IOT Based Smart Irrigation System

Dr.Tahseen.A. Mulla*1, Prithviraj.B. Garud *2Viraj.J. Jadhav*3, Omkar.V. Patil*4, Ruturaj.N. Mohite*5

Head Of Department*1, 2-5*Student, Department of Electrical Engineering, Annasaheb Dange College of Engineering and Technology, Ashtha Maharashtra, India

*Corresponding Author: Prithvirajgarud9922@gmail.com *2

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ABSTRACT:

The rapid advancement of technology has opened new avenues for improving agricultural practices, especially in water management. An IoT-based smart irrigation system is an innovative solution designed to optimize water usage, enhance crop productivity, and reduce human effort. This system integrates sensors, microcontrollers, and wireless communication to automate irrigation processes based on real-time environmental conditions. The core of the system lies in its ability to monitor soil moisture, temperature, and humidity using various sensors deployed in the field. These sensors continuously collect data and transmit it to a central controller, which processes the information and determines whether irrigation is required. When the soil moisture level falls below a predefined threshold, the system automatically activates water pumps or valves, ensuring that crops receive the necessary amount of water without delay. Once the optimal moisture level is achieved, the system turns off the irrigation, preventing overwatering. One of the significant advantages of this system is its remote monitoring capability. Farmers can access real-time data through mobile applications or web interfaces, enabling them to make informed decisions from anywhere. This reduces the need for constant physical presence in the field and allows better management of resources. Additionally, historical data collected by the system can be analyzed to understand patterns and improve future irrigation planning.

The implementation of IoT in irrigation also contributes to water conservation, which is crucial in regions facing water scarcity. By delivering precise amounts of water only when needed, the system minimizes wastage and promotes sustainable agricultural practices. Furthermore, automation reduces labor costs and increases operational efficiency, making it a cost-effective solution in the long term. Despite its advantages, challenges such as initial setup costs, connectivity issues in rural areas, and maintenance requirements must be addressed for widespread adoption.

KEY WORDS: Smart Irrigation System, Precision Agriculture,

INTRODUCTION:

Agriculture plays a vital role in sustaining human life and supporting the global economy. However, traditional farming practices often rely on manual irrigation methods that are inefficient, time- consuming, and highly dependent on unpredictable environmental conditions. One of the major challenges faced by farmers today is the effective management of water resources. Excessive irrigation leads to water wastage and soil degradation, while insufficient watering can negatively impact crop growth and yield. In this context, the integration of modern technologies into agriculture has become essential to ensure sustainability and productivity. One such advancement is the Internet of Things (IoT)-based smart irrigation system. The Internet of Things refers to a network of interconnected devices that collect, exchange, and process data through the internet without requiring significant human intervention. In agriculture, IoT technology enables real-time monitoring and control of various environmental parameters such as soil moisture, temperature, humidity, and water levels. By utilizing these data-driven insights, farmers can make informed decisions and automate irrigation processes to achieve optimal crop growth.

An IoT-based smart irrigation system is designed to address the limitations of conventional irrigation techniques by providing a more precise and efficient method of water management. The system typically consists of soil moisture sensors, environmental sensors, microcontrollers, water pumps, and communication modules. These components work together to continuously monitor field conditions and determine the exact water requirements of crops. When the soil moisture level drops below a predetermined threshold, the system automatically activates irrigation, ensuring that plants receive the appropriate amount of water at the right time. Once the desired moisture level is reached, the system stops the water flow, thereby preventing over-irrigation. One of the key features of this system is its ability to operate remotely. Farmers can monitor field conditions and control irrigation systems using smartphones or computers through dedicated applications or web platforms. This capability significantly reduces the need for manual labor and allows farmers to manage their fields more efficiently, even from distant locations. Additionally, real-time alerts and notifications can be sent to users in case of abnormal conditions, such as sudden drops in moisture levels or equipment failures.

