APPLICATION OF IOT IN IRRIGATION SYSTEM MONITORING AND CONTROL

Project Report

Submitted for the partial fulfillment of the degree of

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In

Internet of Things (IOT)

Submitted By

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Deemed University
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Jul-Dec 2024

DECLARATION BY THE CANDIDATE

I hereby declare that the work entitled "**APPLICATION OF IOT IN IRRIGATION SYSTEM MONITORING AND CONTROL**" is my work, conducted under the supervision of **Dr.Soumyajit Ghosh, Assistant Professor ,** during the session Jul-Dec 2024. The report submitted by me is a record of bonafide work carried out by me.

I further declare that the work reported in this report has not been submitted and will not be submitted, either in part or in full, for the award of any other degree or diploma in this institute or any other institute or university.

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PLAGIARISM CHECK CERTIFICATE

This is to certify that I, a student of B.Tech. in **Internet of Things (IOT)** have checked my complete report entitled "**APPLICATION OF IOT IN IRRIGATION SYSTEM MONITORING AND CONTROL**" for similarity/plagiarism using the "Duplichecker" software available in the institute.

This is to certify that the similarity in my report is found to be ~~2%~~ 15% which is within the specified limit (20%).

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ABSTRACT

APPLICATION OF IOT IN IRRIGATION SYSTEM MONITORING AND CONTROL

Traditional farming techniques have been transformed by the use of the Internet of Things (IoT) in irrigation system monitoring and control, opening the door to improved crop productivity and effective water management. IoT monitors environmental parameters including temperature, humidity, and soil moisture by combining sophisticated sensors, cloud computing, and automated control systems. These systems make it easier to gather and analyze data in real time, which allows for accurate irrigation scheduling and reduces water waste. IoT technologies also improve decision-making by offering practical insights, which are essential for modern agriculture's resource optimization. This study examines how important IoT is in tackling issues including labor inefficiencies, water scarcity, and irrigation practices' energy use.

IoT-based smart irrigation systems use actuators and wireless sensor networks (WSNs) to automatically provide water to crops according to their individual requirements. Farmers can use web interfaces or smartphones to remotely view system performance data and manage watering procedures. By preserving natural resources, these developments not only boost output but also support environmental sustainability. Important Points: Improved Monitoring: Real-time field condition awareness is ensured by IoT's ability to continuously track vital metrics including soil moisture, temperature, and humidity. Water Conservation: IoT-based automated irrigation systems reduce water waste by supplying precisely the right amount of water at the right time. Energy Efficiency: By streamlining irrigation scheduling and pump operations, IoT lowers energy consumption. Remote Accessibility: With the help of intuitive apps, farmers may remotely monitor and manage irrigation systems.

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CONTENT

Table of Contents

Declaration by the Candidate..i

Plagiarism Check Certificate..ii

Abstract..iii

Acknowledgement..iv

Content..vi

Nomenclature..vii

List of Figures..viiix

Chapter 1: Introduction..1

Chapter 2: Literature Survey..3

Chapter 3:Hardware Tools..4

Chapter 4:Methodology and Algorithm..7

Chapter 5:Modelling and Quick Design..9

Chapter 6:Results Analysis..10

Chapter 7:Conclusions and Future Scope..11

References..12

Annexures

Self-evaluation of Project..14

NOMENCLATURE

General Technology Terms:

The Internet of Things, or IoT, is a network of linked devices that exchange information and communicate in order to automate and improve procedures.

Intelligent Watering :An automated system that monitors and regulates water distribution using Internet of Things devices in accordance with crop needs and environmental conditions.

Sensors :Sensors are tools for measuring environmental factors like light intensity, temperature, humidity, and soil moisture.

Actuators : Mechanical parts that respond to sensor inputs by performing operations, like opening or closing valves.

Sensor for Soil Moisture: A tool for calculating the amount of water in soil to determine when irrigation is necessary.

The controller : A processing unit that decodes sensor data and instructs actuators (such as an Arduino or Raspberry Pi).

Cloud computing : Data gathered from IoT devices is processed and stored on distant computers, allowing for remote monitoring and enhanced analytics.

Mobile Application : An interface on a smartphone that enables farmers to remotely monitor and manage the irrigation system.

Automation : The process of carrying out irrigation activities without human assistance by using Internet of Things technologies.

Efficiency Metrics : Metrics used to assess system performance, such as energy and water use efficiency (WUE).

Sustainability : Methods that guarantee a low influence on the environment, such as conserving water and using less energy.

The location of sensors, controllers, or actuators in a network that connects to the system is called a node.

Real-time monitoring allows for quick modifications to irrigation procedures by continuously observing field conditions.

