.1.2 NodeMCU Program

The hardware components of the Node MCU board are controlled through the code in Node MCU program. Arduino IDE interface is used for programming NodeMCU. The development happens through this interface. It is exclusive to Arduino and it runs on cross-platform operating systems such as, Windows, Linux and Macs. It mainly supports Java language, C and C++ with some special conditions attached to it.

The typical process of programming Node MCU involves the inclusion of necessary libraries, the definition of pin configurations.

After installing the Arduino IDE tool on the PC, connect the NodeMCU to the computer using the USB cable. Open the Arduino IDE and select the appropriate board by going to Tools–>Board. Select the appropriate Port by going to Tools–>Port on the Arduino Uno. This board can be programmed using the Arduino programming language, which is dependent on Wiring.

Once the setup is in place, your first program can be written. the setup of initial configurations in the setup function, and the implementation of desired logic in the loop () function. Connectivity to Wi-Fi networks is enabled by Node MCU's built-in Wi-Fi capabilities. Through the utilization of General-Purpose Input/Output (GPIO) pins, sensors, actuators, and other components can be interfaced.

2.1.3 Advantages of NodeMCU

- NodeMCU has built-in WiFi and Bluetooth connectivity, which makes it easy to connect to the internet or other devices.
- It consumes less power, which makes it ideal for battery-powered applications.
- It is a small and compact board, which makes it easy to integrate into projects.
- It is affordable, which makes it a great option for budget-minded projects.

2.1.4 Applications of NodeMCU

- IoT gateways
- Home automation
- Wearables
- Data logging
- Security alarms
- Incubator controller
- VR Tracker

2.2 DHT11 Sensor

DHT11 is a digital sensor for measuring temperature and humidity. This sensor can be easily interfaced with any micro-controller such as Arduino, Raspberry Pi. DHT11 sensor is available as a sensor and as a module. The difference between this sensor and module is the pull-up resistor and a power-on LED. DHT11 is a relative humidity sensor. To measure the surrounding air this sensor uses a thermistor and a capacitive humidity sensor. Comparison of DHT11 and DS18B20 is as shown in table 2.2.

Table 2.2: Comparison between DHT11 AND DS18B20

Feature	DHT11	DS18B20
Accuracy	±2°C	±0.5°C
Resolution	1°C	0.0625°C
Sampling rate	1Hz	125Hz
Communication protocol	Single-wire	1-Wire
Difficulty of use	Easy	Moderate

2.3 Soil Moisture Sensor

A soil moisture sensor is a device designed to measure the moisture content in soil. It consists of two electrodes that are inserted into the ground, and the resistance between these electrodes changes based on the moisture level in the soil. When the soil is dry, the resistance is high, and as the soil becomes moister, the resistance decreases. By measuring this resistance, the sensor provides an indication of the soil moisture level. Comparison between capacitive soil moisture sensor and resistive soil moisture sensor is as shown in table 2.3.

Table 2.3: Comparison of resistive and capacitive soil moisture sensor

Feature	Resistive soil moisture sensor	Capacitive soil moisture sensor
Working principle	Measures the resistance of the soil	Measures the capacitance of the soil
Accuracy	Less accurate	More accurate
Cost	Less expensive	More expensive
Ease of use	Simple to use	More complex to use
Range of applications	Wide range of applications	More specialized applications
Sensitivity to other factors	Sensitive to temperature and type of soil	Less sensitive to temperature and type of soil

2.4 Motor Driver Circuit

The operation of motor driver ICs involves the control and management of the motor's movement and power. The input signals provided to the motor driver ICs dictate the motor's direction, speed, and braking, which are then translated into the appropriate power signals delivered to the motor.The most commonly used motor driver IC’s are L293 and L298 series such as L293D, L293NE and L298N, etc. These ICs are designed to control 2 DC motors simultaneously. Both Motor Drivers consist of H-bridge. H-bridge is the simplest circuit for controlling a low current rated motor. Comparison between L298N and L293D is as shown in table 2.4.

Table 2.4: Comparison between L298N and L293D

S No.	L298N	L293D
1	L298N can be Operates at up to 46V	L293D Drivers Operates at 4.5V to 36V
2	L298N Motor Driver can draw up to 2A from both channels	Maximum 600mA Current can be drawn through both channels of L293D
3	L298 is a dual full-H driver i.e, in L298, a half-H driver cannot be used independently, only a full H driver has to be used.	L293 is a quadruple motor driver that uses a half-H driver i.e, in L293 all four input-output lines are independent
4	It is 2A for L298. Hence, the heat sink is provided in L298 motor drivers.	As L293 output current for each channel is 650mA
5	EMFs are provided externally in L298	EMFs are provided internally in L293D
6	L298N has the advantage of higher output current up to 2A and therefore it is suitable for high torque and high RPM motors like Johnson motors and high torque DC Geared motors.	L293D is suitable for small current drawing motors like BO motor, DC geared motors up to 500 RPM, and small stepper motors which take less current up to 600mA at their highest torque rating.

Summary

This chapter discusses the theory and fundamentals of the principles of Microcontroller, and its applications, as well as a comparison of different sensors is described in details.

CHAPTER 3
HARDWARE AND SOFTWARE REQUIREMENTS

Chapter 3

HARDWARE AND SOFTWARE REQUIREMENTS

In this chapter the hardware and software components required are briefly discussed. The hardware components required are NodeMCU (ESP8266), battery, single channel Relays, DC motor, moisture sensor, DHT11 sensor.The software's like Arduino IDE, google Collaboratory and firebase tool have been discussed.

3.1 Circuit Diagram of the intelligent irrigation System

The circuit diagram of intelligent irrigation system is as shown in figure 3.1. The NodeMCU consists of Wi-Fi module. Itis interfaced with soil moisture sensor, DC motor, single channel relay, DHT11 sensor.