Another important aspect of IoT-based irrigation is its contribution to resource conservation. Water scarcity is a growing concern in many parts of the world, and agriculture accounts for a significant portion of water consumption. By using precise irrigation techniques, the system ensures that water is used only when necessary and in the required quantity. This not only conserves water but also reduces energy consumption associated with pumping and distribution. Furthermore, controlled irrigation helps maintain soil health by preventing waterlogging and nutrient loss, ultimately leading to better crop quality and higher yields. The system also enables data collection and analysis over time. Historical data on soil conditions, weather patterns, and irrigation schedules can be stored and analyzed to identify trends and improve decision-making. Advanced systems may incorporate machine learning algorithms to predict irrigation needs based on past data and environmental conditions, making the system even more intelligent and adaptive. Despite its numerous advantages, the adoption of IoT-based smart irrigation systems may face certain challenges. Initial installation costs, lack of technical knowledge among farmers, and limited internet connectivity in rural areas can hinder implementation. However, with increasing awareness, government support, and advancements in affordable technology, these barriers are gradually being reduced.

LITERATURE REVIEW

In recent years, many studies have focused on developing IoT based smart irrigation systems to make better use of water and improve farm productivity. Conventional irrigation practices mostly depend on manual control or fixed timing, which can lead to improper water usage and inefficiency. To overcome these issues, researchers have introduced automated irrigation solutions that use IoT technologies. These modern systems combine sensors, wireless networks, and cloud-based platforms to monitor field conditions continuously. By collecting real-time data, they help farmers manage water more accurately and ensure that crops receive the right amount of irrigation at the right time.

OBJECTIVE

The goal of this project is to create an IoT-based smart irrigation system that can observe soil and environmental conditions in real time and automatically manage the water supply to crops. This approach helps in minimizing unnecessary water use while supporting better crop growth and increasing overall farm productivity.

-To design and build an automated irrigation system using IoT technology.

-To continuously track soil moisture, temperature, and humidity through sensors in real time.

-To operate the water pump automatically depending on the moisture level of the soil.

HARDWARE USED

Microcontroller (Arduino Uno)

The Arduino Uno serves as the central controller in the IoT based smart irrigation system. It functions as the core unit that handles tasks such as collecting data from sensors and controlling the watering process. Built on the ATmega328P microcontroller, it is popular for its user-friendly design, affordability, and simple programming. The board includes both digital and analog input/output pins, allowing it to easily connect with various sensors and devices used in the system.

Soil Moisture Sensor

This sensor operates by measuring the electrical resistance between two probes placed in the soil. When the soil is wet, it allows electricity to pass through more easily, which leads to lower resistance. On the other hand, dry soil resists the flow of electricity, resulting in higher resistance. Using this concept, the sensor generates either an analog or digital signal that represents the level of moisture in the soil.

DHT 11 Sensor

The DHT11 sensor is designed to measure both temperature and humidity. It uses a thermistor to sense temperature changes and a capacitive element to detect moisture in the air. The sensor delivers a pre-calibrated digital signal, which makes it simple to connect and use with microcontrollers such as the Arduino Uno.

5V Water Pump

The water pump is operated with the help of a relay module connected to the Arduino Uno. When the system detects that the soil lacks sufficient moisture, the microcontroller sends a command to the relay to switch the pump on. After the soil reaches the required moisture level, the system automatically turns the pump off, ensuring efficient water usage.

Jumper Wire

A jumper wire is a simple yet essential electrical connector used to establish temporary or flexible connections between components in a circuit. It typically consists of a thin conductive wire with connector pins at each end, allowing it to be easily inserted into devices such as breadboards.

BLOCK DIAGRAM AND WORKING

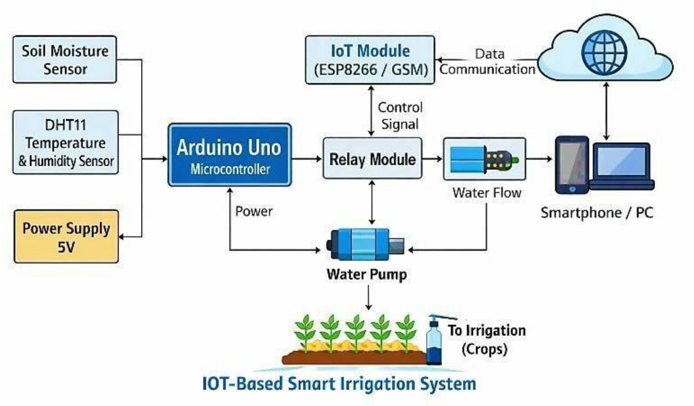

Fig.1. IoT-Based Smart Irrigation System

The IoT-based smart irrigation system functions by regularly checking the condition of the soil and surrounding environment, and then automatically managing the watering process based on that information.