List of Figures

- Figure 1: Smart Irrigation System Setup
- Figure 2: NodeMcu ESP8266
- Figure 3: Rain Drop Sensor
- Figure 4: Soil Moisture Sensor
- Figure 5: DHT11
- Figure 6: Jumper
- Figure 7: PIR Sensor
- Figure 8: Breadboard
- Figure 9: Prototype Design

CHAPTER 1: INTRODUCTION

The rapid growth of global agriculture has necessitated innovative approaches to enhance productivity while conserving natural resources. Among these, the application of the Internet of Things (IoT) in irrigation system monitoring and control has emerged as a transformative technology, offering precision, efficiency, and sustainability. Traditional irrigation practices often result in significant water wastage due to over-irrigation, inefficiencies, or reliance on manual intervention. With water scarcity becoming a critical global issue, smart irrigation systems leveraging IoT provide a much-needed solution to optimize water usage, improve crop health, and reduce operational costs.

IoT in irrigation integrates various advanced technologies, such as sensors, wireless networks, and data analytics, to collect and process real-time data on environmental conditions. Sensors deployed in fields monitor parameters like soil moisture, temperature, and humidity, while weather forecasting systems provide additional insights. This data is transmitted to a central processing unit, often hosted on the cloud, where intelligent algorithms analyze it to determine the optimal irrigation schedule. Based on the analysis, actuators control water valves and pumps to deliver precise amounts of water, minimizing waste and ensuring plants receive adequate hydration.

The benefits of IoT-based irrigation extend beyond water conservation. These systems enhance energy efficiency by automating pump operations and scheduling irrigation during optimal periods, reducing electricity usage. Remote monitoring and control via mobile applications or web dashboards provide farmers with convenience and flexibility, enabling them to oversee their fields and make timely adjustments from anywhere. Furthermore, IoT promotes sustainable farming practices by preventing over-irrigation, protecting soil health, and conserving water resources for future generations.

IoT irrigation systems also incorporate automation, which significantly reduces labor dependency and operational inefficiencies. Actuators, controlled by microcontrollers or cloud-based algorithms, can open or close irrigation valves, adjust water flow rates, or activate pumps based on real-time data. This automation not only optimizes water usage but also minimizes human intervention, freeing up time for farmers to focus on other critical tasks.

