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IoT Based Smart Irrigation System using ESP8266 for Efficient Water Management

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Abstract - Efficient water management is an important challenge in modern agriculture due to increasing water scarcity and inefficient traditional irrigation practices. Conventional irrigation methods often depend on manual monitoring and fixed watering schedules, which may lead to water wastage or insufficient irrigation. This paper presents the design and implementation of a smart irrigation system using an ESP8266 microcontroller and soil moisture sensor. The system continuously monitors soil moisture levels and automatically controls a water pump based on predefined threshold values. When the soil becomes dry, the system activates irrigation, and when sufficient moisture is detected, the pump is turned off automatically. The system is also connected to an Internet based monitoring platform that allows users to observe soil conditions and pump status remotely. This approach improves water efficiency, reduces human effort, and supports sustainable agricultural practices. The proposed system is low cost, easy to implement, and suitable for small scale farms, gardens, and greenhouse applications.

1. INTRODUCTION:

Agriculture plays a vital role in the economy of many countries and is considered the backbone of food production. A large percentage of freshwater resources is used for agricultural irrigation. With the continuous growth in global population and increasing demand for food, efficient management of water resources has become a critical challenge. Traditional irrigation methods mainly depend on manual operation and fixed watering schedules, which often lead to over irrigation or under irrigation of crops. Over irrigation results in unnecessary water wastage and can cause problems such as waterlogging, soil erosion, and nutrient loss. On the other hand, under irrigation can negatively affect crop growth and reduce agricultural productivity. In regions with high evaporation rates, improper irrigation may also increase soil salinity, which damages soil quality and plant health. To overcome these problems, modern technologies such as embedded systems and the Internet of Things have been introduced in agriculture. Smart irrigation systems use sensors and microcontrollers to monitor soil conditions and automate the irrigation process. These systems provide water to crops only when required, thereby improving water efficiency and reducing the need for constant human supervision. This paper presents the design and implementation of an Internet of Things based Smart Irrigation System using an ESP8266 microcontroller and soil moisture sensors. The system continuously monitors soil moisture levels and automatically controls a water pump through a relay module. In addition, the system provides remote monitoring using an Internet based platform, allowing users to observe soil conditions and pump status in real time. The proposed system helps conserve water, reduce manual effort, and improve irrigation efficiency in agricultural applications.

2. LITERATURE REVIEW:

Several research works have been carried out in the field of smart irrigation systems using Internet of Things technology.

An IoT based smart irrigation system using soil moisture sensors and microcontrollers was proposed in [1], where irrigation was automated based on real time soil conditions. The system improved water efficiency but lacked advanced monitoring features.

A cloud based smart irrigation system using IoT was presented in [2], where sensor data was transmitted to a cloud platform for remote monitoring and control. Although the system improved accessibility, it increased system complexity and cost.

In [3], a smart farming system using soil moisture monitoring was developed to automate irrigation. The system efficiently controlled water supply but did not consider environmental parameters such as temperature and humidity.

An automated drip irrigation system using ESP32 was introduced in [4], which improved irrigation efficiency through sensor-based control. However, the system mainly focused on automation and lacked remote monitoring capabilities.

A recent IoT enabled irrigation system for precision agriculture was proposed in [5], where real time data analysis was used to improve irrigation decisions. The system provided better efficiency but required multiple sensors and increased implementation cost.

Another smart irrigation system using ESP8266 and Blynk platform was presented in [6], which enabled real time monitoring and control through a mobile application. However, the system primarily relied on soil moisture data and did not include comprehensive environmental analysis.

An IoT based irrigation system using cloud computing was proposed in [7], which integrated sensors, communication technologies, and cloud platforms for efficient water management. Although effective, the system required complex infrastructure and higher technical expertise.

Based on the limitations of existing systems, the proposed system focuses on developing a low cost and efficient smart irrigation system using ESP8266 and soil moisture sensors. The system provides automatic irrigation control along with real time

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monitoring through an Internet based platform, making it suitable for small scale agricultural applications.

3. PROPOSED SYSTEM:

Water scarcity and inefficient irrigation practices are major challenges in modern agriculture. To overcome these issues, a smart irrigation system based on Internet of Things technology is proposed. The system is designed to automatically monitor soil moisture levels and control irrigation accordingly, ensuring efficient water usage and reduced manual intervention.

The proposed system consists of a soil moisture sensor, ESP8266 microcontroller, relay module, DC water pump, LCD display, and an Internet based monitoring platform. The soil moisture sensor is placed in the soil near the root zone of the plant to measure the water content. The sensor continuously sends analog data to the ESP8266 microcontroller, which processes the data and compares it with a predefined threshold value.

When the soil moisture level falls below the threshold, the ESP8266 sends a signal to the relay module, which activates the water pump. The pump supplies water to the plants until the required moisture level is reached. Once the soil becomes sufficiently moist, the microcontroller turns off the pump automatically. This process ensures that plants receive the right amount of water at the right time.

The ESP8266 microcontroller also enables wireless communication using Wi Fi technology. The system is connected to an Internet based platform such as Blynk, where real time data of soil moisture and pump status is displayed. This allows users to monitor the system remotely and manually control irrigation if required.

Fig.1 shows the block diagram of the proposed smart irrigation system. The system integrates sensing, processing, control, and communication units to provide an efficient and low-cost irrigation solution suitable for agricultural fields, gardens, and greenhouse applications.