Data Collection: The soil moisture sensor is used to detect how much water is present in the soil, while the DHT11 sensor monitors the surrounding temperature and humidity conditions.

Data Processing: The data gathered from the sensors is transmitted to the Arduino Uno microcontroller, where it is analyzed and checked against preset threshold values.

Decision Making: If the soil moisture is below the threshold (dry soil) → irrigation is required If the soil moisture is above the threshold (wet soil) → irrigation is stopped.

Control Action: Based on the decision, the Arduino sends a signal to the relay module: • Relay ON

→ activates the 5V DC Water Pump • Relay OFF → deactivates the pump.

Water Supply: When the pump is switched on, water is delivered to the crops continuously until the soil attains the required moisture level.

IoT Communication: The system incorporates an IoT module such as ESP8266 or GSM to transmit data to the cloud. This enables farmers to view real-time information and manage the irrigation system remotely through their smartphones or computers.

Continuous Monitoring: This cycle runs repeatedly, allowing the system to maintain proper irrigation automatically without the need for human involvement.

RESULT and DISCUSSION

The implementation of the IoT-based smart irrigation system demonstrated significant improvements in water management, crop health, and operational efficiency when compared to traditional irrigation methods. The system was tested under varying environmental conditions to evaluate its performance in real-time monitoring and automated decision-making.

The results showed that the soil moisture sensors accurately detected the moisture content of the soil and transmitted data continuously to the central controller. Based on predefined threshold values, the system successfully automated the irrigation process by activating and deactivating the water supply at appropriate times. This ensured that crops received adequate water without the risk of over-irrigation or under-irrigation. As a result, water usage was reduced considerably, indicating efficient utilization of available resources.

FUTURE SCOPE

The IoT-based smart irrigation system offers strong possibilities for future improvement and expansion. As technology continues to evolve, the system can become more advanced, efficient, and adaptable to meet the changing needs of agriculture. By incorporating features like predictive analytics and machine learning, the system can analyze weather trends and past data to estimate future water requirements.

CONCLUSION

The IoT-based smart irrigation system presents a modern and efficient approach to agricultural water management. By integrating sensors, automated controls, and real-time data communication, the system successfully addresses the limitations of traditional irrigation methods. It ensures that crops receive the right amount of water at the right time, which is essential for maintaining healthy plant growth and maximizing yield. One of the most important outcomes of this system is the significant reduction in water wastage. Through continuous monitoring of soil moisture and environmental conditions, irrigation is performed only when necessary. This not only conserves water but also supports sustainable farming practices, especially in regions where water resources are limited. In addition, the automation of irrigation processes reduces the dependency on manual labor, saving time and operational costs for farmers.

The system also enhances decision-making by providing real-time and historical data. Farmers can remotely monitor their fields and respond quickly to changing conditions, leading to improved efficiency and productivity. The ability to analyze collected data further helps in planning better irrigation strategies for future cultivation cycles. Although the system offers numerous benefits, certain challenges such as initial investment costs, maintenance requirements, and dependence on internet connectivity need to be considered. However, with continuous advancements in technology and increasing accessibility of IoT devices, these limitations are gradually being minimized. In conclusion, the IoT-based smart irrigation system is a reliable and sustainable solution for modern agriculture. It promotes efficient use of resources, improves crop performance, and supports environmentally friendly farming practices. As the agricultural sector continues to evolve, the adoption of such intelligent systems will play a crucial role in ensuring food security and long-term sustainability.

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3. **Data Availability:** The experimental data generated and analyzed during this study are available from the corresponding author upon reasonable request.

4. **Authors' Contribution:** All Group members contribution is helpful and Same.

5. **Use of AI and AI-Assisted Technologies:** Yes, used AI technologies to find some information and making a block diagram

6. **Conflict of Interest:** Here is no conflict of interest regarding the publication of this paper.

7. **Copyright Permissions: yes**

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