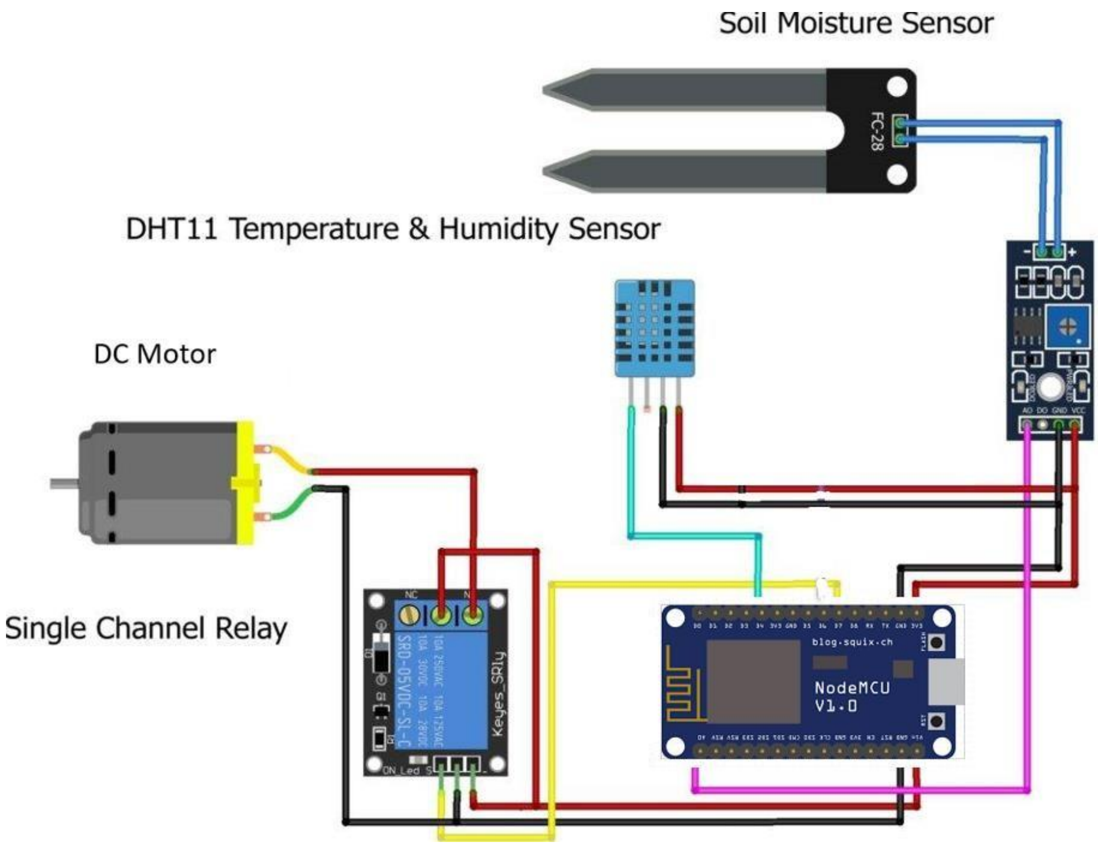

Figure 3.1: Circuit diagram of intelligent irrigation system

The Node microcontroller consists of one analog pin and nine digital pins. The pin connections of the system are:

- Pin A0 is connected to the soil moisture.
- Pin D4 is connected to DHT11 sensor.
- Pin D7 is connected to single channel relay.
- Pin D3 is connected to DC motor.

3.2 Hardware requirements

The hardware components are:

3.2.1 NodeMCU

NodeMCU is commonly used in embedded system applications. NodeMCU microcontroller is shown in figure 3.2. NodeMCU works as 32-bit microcontroller according to Xtensa LX106 family. On-chip FLASH memory is 4MB.

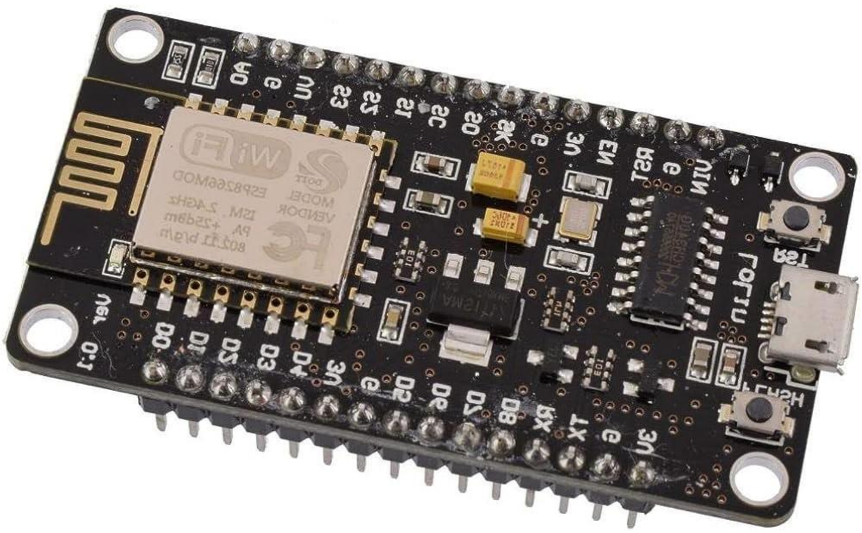

Figure 3.2: NodeMCU

NodeMCU is the brain of intelligent irrigation system. Various functions in the field are enabled through microcontroller. It is connected to the web app through Wi-Fi module. Commands are given by the user using web app and processes are done accordingly.

Specifications

- Microcontroller - ESP-8266 32-bit
- Clock Speed - 80-160 MHz
- USB Connector- Micro USB
- Operating Voltage- 3.3V
- Input Voltage- upto 10V
- Flash Memory/SRAM- 4 MB / 128 KB
- Digital I/O Pins- ` 9
- Analog In Pins- 1
- Wi-Fi- 2.4Ghz

3.2.2 DHT11 sensor

The DHT11 sensor is a commonly used digital temperature and humidity sensor designed for measuring the surrounding air's temperature and relative humidity. It utilizes a resistive humidity sensor and a thermistor to perform thesemeasurements accurately & efficiently. DHT11 sensor is shown in figure 3.3.

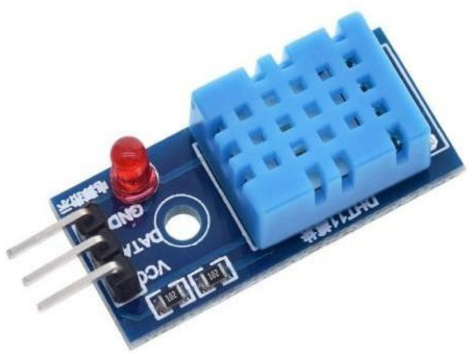

Figure 3.3: DHT11 sensor

Specifications

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

3.2.3 Single channel relay

Relay is a switch which is electromagnetic. It is operated by small currents. It drives thesesmall currents into larger currents. DC water pump in Intelligent irrigation system produces very small currents. Using relay, small current will be able to activatelarge currents. So, relays can be used for two different purposes. It can be used as switch to turn devices on and off. It canbe used as amplifier to convert smaller currentsto larger currents.