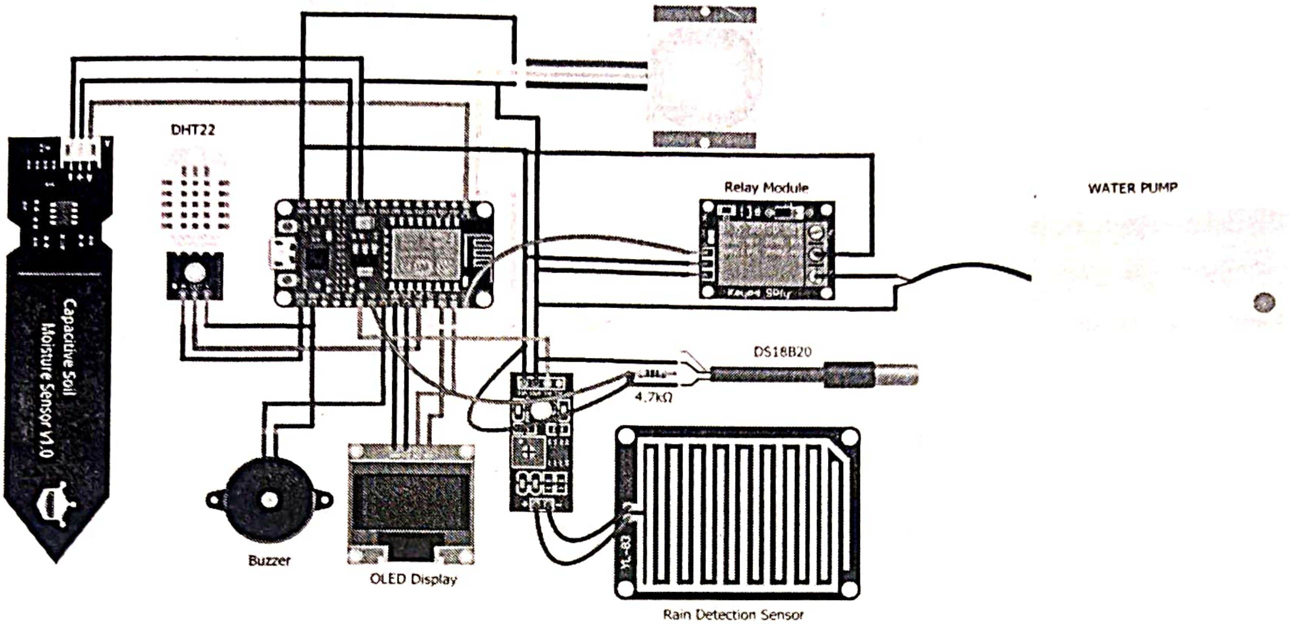

Fig.1 Smart Irrigation System Setup

As agriculture faces mounting challenges such as climate variability, population growth, and limited arable land, IoT-driven irrigation systems present an innovative approach to meet these demands. They empower farmers with actionable insights, enabling data-driven decision-making that maximizes productivity while conserving essential resources. This convergence of technology and agriculture aligns with global efforts to achieve sustainable development goals, particularly in water management and food security. As IoT technologies continue to evolve, their application in irrigation systems will play a pivotal role in shaping the future of smart farming and ensuring a sustainable agricultural ecosystem.

In conclusion, the application of IoT in irrigation system monitoring and control has emerged as a game-changer in modern agriculture. By enabling real-time monitoring, automation, and precise resource management, IoT systems address critical challenges such as water scarcity, labor inefficiency, and environmental degradation. While challenges remain in widespread adoption, the potential benefits far outweigh the limitations, paving the way for a more sustainable and productive agricultural future. As IoT technologies continue to evolve, their integration into irrigation systems will undoubtedly play a central role in shaping the future of farming practices worldwide.

CHAPTER 2: LITERATURE SURVEY

The application of IoT in irrigation system monitoring and control has garnered significant attention from researchers, highlighting its potential to transform traditional farming practices. Numerous studies have explored the integration of IoT technologies to improve water-use efficiency, enhance crop productivity, and promote sustainable agricultural practices. The advancements in sensor technologies, wireless communication, and cloud computing have enabled the development of smart irrigation systems capable of real-time monitoring and automation.

One of the earliest works in this domain focused on the role of soil moisture sensors in determining optimal irrigation schedules. Studies demonstrated that the use of IoT-enabled sensors could drastically reduce water wastage by providing precise information on soil moisture levels. Researchers also emphasized the importance of integrating these sensors with wireless networks, allowing data to be transmitted seamlessly to centralized systems for analysis and decision-making. This integration laid the foundation for the widespread adoption of IoT in agriculture.

Further research explored the use of IoT-based automation in irrigation. Actuators, controlled by microcontrollers, were introduced to manage water delivery systems autonomously based on sensor data. These systems demonstrated the ability to optimize water distribution while minimizing human intervention. Studies also highlighted the role of cloud platforms in storing and analyzing large datasets generated by IoT devices. By leveraging machine learning algorithms, these systems were able to predict irrigation requirements more accurately, further enhancing efficiency.

The environmental and economic benefits of IoT in irrigation have also been widely documented. Research revealed that smart irrigation systems not only conserve water but also reduce energy consumption by optimizing pump operations. Additionally, they contribute to maintaining soil health by preventing over-irrigation and minimizing nutrient leaching. Studies conducted in water-scarce regions confirmed that IoT solutions are particularly effective in mitigating the adverse effects of drought and water shortages.

CHAPTER 3: HARDWARE TOOLS

1 Node MCU: NodeMCU ESP8266 is a low-cost, open-source microcontroller with built-in Wi-Fi, making it ideal for IoT applications like smart irrigation systems. It acts as the central controller, connecting sensors (e.g., soil moisture, temperature, and humidity) and actuators to a wireless network. In a smart irrigation system, the NodeMCU collects sensor data, processes it, and automates water delivery using pumps or valves. Its compatibility with platforms like Blynk allows remote monitoring and control via smartphones. This efficiency reduces water wastage, optimizes resource use, and ensures sustainable farming practices. NodeMCU's versatility makes it a cornerstone in IoT-driven agriculture innovations.

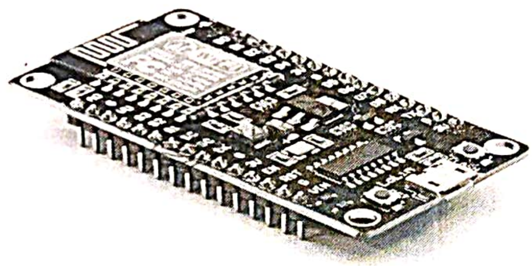

Fig.2 NodeMcu Esp8266

2. Rain Drop Sensor: An essential part of intelligent irrigation systems is a raindrop sensor, which is made to identify when and how much rain is falling. Usually, it is made up of conductive tracks that detect variations in electrical resistance in the presence of water droplets. Through resource conservation, overwatering prevention, and water delivery pauses during rain, this sensor aids in irrigation optimization. Research demonstrates how well it works to ensure crops get enough water while lowering energy and water waste. Raindrop sensors that are connected to the Internet of Things send data in real time to central systems, facilitating automated decision-making and improving the general effectiveness of contemporary irrigation techniques.

