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Real Time IoT-Enabled Smart Plant Irrigation and Weather Monitoring System using the ESP32 microcontroller & MATLAB

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Abstract: *This project is about developing Real Time IoT-Enabled Smart Plant Irrigation and Weather Monitoring System using the ESP32 microcontroller & MATLAB. The main aim of this system is to make irrigation more efficient and reduce water wastage by using real-time data. An ESP32 microcontroller is used as the main controller to connect sensors and send data to the internet.The system uses different sensors such as a DHT11 sensor to measure temperature and humidity, a soil moisture sensor to check the water level in the soil, and an MQ-8 gas sensor to detect gas levels. All the collected data is displayed on an LCD screen and also sent to the Blynk app, where users can monitor it from anywhere.*

The irrigation motor is controlled using a relay module and works in two modes. In automatic mode, the motor turns ON. when the soil becomes dry and turns OFF when enough moisture is present. In manual mode, the user can control the motor directly through the mobile app.

The system also stores data online. MATLAB is used to collect and analyse the data, and ThingSpeak is used to display graphs and store records that can be downloaded as an Excel file.Overall, this project provides a simple, low-cost, and effective solution for smart farming by combining monitoring, automation, and data analysis, helping to save water and improve plant growth.

Keywords: *Smart Plant Irrigation*

I. INTRODUCTION

Agriculture is one of the most important parts of our daily life, as it provides food and supports the economy. However, farmers often face problems like irregular watering, water wastage, and lack of proper information about weather and soil conditions. Traditional irrigation methods usually depend on manual work or fixed timing, which is not always efficient and can lead to poor crop growth. With the help of modern technology like the Internet of Things (IoT), these problems can be solved more effectively[1-10]. IoT allows different devices and sensors to connect with each other and share data in real time. In this project, the ESP32 microcontroller is used as the main controller because it has built-in Wi-Fi and is easy to use for IoT applications. This system is designed to monitor important environmental factors such as temperature, humidity, soil moisture, and gas levels using sensors like DHT11, soil moisture sensor, and MQ-8. The collected data is shown on an LCD display and also sent to the Blynk app, so it can be monitored from anywhere using a smartphone. The irrigation system is made smart by using a relay-controlled motor. It can work automatically by turning ON when the soil is dry and turning OFF when enough water is present. It also has a manual option, where the user can control the motor through the mobile app.In addition, the system stores data online and uses MATLAB for analysis and visualization. This helps in understanding the environmental conditions better over time. Overall, this

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project makes irrigation smarter, saves water, reduces manual effort, and helps in improving crop growth using simple and affordable technology[11-60].

II. PROBLEM STATEMENT

In agriculture, proper irrigation and monitoring of environmental conditions are very important for healthy plant growth. However, many farmers still use traditional irrigation methods, which are based on fixed schedules or manual operation. These methods do not consider real-time conditions like soil moisture, temperature, or humidity, leading to overwatering or underwatering of crops. This results in water wastage, increased labour, and reduced crop productivity.

Another major problem is the lack of continuous monitoring of environmental factors. Farmers often do not have access to real-time data about their fields, making it difficult to take timely decisions. Also, manual monitoring is time-consuming and not always accurate.

There is a need for a smart and automated system that can monitor environmental conditions in real time and control irrigation accordingly. Such a system should also allow remote access so users can check data and control devices from anywhere.

Therefore, this project aims to develop an IoT-based smart irrigation and weather monitoring system using ESP32 and MATLAB, which can automatically manage irrigation based on soil moisture levels, provide real-time data monitoring, and reduce water wastage while improving overall efficiency in agriculture.

III. LITERATURE SURVEY

Singh et al. (2023)

Introduced automation in irrigation by setting threshold values for soil moisture. The system automatically turned the water pump ON and OFF, reducing the need for manual intervention.

Reddy et al. (2023)

Worked on cloud-based data storage using platforms like ThingSpeak. Their system allowed users to view historical data and analyze trends for better decision-making.

Verma et al. (2024)

Integrated mobile applications for remote control and monitoring. Users could control irrigation systems from anywhere, improving convenience and efficiency.

Joshi et al. (2024)

Focused on data analysis using MATLAB, where sensor data was collected and visualized in graphical form. This helped in understanding environmental patterns over time.

Kumar et al. (2021)

Developed an IoT-based smart irrigation system using soil moisture sensors and automated water control. The system helped reduce water wastage by supplying water only when required.

Sharma et al. (2022)

Focused on real-time monitoring of environmental conditions using temperature and humidity sensors. Their system allowed farmers to remotely monitor field conditions through a mobile application.

Patel et al. (2022)

Designed a low-cost irrigation system using the ESP32 microcontroller. They emphasized easy implementation and affordability, making the system suitable for small-scale farmers.

PROJECT DESCRIPTION

This project is about building a smart irrigation and weather monitoring system using IoT technology. The main goal is to make plant watering more efficient and reduce water wastage by using real-time data. The system is built around the ESP32 microcontroller, which connects different sensors and sends data to the internet. In this system, a DHT11 sensor is used to measure temperature and humidity, while a soil moisture sensor checks how dry or wet the soil is. An MQ-8

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gas sensor is also included to monitor gas levels in the environment. All the sensor data is shown on a 16×2 LCD display so that it can be viewed directly at the site. The system is also connected to the Blynk mobile application, where users can see real-time data using gauges and indicators. This allows remote monitoring from anywhere. The irrigation motor is controlled using a relay module and works in two different modes. In automatic mode, the motor turns ON when the soil becomes dry and turns OFF when enough moisture is present. In manual mode, the user can control the motor directly through the mobile app. additionally; the system sends data to cloud platforms for storage and analysis. MATLAB is used to collect and analyse the data through an API, and graphs are generated to understand trends over time. The data is also uploaded to ThingSpeak, where it can be visualized and downloaded as an Excel file.