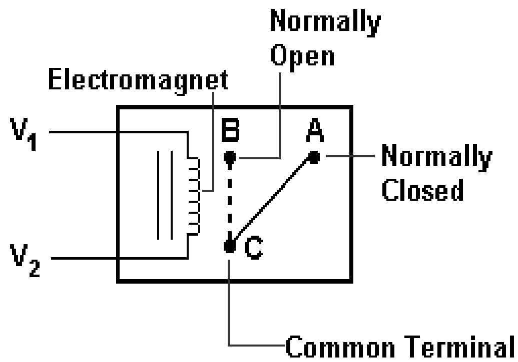

Figure 3.4: Relay Circuit

The relay's switch connections are labeled NC, NO and COM as shown in figure 3.4.

- COM = Common. It is the moving part of the switch. Always connect to common.
- NC = Normally Closed. When the relay coil is off, common is connected to NC.
- NO = Normally Open. When the relay coil is on, common is connected to NO

Specifications

- Input logic- 5 V level
- Used for home automation configured with micro-controller
- Used to control solenoids, motors etc.
- High voltage handling capacity with full protection
- Relay specification 10 A at 250 VAC

3.2.4 Moisture Sensor

Moisture sensor is shown in figure 3.5. It is used to measure the water levels in soil. The sensor can be interfaced in both the analog and digital mode. In digital mode, the sensor gives an output of 0V when the moisture content is lower than threshold. When the moisture level is greater than the fixed threshold value, it gives an output of 5V which makes the LED to glow. The sensor used in the system outputs in analog mode The analog mode of interfacing is more accurate.

This sensor works on the principle that, when the probes are inserted into soil, it conducts electricity due to more moisture content and less resistance. This value is mapped to affixed scale between 0 and 100% by comparing the current from the probeand current equivalent of threshold resistance. The ideal range suitable for most crops is 0to 40%. The sensor consists of a potentiometer to fix a desired threshold value to measurethe moisture levels of soil. This value can be changed according to the type of crop being cultivated.

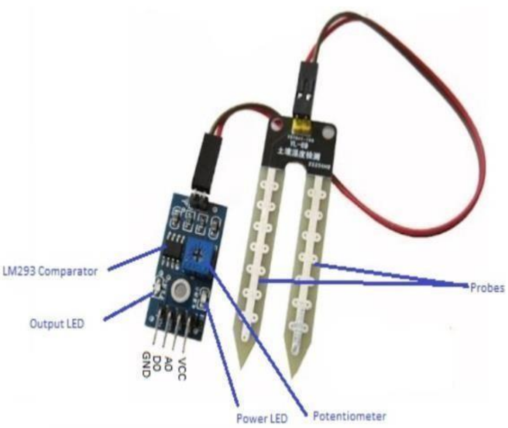

Figure 3.5: Moisture sensor

Specifications

- Operating Voltage: 3.3-5V
- Operating Current: 20mA
- Interface type: Analog or digital
- Working Temperature: 10° to 50°C
- Range: 0 to 45% of water content
- Accuracy: ±4% typical
- Typical Resolution: 0.1%
- Dimensions: 8.9 cm × 1.8 cm × 0.7 cm

3.2.5 Water Pump

The water pump is shown in figure 3.6 and it is used for irrigating the field after sowing the seeds. The main principle behind the working of water pump is the conversionof electrical energy into mechanical energy to create pressure. This pressure pumps water from bore-well through the pipe. 1 channel relay is used for charging the pump.

The pump is switched on manually when the moisture levels of soil goes lower than the desired value. The moisture level is constantly checked and pump is switched off.

Figure 3.6: Water Pump

Specifications

- Operating Voltage: 3V To 6V
- Operating current: 130-220 mA
- Dc Power Consumption: 0.4W To 1.5W
- Rate Of Flow: 80 - 120L/Hr
- Lift: 110 mm Max
- Continuous working life: 500 hours
- Type: Submersible
- Dimension: 45 X 24 X 30 (Lxhxb)mm

3.2.6 Power supply

Figure 3.7: Battery

A 9-volt battery as shown in figure 3.7 is a type of small, compact power source commonly used in various electronic devices. It's characterized by its rectangular shape and the voltage it provides, which is typically around 9 volts, though it can vary slightly depending on the specific chemistry and manufacturer. These batteries are widely used in devices where a compact power source is required, such as smoke detectors, remote controls and portable radios etc.

3.3 Machine learning model

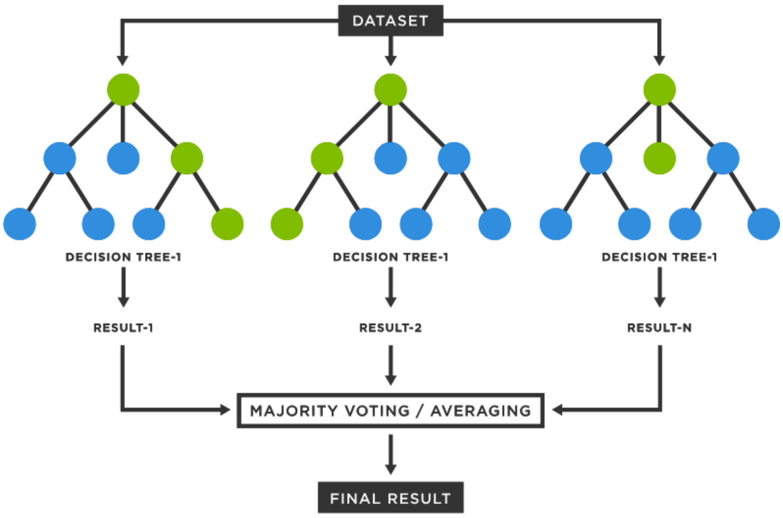

Figure 3.8: Random forest algorithm

Using the Random Forest algorithm for crop recommendation is an effective approach, as it can take into account multiple variables and provide accurate predictions based on historical data as shown in figure 3.8.

Once the soil data has been collected, it is split into two sets: a training set and a test set. The training set will be used to train the decision trees, and the test set will be used to evaluate the model's performance.

The random forest algorithm then builds a number of decision trees on the training set. Each decision tree is built by randomly selecting a subset of the soil data and a subset of the features. This process helps to ensure that the decision trees are not too correlated with each other, which can help to prevent overfitting.

Once the decision trees have been built, they are used to make predictions on the test set. The predictions from each decision tree are then combined to make a final decision. The final decision is made by taking the majority vote of the decision trees.

The random forest algorithm is a powerful tool that can be used to recommend crops that are most likely to grow well in a specific area.

3.4 Software Requirements

The Arduino Integrated Development Environment (IDE) is a software platform that serves as the primary tool for programming and developing projects using Arduino boards and NodeMCU. Arduino is a popular open-source electronics platform that enables enthusiasts, hobbyists, and professionals to create interactive and programmable electronic projects without needing an extensive background in electronics or programming. The Arduino IDE provides a user-friendly interface and essential features for writing, compiling, and uploading code to Arduino boards. Figure 3.9 shows screenshot of Arduino IDE.