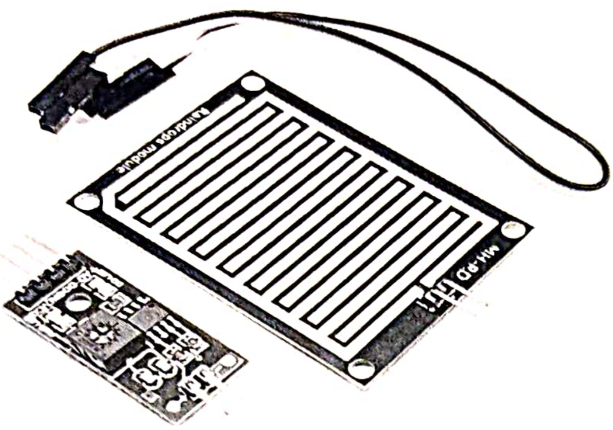

Fig.3 Rain Drop Sensor

3. Soil moisture Sensor : A moisture sensor is a critical component in smart irrigation systems, designed to measure the volumetric water content in soil. These sensors provide real-time data on soil moisture levels, enabling precise irrigation scheduling to meet crop requirements. By integrating with IoT platforms, moisture sensors transmit data to centralized systems, allowing for automated irrigation based on soil conditions. This minimizes water wastage and prevents over-irrigation, ensuring efficient resource utilization. Studies highlight their role in enhancing water-use efficiency and promoting sustainable agriculture, particularly in regions prone to water scarcity, making them indispensable in modern smart irrigation systems.

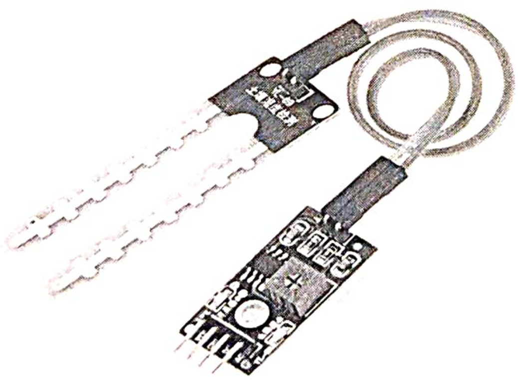

Fig.4 Soil Moisture Sensor

4. DHT11 Sensor: The DHT11 is a low-cost digital sensor used to measure temperature and humidity, commonly employed in IoT-based smart irrigation systems. It provides accurate readings of environmental conditions, which are essential for determining irrigation needs. In smart irrigation, the DHT11 sensor helps monitor soil and air temperature and humidity levels, enabling automated systems to trigger irrigation when necessary. By integrating this sensor with IoT platforms, it ensures precise water usage, reducing waste and promoting efficient resource management. Its simplicity and affordability make it an ideal choice for precision agriculture, contributing to sustainable water management practices in irrigation.

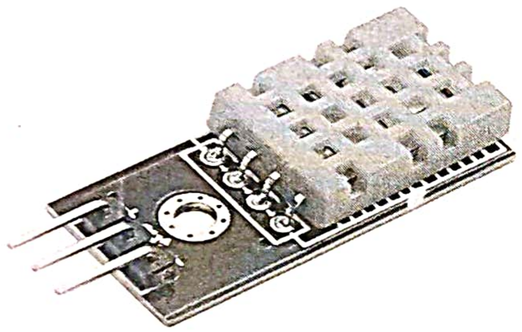

Fig.5 DHT11 SENSOR

5. Jumper Wires: Jumper wires are straightforward electrical cables with connector pins on both ends that are used to connect parts of a microcontroller or a breadboard temporarily. Depending on the needs of the connection, they can be classified as male-to-male, female-to-female, or male-to-female. In an IoT helmet are connected to the NodeMCU via jumper wires, which facilitates seamless data transfer between the parts.