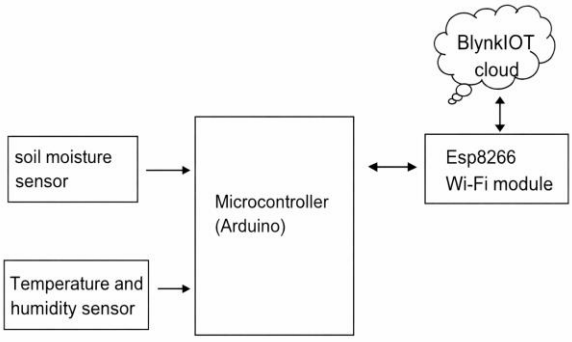

Fig.1. Transmitter module

4. WORKING PROCESS:

The working of the proposed smart irrigation system is based on continuous monitoring of soil moisture and automatic control of the water pump. Fig.2 shows the flowchart of the system operation.

Initially, when the system is powered on, the ESP8266 microcontroller initializes all the connected components such as the soil moisture sensor, relay module, and LCD display. After initialization, the system begins collecting real time data from the soil moisture sensor, which measures the water content present in the soil.

The collected data is then processed by the microcontroller and displayed on the LCD screen for local monitoring. The system continuously compares the measured soil moisture value with a predefined threshold value to determine whether irrigation is required or not.

If the soil moisture level is found to be below the threshold value, the system activates the relay module, which turns on the water pump and supplies water to the plants. If the moisture level is above the threshold, the relay remains off, and the water pump stays in the off condition.

This process repeats continuously, ensuring that the soil maintains an optimal moisture level at all times. The automation of irrigation reduces manual effort, prevents water wastage, and improves overall efficiency of the irrigation system.

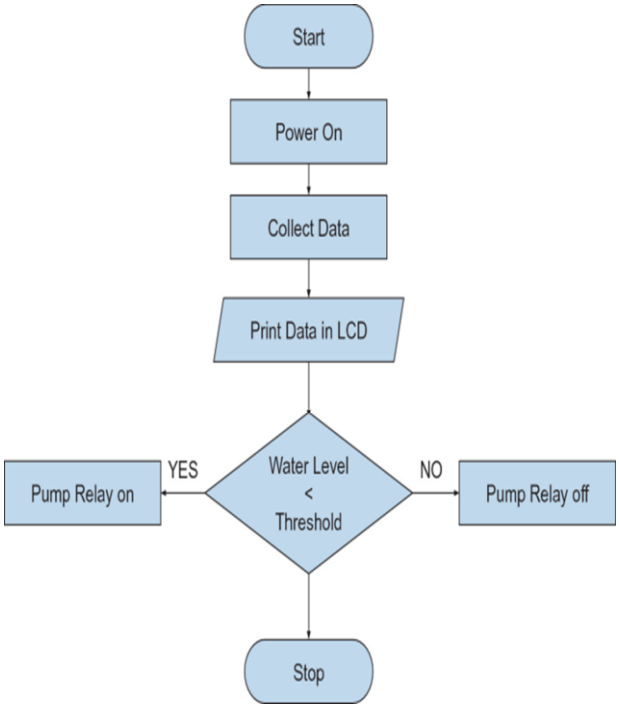

Fig.2 Flowchart of Smart Irrigation System

5. RESULT:

The proposed smart irrigation system was tested under different soil moisture conditions to evaluate its performance and efficiency. The system successfully monitored soil moisture levels and automatically controlled the water pump based on predefined threshold values. The ESP8266 microcontroller processed the sensor data accurately and responded in real time to changes in soil conditions.

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Table 1 shows the observed soil moisture levels and corresponding pump operation during testing.

Sr.No.	*Soil Moisture Level (%)*	*Pump Status*
1.	20	ON
2.	25	ON
3.	30	ON
4.	40	OFF
5.	50	OFF
6.	60	OFF

Table 1. Soil Moisture vs. Pump Operation

From the table, it is observed that the water pump is activated when the soil moisture level falls below the threshold value of approximately 35%. When the moisture level exceeds the threshold, the system automatically turns off the pump, thereby preventing over irrigation.

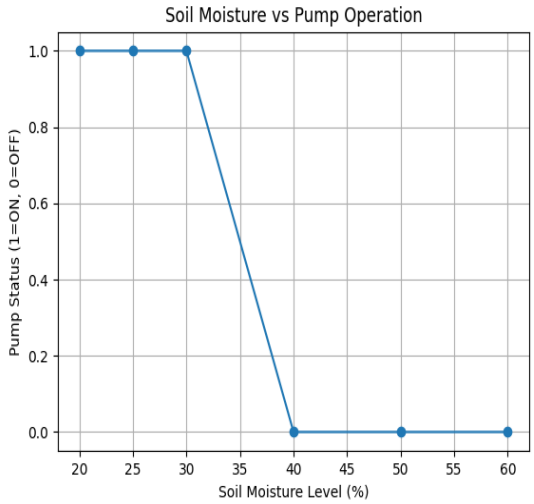

Fig.3 Soil Moisture vs. Pump Operation Graph

Fig.3 shows the graphical representation of soil moisture levels versus pump operation. The graph clearly indicates that the pump operates only when the moisture level is low and remains off when sufficient moisture is present in the soil. This demonstrates that the system efficiently maintains optimal soil moisture levels.

The IoT platform (Blynk) successfully displayed real time data of soil moisture and pump status, allowing users to monitor the system remotely. The results confirm that the proposed system reduces water wastage, minimizes manual effort, and ensures efficient irrigation control in agricultural applications

6. CONCLUSION:

The IoT based smart irrigation system presented in this paper provides an efficient solution for automated irrigation using soil moisture monitoring. The system successfully controls the water pump based on real time soil conditions, thereby reducing water wastage and manual effort. The integration of ESP8266 with an Internet based platform allows remote monitoring and improves system usability. The proposed system is cost effective, reliable, and suitable for small scale agricultural applications. Overall, the system contributes to sustainable water management and improved agricultural productivity.

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