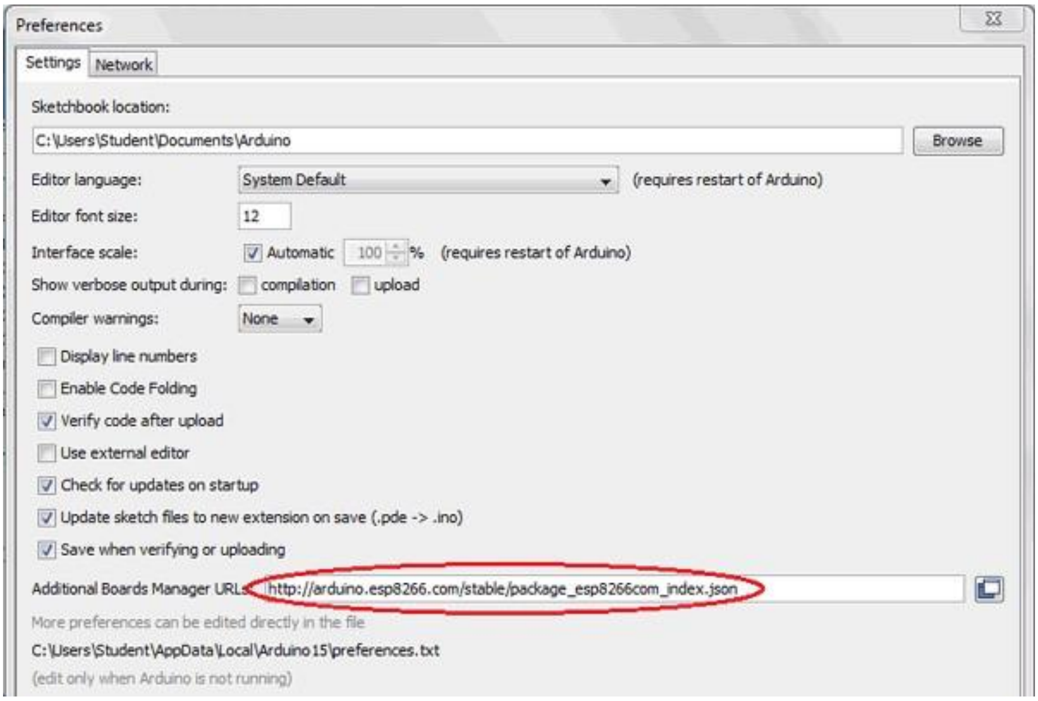

Figure 3.9: Screenshot of Arduino IDE

Google Collaboratory is used for recommendation of crop to be grown using Machine Learning. Thereal time data are given as input for the features to be extracted. The suitable crop for soil is determined and displayed depending on soil moisture, temperature and humidity.

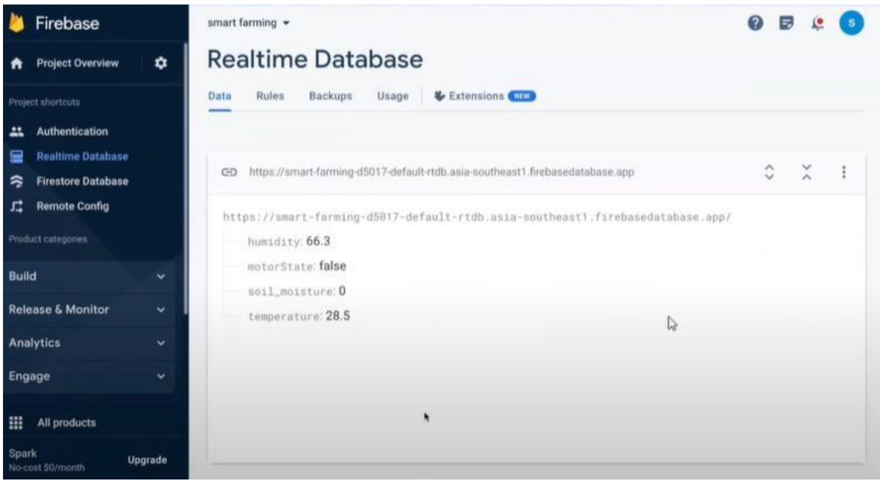

Figure 3.10: Screenshot of Firebase

Firebase is a backend as a service (BaaS) platform that provides developers with a variety of tools and services to help them build, deploy, and scale their mobile and web applications. Firebase offers a real-time database, authentication, cloud storage, and other features that can help developers save time and focus on building great apps. Figure 3.10 shows the screenshot of firebase.

Summary

This chapter provides a brief description and design specifications of hardware components as well as software tools for the development of an intelligent irrigation system using Machine Learning.

CHAPTER 4

DESIGN AND IMPLEMENTATION

Chapter 4

DESIGN AND IMPLEMENTATION

In this chapter the implementation of Intelligent irrigation system is briefly explained. The working of the system is discussed in detail using flow charts.

4.1 Block Diagram of Intelligent irrigation system

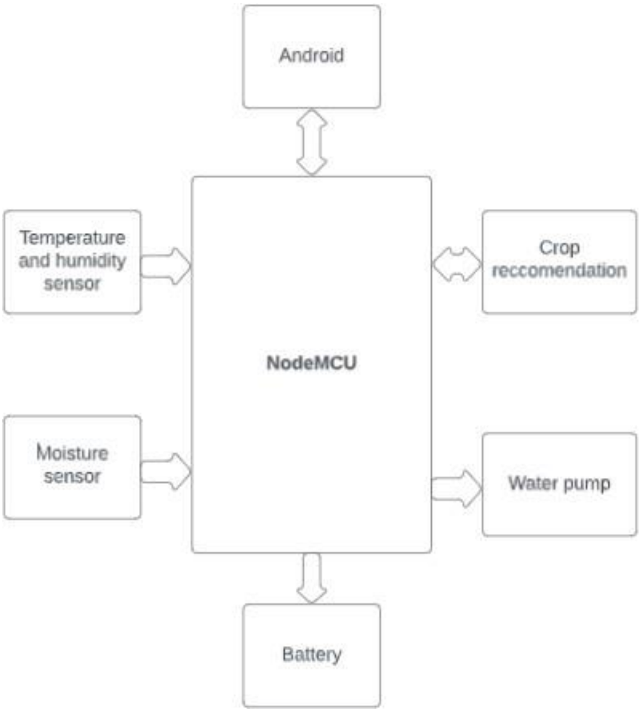

Figure 4.1: Block Diagram of intelligent irrigation system

Block diagram of intelligent irrigation system is shown in figure 4.1. It consists of Power Supply (battery), water Pump, Moisture Sensor, Temperature-humidity Sensor and using data from the sensors crop is recommended through android.