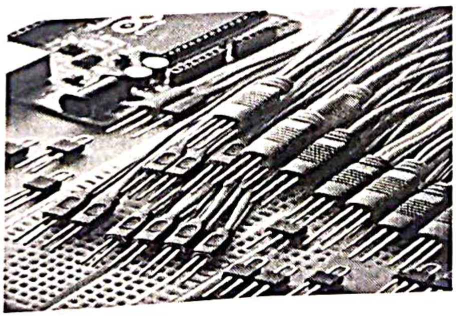

Fig 6: Jumper Wire

6. PIR SENSOR : A Passive Infrared (PIR) sensor detects infrared radiation emitted by warm objects, such as humans or animals, by measuring changes in heat within its field of view. In the context of smart irrigation systems, PIR sensors can be employed for motion detection to optimize irrigation schedules and detect the presence of people or animals in the field. For instance, PIR sensors can trigger an irrigation system to activate or deactivate when motion is detected, ensuring that water is not wasted when no activity is present. This enhances the efficiency of the irrigation system by preventing unnecessary water usage in specific areas.

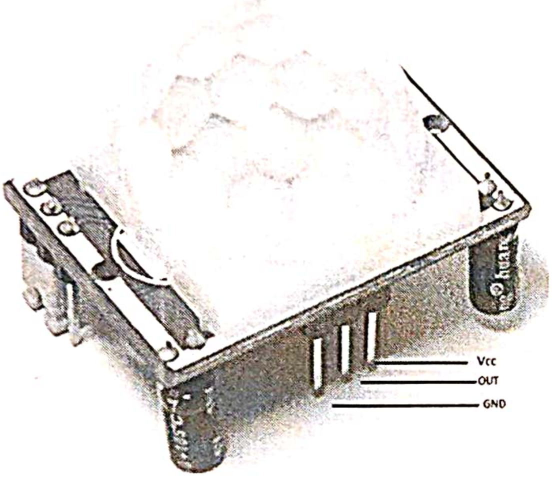

Fig 7: PIR SENSOR

7. RELAY MODULE : A Relay Module in a smart irrigation system is an essential component that allows the control of high-power devices, such as water pumps or valves, based on input from low-power sensors or microcontrollers. The relay module acts as a switch, triggered by the microcontroller to open or close electrical circuits, thus activating or deactivating irrigation equipment. When integrated with sensors like soil moisture detectors, it enables automatic irrigation by turning on the water supply when the soil moisture falls below a certain threshold. This automation enhances water efficiency, ensuring optimal irrigation with minimal human intervention in smart farming applications.

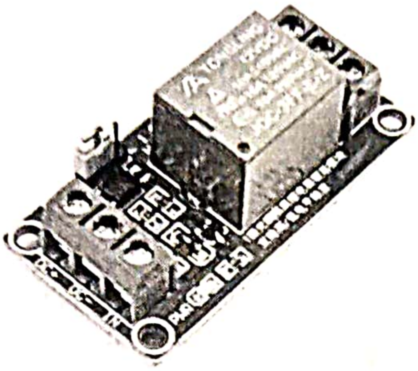

Fig 8: Relay Module

6. BREADBOARD : A **breadboard** is a specific tool used for the prototyping electronic circuits,there is no need of soldering. In the context of a **smart irrigation system**, a breadboard can be used to assemble and test various components such as **soil moisture sensors**, **microcontrollers** (e.g., Arduino or ESP8266), **relay modules**, and **actuators**. It allows for easy connection of these components to simulate and troubleshoot irrigation control systems before finalizing the design. Using a breadboard ensures that circuit connections are reliable and that the system functions correctly in response to real-time data from environmental sensors, optimizing water use in agricultural applications.

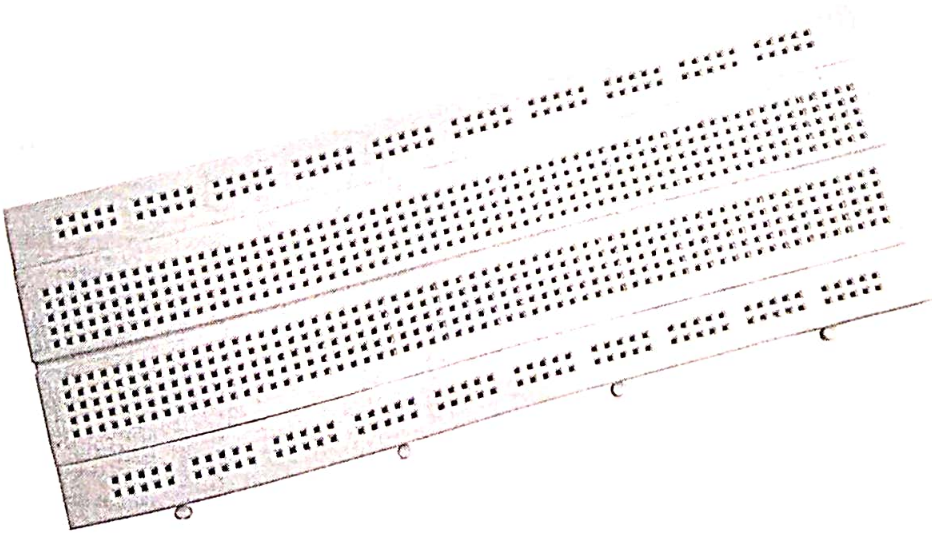

Fig 9: Breadboard

CHAPTER 4: METHODOLOGY AND ALGORITHM

METHODOLOGY

The methodology for implementing an IoT-based irrigation system monitoring and control uses a combination of sensors and a NodeMCU microcontroller to automate and optimize irrigation processes. The system starts with the **NodeMCU**, a low-cost, Wi-Fi-enabled microcontroller, which acts as the central unit for data collection, processing, and communication. **Soil moisture sensors** are deployed in the soil to continuously measure moisture levels. When the moisture content drops below a preset threshold, indicating the need for irrigation, the NodeMCU triggers the irrigation system. Additionally, the **DHT11 sensor** monitors environmental parameters such as temperature and humidity, providing crucial data for more accurate irrigation decisions. A **PIR (Passive Infrared) sensor** is used to detect the presence of human activity, ensuring the system's operation is optimized only when necessary, preventing unnecessary water usage during manual interventions. To further optimize water conservation, a **Rain drop sensor** is incorporated to detect rainfall. If it senses rain, the system automatically halts irrigation to avoid overwatering. The **Relay module** acts as an interface between the NodeMCU and the irrigation system, controlling the water flow to the crops by opening or closing the valve based on sensor inputs. All data collected by the sensors is sent to a cloud platform, where it can be accessed remotely via a smartphone application, enabling farmers to monitor the system in real-time and make manual adjustments if required. This method ensures efficient water usage, reduces energy consumption, and automates irrigation, making farming more sustainable and cost-effective. The system is designed for scalability and can be expanded with additional sensors and devices as needed.

ALGORITHM

The algorithm for the smart irrigation system aims to monitor and control irrigation based on environmental conditions such as soil moisture, temperature, humidity, and rainfall. The system uses various sensors and actuators, with data processed by the NodeMCU ESP8266. The following points outline the detailed step-by-step algorithm for the system.

Step 1: Initialize System

1. **Initialize NodeMCU ESP8266:**
   - Set up NodeMCU ESP8266 to connect to a Wi-Fi network for remote monitoring and control.
   - Establish serial communication for debugging.
2. **Initialize Sensors and Modules:**
   - Initialize the Soil Moisture Sensor to measure the moisture level in the soil.
   - Initialize the DHT11 Sensor to read temperature and humidity data.
   - Initialize the PIR Sensor to detect human presence.
   - Initialize the Rain Drop Sensor to detect rainfall.
   - Initialize the Relay Module to control the irrigation valve.

Step 2: Read Sensor Data

3. **Read Soil Moisture:**
   - Continuously monitor the soil moisture level using the soil moisture sensor.
   - If the moisture level falls below a defined threshold (e.g., 40%), it indicates the need for irrigation.
4. **Read Temperature and Humidity (DHT11):**
   - Collect data from the DHT11 sensor for temperature and humidity.
   - Use this data to adjust irrigation logic if required (e.g., higher temperatures could trigger more frequent irrigation).
5. **Detect Rainfall:**
   - Check the output of the rain drop sensor to detect if it is raining.
   - If rain is detected, stop irrigation immediately to avoid overwatering.
6. **Monitor Human Presence (PIR Sensor):**
   - Check the PIR sensor for human movement.

- If human presence is detected, suspend or delay irrigation if it is not needed, ensuring no wasteful irrigation occurs during manual intervention.

Step 3: Decision Making

7. **Analyze Data for Irrigation Decision:**
    - If soil moisture is below threshold and no rain is detected, the system decides to turn on irrigation.
    - If rain is detected, the irrigation is suspended regardless of the soil moisture level.
    - If temperature and humidity values are high, the system may increase the irrigation duration.
    - If PIR sensor detects no movement, proceed with normal irrigation.

Step 4: Activate Irrigation

8. **Control Relay for Irrigation:**
    - If irrigation is needed (based on sensor data), activate the Relay Module to turn on the irrigation valve and allow water to flow.
    - Set a timer for the irrigation duration based on soil moisture levels and environmental data.
    - Turn off the irrigation after the predefined time or when moisture levels are adequate.