The block diagram's operation is summarized below

Android Device

The Android device takes on a dual role in this system. It serves as both the controller for the water pump and the conduit for providing crop recommendations. By communicating with the NodeMCU, it sends commands to activate or deactivate the water pump based on user need. Furthermore, it shares critical data with the NodeMCU to facilitate informed crop recommendations.

Temperature and Humidity Sensor

The temperature and humidity sensor plays an integral part by continuously measuring the surrounding air's temperature and humidity. This data is pivotal for two aspects: firstly, the Android device utilizes it to turn on/off as per user need.. Secondly, the NodeMCU leverages this data to generate crop recommendations tailored to the prevailing climate conditions.

Moisture Sensor:

Monitoring soil moisture levels is essential for effective irrigation management. The moisture sensor is responsible for gauging the soil's moisture content. Similar to the temperature and humidity data, both the Android device and the NodeMCU utilize this information. The user decides whether to activate the water pump based on the moisture content in the soil, while the NodeMCU factors it into its crop recommendations.

NodeMCU:

The NodeMCU serves as the linchpin of this system, orchestrating both water pump control and crop recommendations. It executes commands from the Android device to manage the water pump's operation. Additionally, it processes data from both the temperature and humidity sensor and the moisture sensor to offer insightful crop recommendations. This involves analysing the sensor data against the crop recommendation database.

Crop Recommendation Database:

The crop recommendation database acts as an invaluable repository of information about various crops. It contains details such as individual crop water requirements, specific soil moisture thresholds, and preferred climatic conditions. The system taps into this database

to generate customized crop recommendations, aligning with the environmental data gathered from the sensors.

Water Pump:

The water pump remains the core mechanism responsible for transferring water from a reservoir to the intended location, facilitating efficient irrigation. Upon receiving the signal from the NodeMCU, it engages to regulate water supply as necessary.

Battery:

Providing essential power, the battery fuels the operation of the entire system. It ensures continuous functionality for the NodeMCU, and the water pump, even in areas lacking a stable power source.

4.2 Interfacing of water pump

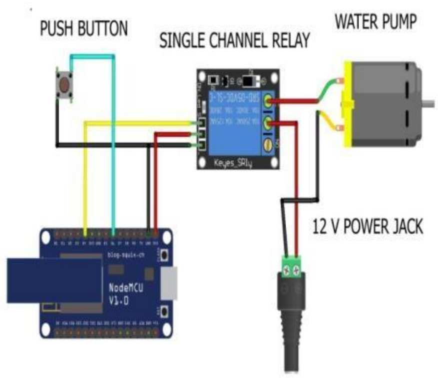

Figure 4.2: Interfacing of water pump

To interface a water pump with the NodeMCU is as shown in figure 4.2, there’s a need for relay module. A relay module is a device that can be used to control high-power devices from a low-power microcontroller like the NodeMCU

To connect the water pump to the NodeMCU, the following pins are to be connected

- The VCC pin of the relay module to the +5V pin of the NodeMCU.
- The GND pin of the relay module to the ground pin of the NodeMCU.
- The IN pin of the relay module to a digital output pin of the NodeMCU.
- The digital input pin of NodeMCU to water pump.

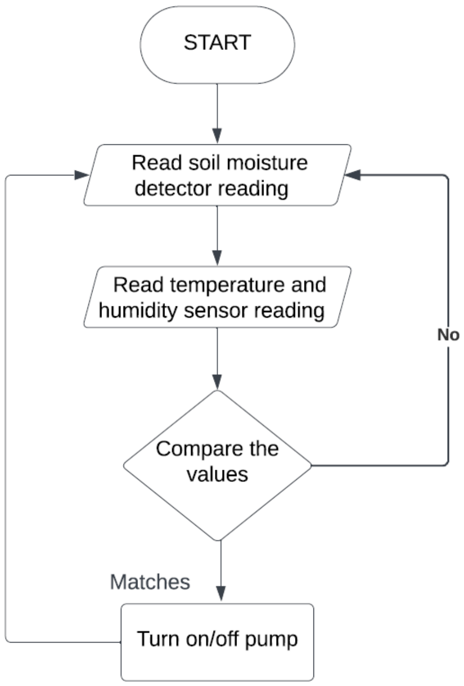

Figure 4.3: Flowchart for irrigation

Flowchart for irrigation is depicted in figure 4.3. When the NodeMCU is turned on, it first activates the soil moisture sensor, temperature humidity sensor. The soil moisture sensor measures the moisture content in the soil, while the DHT11 sensor measures the temperature and humidity in the air. The NodeMCU then sends this data tothe farmer, who uses their knowledge and experience to determine if the farm needs to be irrigated. If the farmer decides that irrigation is necessary, they manually switch on the motor to pump water to the crops.

4.3 Interfacing of DHT11 sensor

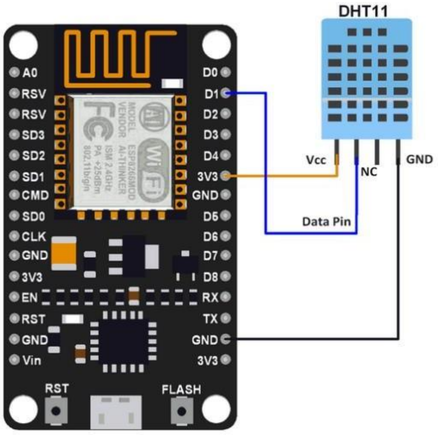

Figure 4.4: Interfacing of DHT11 sensor

The DHT11 is a digital temperature and humidity sensor that can be interfaced with the NodeMCU using the following pins as shown in figure 4.4.

- VCC: This pin is connected to the +5V pin of the NodeMCU.
- GND: This pin is connected to the ground pin of the NodeMCU.
- Data: This pin is connected to a digital input pin of the NodeMCU.

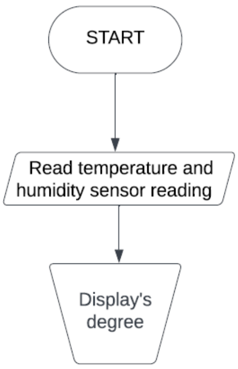

Figure 4.5: Flowchart to measure temperature and humidity

The temperature and humidity sensor works by measuring the capacitance or resistance of air samples. The capacitance or resistance of the sensor changes depending on the amount of moisture in the air. This change is then converted into a digital signal that can be displayed on a screen. The flowchart is shown in figure 4.5

4.4 Interfacing of soil moisture sensor

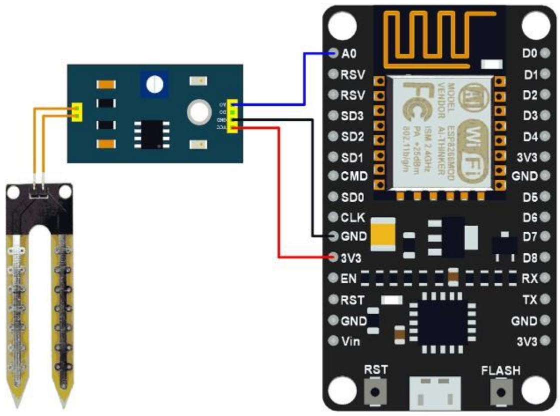

Figure 4.6: Interfacing of soil moisture sensor

The figure 4.6 shows the interfacing of soil moisture sensor with NodeMCU, the following connections are to be made:

- Connect the VCC pin of the soil moisture sensor to the 3.3V pin of the NodeMCU.
- Connect the GND pin of the soil moisture sensor to the GND pin of the NodeMCU.
- Connect the analog output pin of the soil moisture sensor to the A0 pin of the NodeMCU.

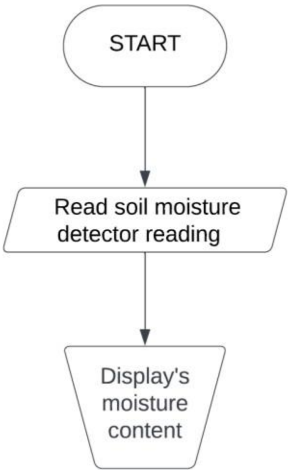

Figure 4.7: Flowchart to measure soil moisture

The figure 4.7 shows a soil moisture detector reading a display's moisture content. The sensor is inserted into the soil and the display shows the moisture level.

The moisture level is important for plant growth, as plants need water to survive and sensor can be used to monitor the moisture level in the soil and to ensure that plants are getting enough water.

4.5 Crop recommendation

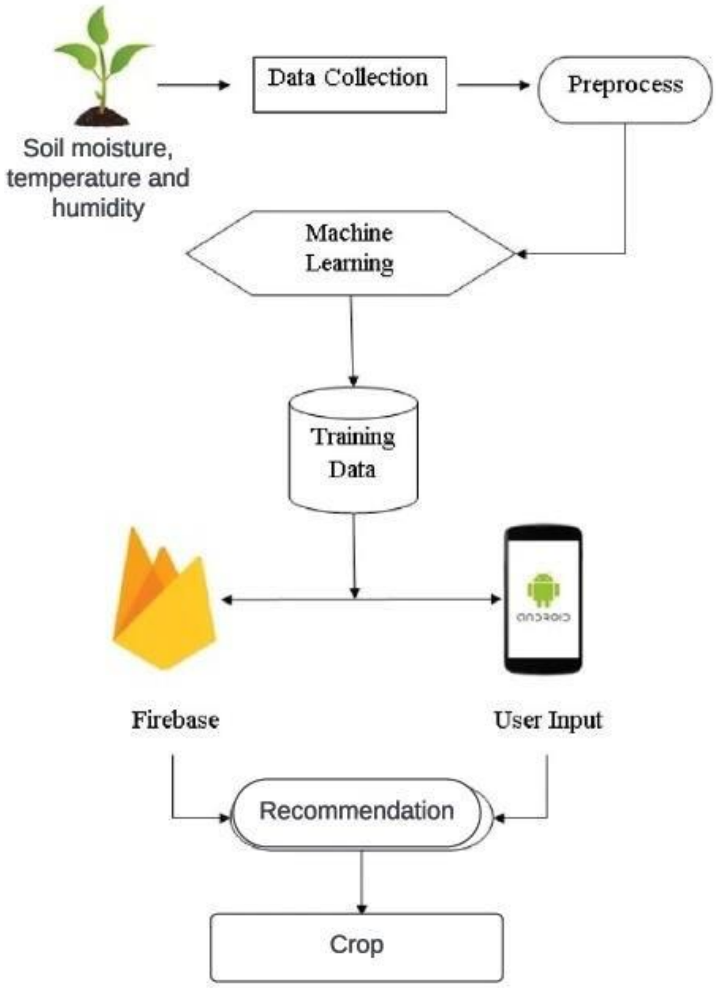

Figure 4.8: Flowchart for crop recommendation

The figure 4.8 depicts the process of crop recommendation. Each step is explained in detail below:-

- Data collection: The data collector will use sensors to collect data on soil moisture, temperature, and humidity from the crop field. The data will be collected at regular intervals, such as every hour or every day.

- Data preprocessing: The data will be cleaned and normalized before it is used to train the machine learning model. This involves removing any outliers and ensuring that all of the values are on the same scale.
- Machine learning: The machine learning model will be trained on the pre-processed data. The model will learn the relationship between the soil moisture, temperature, and humidity data and the crop yield using random forest algorithm.
- Training: Train the Random Forest algorithm on the training data. The algorithm will create an ensemble of decision trees and make predictions by aggregating their outputs.
- Crop Recommendation: Given a new set of input features (soil moisture, temperature, humidity, etc.), use the trained Random Forest model to predict the most suitable crops. The model will provide predictions based on the patterns it learned from the training data.
- Deployment: To create a user-facing system, built a simple interface where users can use the real time data or input their environmental conditions, and the model provides crop recommendations in real-time. This is done using firebase and android.

Summary

This chapter describes the hardware implementation of Intelligent Irrigation system using Machine Learning as well as the crop recommendation process.

CHAPTER 5

RESULTS AND ANALYSIS

CHAPTER 5

RESULTS AND ANALYSIS

Use of machine learning techniques along with the hardware components mentioned can lead to significant advancements in soil and crop management.

The hardware setup is shown in figure 5.1.

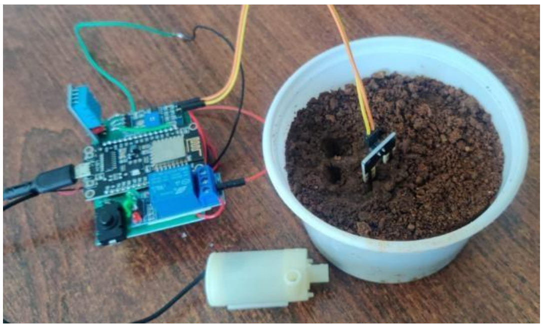

Figure 5.1: Hardware setup

The figure 5.2 shows the real-time temperature data collected when the setup was first used. The temperature at that time was 30.8 degrees.