Step 5: Cloud Integration (Optional)

9. **Send Data to Cloud/Server:**
    - Send real-time data from sensors (soil moisture, temperature, humidity, etc.) to the cloud for remote monitoring via a web interface or mobile app.
    - Provide alerts if the system requires manual intervention (e.g., if there's an issue with the water supply or sensors).

Step 6: Monitor and Repeat Process

10. Loop and Repeat Process:

- Continuously monitor the sensors in a loop, adjusting irrigation based on real-time data.
- Recheck the status of each sensor periodically (e.g., every minute) to ensure irrigation is accurate and efficient.
- The system repeats this process indefinitely to ensure optimal water use and soil health.

CHAPTER 5: MODELLING AND QUICK DESIGN

The design of a **smart irrigation system** involves integrating various sensors, controllers, and actuators to automate the process of irrigation based on environmental parameters. The system is primarily based on **IoT technology** to monitor and control irrigation remotely, optimizing water usage for improved agricultural practices.

The design begins with the **NodeMCU**, a Wi-Fi-enabled microcontroller that serves as the central control unit. The NodeMCU receives data from multiple sensors placed in the field, including the **soil moisture sensor, DHT11 sensor** for temperature and humidity, **PIR sensor** for detecting human presence, and a **rain drop sensor** for identifying rainfall. Each of these sensors plays a pivotal role in determining when and how much water the crops require.

1. **Sensor Integration:**

- The **soil moisture sensor** continuously monitors the moisture content of the soil. When moisture levels drop below a set threshold, the system triggers irrigation.
- The **DHT11 sensor** monitors environmental conditions, providing temperature and humidity data that can further fine-tune irrigation decisions.
- The **PIR sensor** detects any human presence or movement in the field, which can prevent the irrigation system from running unnecessarily when people are present.
- The **rain drop sensor** halts irrigation automatically when it detects rainfall, preventing overwatering and conserving water.

2. **Controller and Actuators:**

The **relay module** is used to control the water pump or valve, acting as an actuator. When the conditions (e.g., moisture levels) require irrigation, the relay is activated by the NodeMCU to start the water flow. The relay also stops the water flow when sensors indicate sufficient moisture or rainfall.

3. **Data Communication and Monitoring:**

The system transmits sensor data to a cloud platform or a mobile application. Farmers can access this data remotely via their smartphones or computers, allowing them to monitor soil conditions, weather, and system performance in real time.

4. **Automation and Efficiency:**

This design ensures automated irrigation based on real-time data, significantly reducing water wastage. By utilizing IoT and smart sensors, the system can make more accurate decisions and ensure the optimal amount of water is delivered at the right time, improving crop health and resource efficiency.

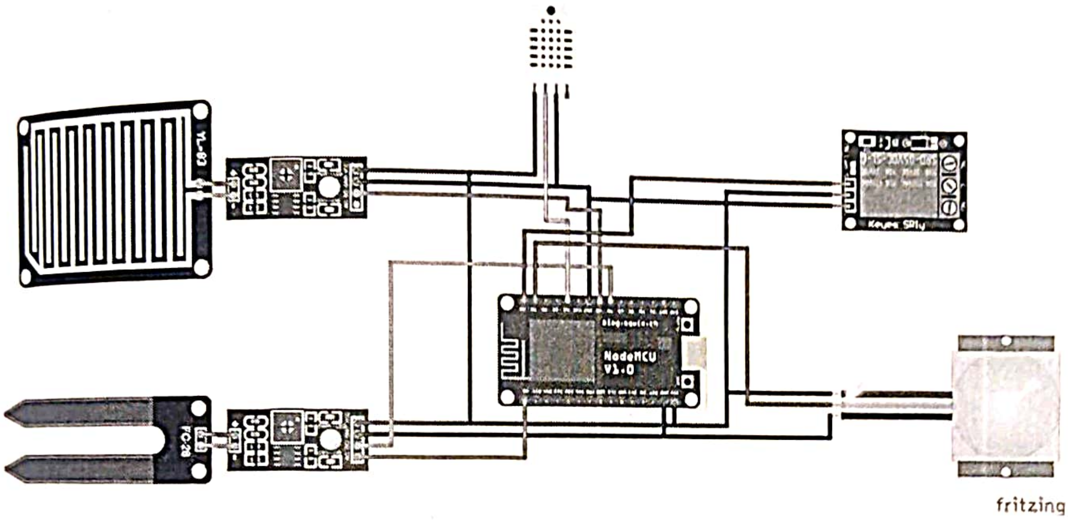

Fig.10 Design Process

CHAPTER 6: RESULTS ANALYSIS

This section summarizes the results from implementing an IoT-based irrigation system using NodeMCU, PIR sensor, soil moisture sensor, DHT11 sensor, raindrop sensor, and relay module. The system automates irrigation by collecting real-time data from the environment.

Step 1: System Setup The system was assembled using NodeMCU (ESP8266) to enable remote monitoring. The PIR sensor detects human presence, ensuring the system operates only when needed. Soil moisture and DHT11 sensors measure soil moisture and environmental conditions like temperature and humidity. The raindrop sensor detects rain to prevent unnecessary irrigation.

Step 2: Data Collection The sensors provided real-time data, which was transmitted to the cloud. The soil moisture sensor successfully determined when irrigation was needed by comparing moisture levels against a preset threshold. The DHT11 sensor contributed environmental data, optimizing watering schedules.

Step 3: Relay Control and Automation The relay module controlled the irrigation system, activating the water pump only when required. If moisture was low and no rain was detected, the relay activated the irrigation process.
Step 4: Remote Control NodeMCU enabled remote access, allowing users to monitor and control the system from a mobile app. This feature provided convenience and improved efficiency.

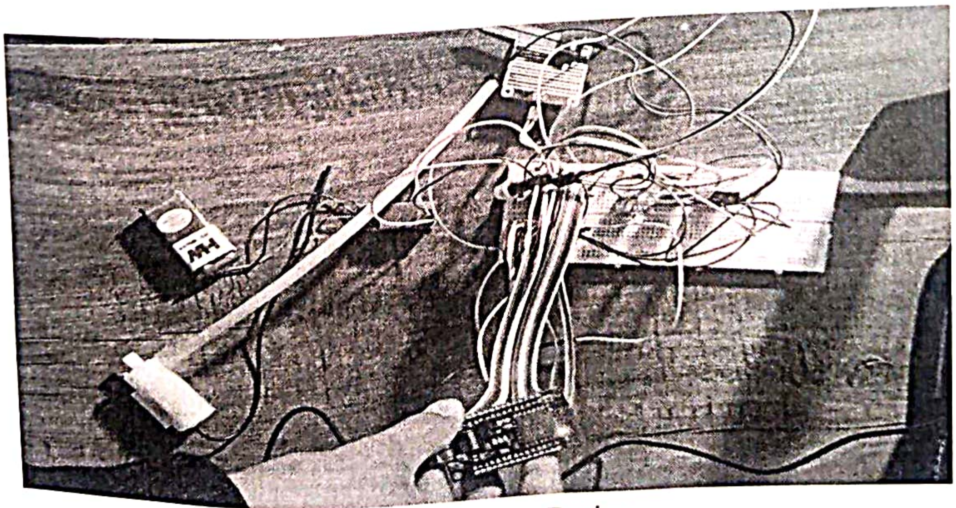

Fig-11 Prototype Design

CHAPTER 7: CONCLUSION AND FUTURE SCOPE

The integration of **IoT in irrigation system monitoring and control** has demonstrated significant improvements in water management and resource optimization. By using devices such as **NodeMCU, soil moisture sensors, DHT11, PIR sensors**, and **raindrop sensors**, the system effectively automates irrigation based on real-time environmental data. The **relay module** enables precise control of water distribution, ensuring irrigation occurs only when necessary, thus conserving water and energy.

This IoT-based approach eliminates the need for manual intervention, enhancing efficiency and reducing labor costs. Remote monitoring and control through mobile applications further increase convenience, providing farmers with up-to-date information on soil conditions and system status. The system also contributes to sustainability by minimizing water wastage and reducing energy consumption.

Future Scope

While the current system shows promising results, there are several areas for improvement and future expansion. Integrating additional sensors for **light intensity**, **pH levels**, or **nutrient content** can further optimize irrigation processes. Machine learning algorithms could be incorporated to predict weather patterns, improving irrigation scheduling. Additionally, extending the system's capabilities to handle larger agricultural fields with enhanced connectivity could make IoT-based irrigation systems more accessible and beneficial on a wider scale, promoting smarter, sustainable farming practices globally.

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The study focuses on the automation of irrigation systems using IoT technology, emphasizing real-time monitoring, control, and resource optimization.

ANNEXURE

SELF-EVALUATION OF THE PROJECT

Month	Start date – End date (DD/MM/YY) - (DD/MM/YY)	Progress of Project
Month- 1	05/08/24 - 31/08/24	Topic Selection and Project planning
Month- 2	01/09/24 - 30/09/24	Hardware selection and Prototype Development
Month- 3	01/10/24 - 31/10/24	Data Analysis and Results
Month- 4	01/11/24 - 18/11/24	Documentation of the Project

Dr. Soumyajit Ghosh
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MITS, Gwalior

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