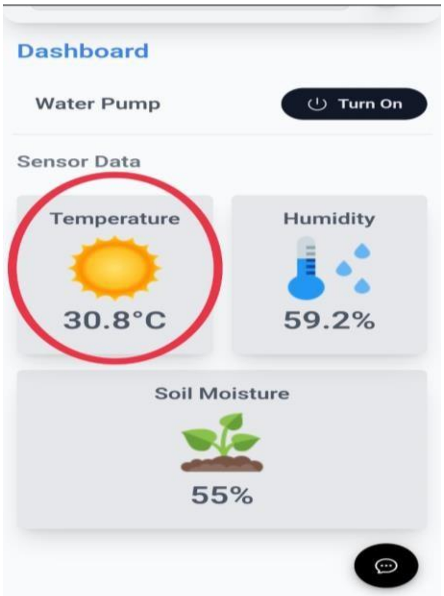

Figure 5.2: Real time temperature data

The figure 5.3 shows the real-time humidity data collected when the setup was first used. The humidity at that time was 59.2%.

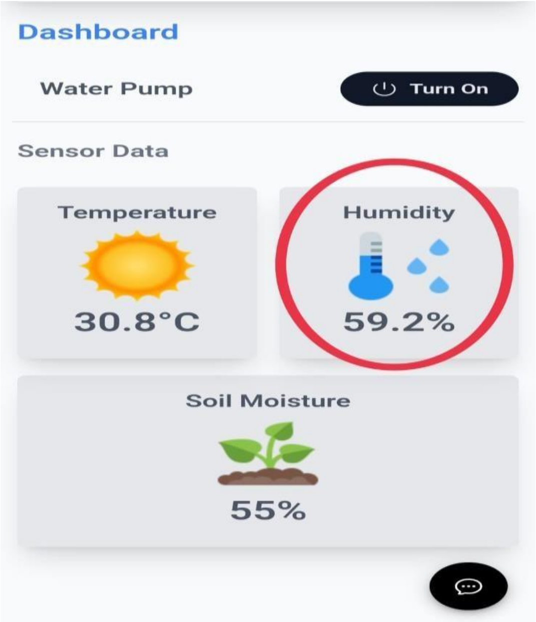

Figure 5.3: Real time Humidity data

The figure 5.4 shows the real-time soil moisture data collected when the setup was first used. The soil moisture at that time was 55%.

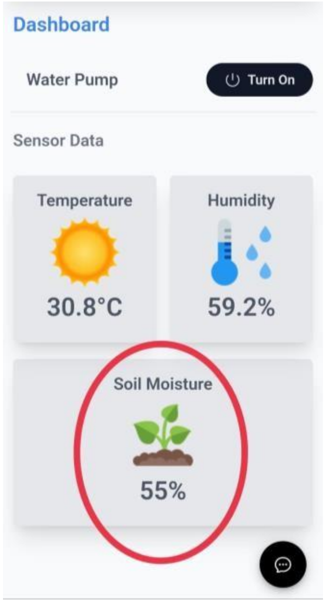

Figure 5.4: Real time soil moisture data

The figure 5.5 shows a manual water pump control switch that can be used to turn the pump on or off as needed.

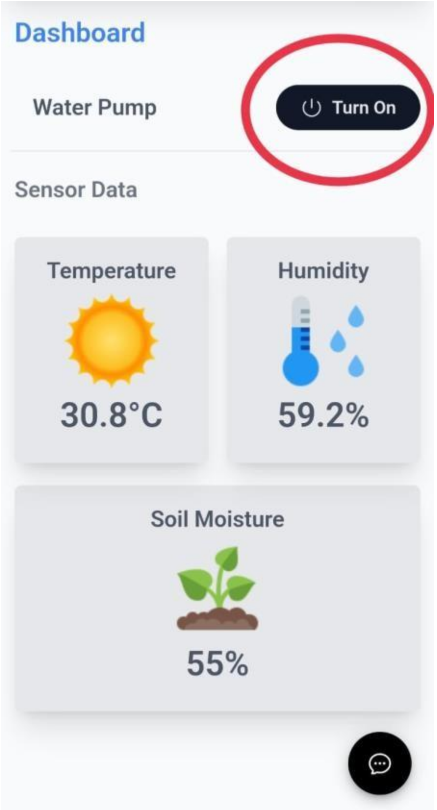

Figure 5.5: Water pump control switch

The icon in the figure 5.6 links to a platform that suggests crops to grow.

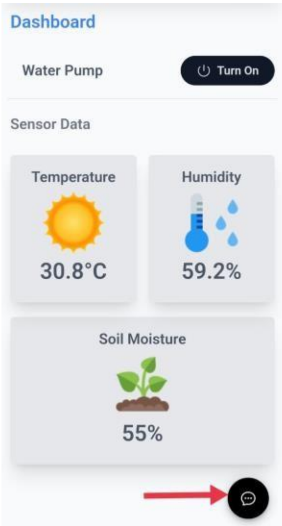

Figure 5.6 :Link

Using the following dataset obtained from Kaggle, as shown in figure 5.7, we were able to achieve an accuracy of 99% when using the random forest algorithm to recommend crops.

N	P	K	temperature	humidity	ph	rainfall	label
90	42	43	20.8797437	82.00274	6.502985	202.9355	rice
85	58	41	21.7704617	80.31964	7.038096	226.6555	rice
60	55	44	23.0044592	82.32076	7.840207	263.9642	rice
74	35	40	26.4910964	80.15836	6.980401	242.864	rice
78	42	42	20.1301748	81.60487	7.628473	262.7173	rice
69	37	42	23.0580487	83.37012	7.073454	251.055	rice
69	55	38	22.708838	82.63941	5.700806	271.3249	rice
94	53	40	20.2777436	82.89409	5.718627	241.9742	rice
89	54	38	24.5158807	83.53522	6.685346	230.4462	rice
68	58	38	23.2239739	83.03323	6.336254	221.2092	rice
91	53	40	26.5272351	81.41754	5.386168	264.6149	rice
90	46	42	23.9789822	81.45062	7.502834	250.0832	rice
78	58	44	26.800796	80.88685	5.108682	284.4365	rice
93	56	36	24.0149762	82.05687	6.984354	185.2773	rice
94	50	37	25.6658521	80.66385	6.94802	209.587	rice
60	48	39	24.2820942	80.30026	7.042299	231.0863	rice
85	38	41	21.5871178	82.78837	6.249051	276.6552	rice
91	35	39	23.7939196	80.41818	6.97086	206.2612	rice
77	38	36	21.8652524	80.1923	5.953933	224.555	rice
88	35	40	23.5794363	83.5876	5.853932	291.2987	rice
89	45	36	21.3250416	80.47476	6.442475	185.4975	rice
76	40	43	25.1574553	83.11713	5.070176	231.3843	rice
67	59	41	21.9476674	80.97384	6.012633	213.3561	rice
83	41	43	21.0525355	82.6784	6.254028	233.1076	rice
98	47	37	23.4838134	81.33265	7.375483	224.0581	rice
66	53	41	25.0756354	80.52389	7.778915	257.0039	rice
97	59	43	26.3592716	84.04404	6.2865	271.3586	rice

Figure 5.7:Dataset

Figure5.8 showcases the Intelligent Irrigation System WebApp's Crop Recommendation feature which empowers users to make optimal crop choices based on real-time/current data and can manually add the data based on the requirement.

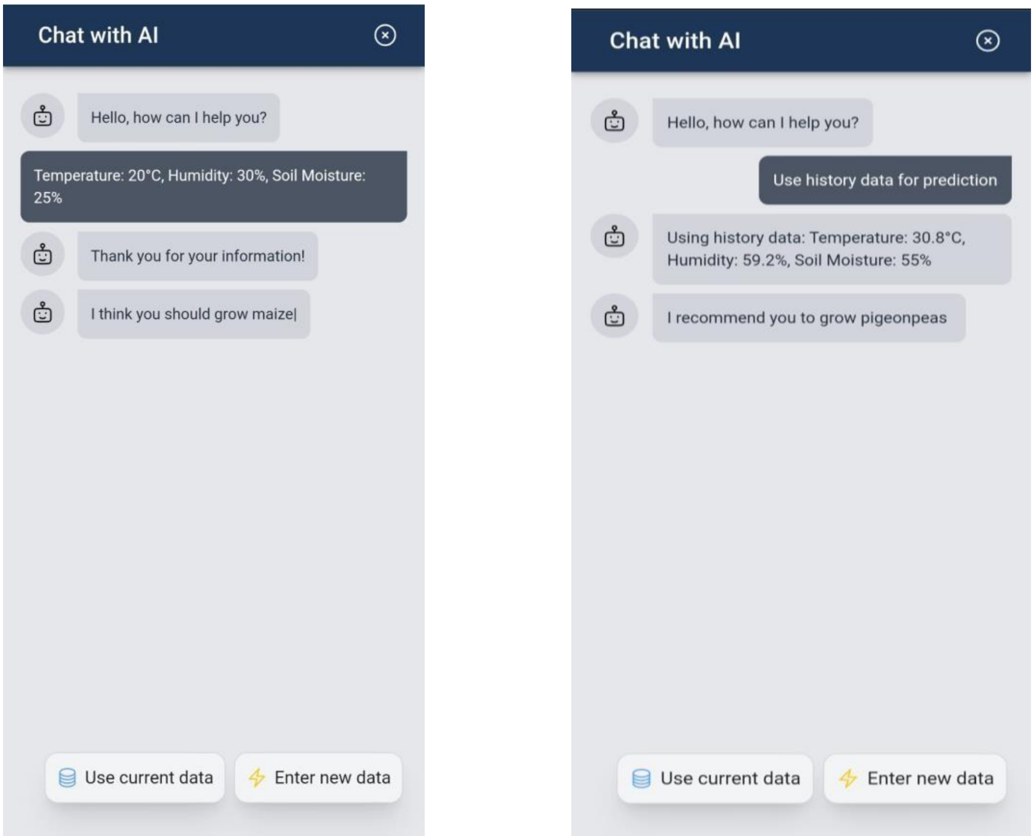

Figure 5.8: Crop recommendation

Summary

This chapter contains the obtained results for operation of intelligent irrigation system using machine learning. The detected values of temperature, humidity and soil moisture from the sensors is displayed on the webapp and the crop recommendation operation is also shown in this chapter.

CHAPTER 6

CONCLUSION AND FUTURE SCOPE

CHAPTER-6

CONCLUSION AND FUTURE SCOPE

6.1 Conclusion

In conclusion, our comprehensive agricultural application seamlessly integrates machine learning algorithms to provide crop recommendations, The Intelligent irrigation system employing Node MCU optimizes water utilization for sustainable agriculture, while the Python GUI offers user- friendly access. With the help of this comprehensive solution, farmers can make data- driven decisions that boost crop yields, resource efficiency, and agricultural resilience.

In our hardware architecture, the DHT11 sensor is employed to measure the ambient temperature and humidity levels. The soil moisture sensor is employed to detect the moisture content in the soil. Data from the DHT11 and soil moisture sensor is collected by the NodeMCU. The farmer understands which crop to grow from the web interface. The result on this interface is impacted by the values obtained from the hardware. Communication between the hardware and the interface is enabled by IoT based platform, Firebase

The most suitable crop is often not cultivated by farmers due to a lack of awareness about the environmental parameters. This issue is addressed by the Smart Irrigation System. It takes the values of temperature, humidity and soil moisture as input and predicts the most suitable crop that can be grown. This prediction is done by the Random Forest Algorithm of Machine Learning which is trained by the dataset taken from Kaggle.

6.2 Future Scope

In the near future, more sensors can be added to measure additional parameters such as light intensity nutrient levels, and atmospheric pressure

A mesh network can be established among multiple NodeMCU devices, allowing them to share data and collectively optimize irrigation schedules for larger areas or different zones: Further, localized weather prediction models can be incorporated to enhance irrigation planning and adapt to changing environmental conditions.

A user feedback loop can be implemented where farmers can input outcomes, yield data, and observations, allowing the system to learn and improve its recommendations over time. Information related to the health of the plant can also be integrated in the interface which additionally might predict the chances of the plant having a disease.

6.3 Learning Outcomes

The learning outcomes of this project are:

- Learned about NodeMCU, including its operation and pin definitions.
- Got acquainted with the use of soil moisture sensor and DHT11 sensor.
- Learned about Random Forest Algorithm and how it is used in crop recommendation
- Learned how to program in Arduino IDE.
- Debugging of the python code in Google Colab for the usage of real time data in hardware projects.

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CO – PO Mapping

Mapping of **"Intelligent Irrigation system using Machine learning"** to Program Outcomes (PO)

Program Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Intelligent irrigation system using ML	M	M	H	H	H	M	H	M	H	M	M	H

Mapping of **"Intelligent Irrigation system using Machine learning"** to Course Outcomes (CO)

Course Outcomes	CO1	CO2	CO3	CO4
Intelligent Irrigation system using Machine learning	H	H	H	M

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