Overall, this project combines sensing, automation, and cloud technology to create a smart and efficient irrigation system. It helps in saving water, reducing human effort, and improving plant growth, making it useful for modern agriculture.

OBJECTIVE OF SYSTEM

The main objective of this project is to develop a smart and efficient irrigation system that can help in better water management and improve plant growth using IoT technology. The system is designed to reduce the need for manual watering and make the irrigation process automatic and reliable.

Another important objective is to continuously monitor environmental conditions such as temperature, humidity, soil moisture, and gas levels in real time. This helps in understanding the condition of the plant environment and taking timely actions when needed.

The system also aims to automate irrigation based on soil moisture levels so that water is supplied only when it is required. This helps in avoiding both overwatering and underwatering, which are common problems in traditional farming methods.

A further objective is to enable remote monitoring and control of the system using a mobile application. This allows users to check sensor data and control the water pump from anywhere using the internet.

In addition, the project aims to store and analyse data using cloud platforms and MATLAB. This helps in tracking changes over time and making better decisions for improving agricultural efficiency.

Overall, the objective is to create a low-cost, smart, and user-friendly system that saves water, reduces human effort, and supports modern agriculture practices. One of the key objectives is to continuously monitor important environmental parameters such as temperature, humidity, soil moisture, and gas levels using different sensors. This helps in understanding real-time field conditions without manual inspection.

Another objective is to automate the irrigation process based on soil moisture levels. The system should intelligently turn the water pump ON when the soil is dry and OFF when sufficient moisture is present, ensuring proper watering of plants. The project also aims to reduce water wastage by providing irrigation only when it is needed. This helps in conserving water resources and promoting sustainable agriculture practices.

Another important objective is to provide both manual and automatic control options. This allows users to switch between automated operation and manual control of the water pump depending on the situation.

The system is also designed to enable remote monitoring and control using IoT platforms like Blynk. This allows farmers or users to check field conditions and control irrigation from anywhere using a smartphone.

IV. ADVANTAGES & APPLICATIONS

ADVANTAGES

1. Efficient Water Usage

The system supplies water only when the soil moisture is low, which helps in avoiding unnecessary watering and saves a significant amount of water.

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2. Automation of Irrigation
Irrigation is controlled automatically based on sensor data, reducing the need for human intervention and making the process more reliable.

3. Real-Time Monitoring
Users can continuously monitor temperature, humidity, soil moisture, and gas levels in real time, helping them understand plant conditions better.

4. Remote Access and Control
Through the mobile application, users can check data and control the irrigation system from anywhere, providing convenience and flexibility.

5. Data Storage and Analysis
The system stores data on cloud platforms and allows analysis using MATLAB, which helps in tracking patterns and making better decisions.

6. Cost-Effective Solution
The system uses affordable components like ESP32 and basic sensors, making it suitable for both small and large-scale use.

7. Improved Plant Growth
By maintaining proper soil moisture and environmental conditions, the system supports healthier plant growth and better yield.

8. Time and Labor Saving
Since the system works automatically, it reduces the need for manual monitoring and watering, saving both time and effort.

Application:

1. Agriculture Fields
The system can be used in farms to automate irrigation and monitor crop conditions, improving efficiency and productivity.

2. Greenhouses
It helps maintain controlled environmental conditions inside greenhouses, ensuring optimal plant growth.

3. Home Gardening
Individuals can use this system to take care of their plants easily without needing constant attention.

4. Plant Nurseries
Nurseries can use the system to maintain proper moisture and environmental conditions for growing plants.

5. Parks and Lawns
Automatic irrigation can be applied in public parks and lawns to maintain greenery while saving water.

6. Landscaping Areas
It is useful in maintaining landscapes where regular watering is required but manual effort is difficult.

7. Research and Education
Students and researchers can use this system to study IoT, environmental monitoring, and smart agriculture techniques.

8. Urban and Rooftop Farming
The system supports modern farming methods in cities where efficient use of space and water is important.

V. RESULT

Easy to Upgrade: We proved the design is flexible by adding extra sensors (like ultrasonic ones for obstacle detection) without any issues.

High Value, Low Cost: We built the entire prototype using affordable parts, proving you don't need a massive budget to create a working surveillance tool.

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Better Reach: Since the car can move around, it was able to see into corners and hidden spots that a normal wall-mounted camera would miss.

A Great Learning Tool: It really proved its worth as a hands-on project for anyone studying robotics or smart tech, making complex ideas much easier to test.

VI. FUTURE SCOPE

In the future, this system can be further improved by adding more advanced sensors to measure additional parameters such as soil nutrients, pH level, and light intensity, which will provide a more complete understanding of plant health. The use of artificial intelligence and machine learning can make the system smarter by predicting irrigation needs based on past data and weather conditions. Integration with weather forecasting services can help adjust irrigation automatically by considering rainfall and temperature changes in advance. The mobile application can also be enhanced with better design, real-time alerts, and notifications to improve user experience.

Additionally, the system can be powered using solar energy, making it more suitable for remote and rural areas. It can also be expanded for large-scale farming by connecting multiple sensors and controllers across bigger fields. Future improvements may include automatic fertilizer control along with irrigation, which will further reduce manual effort and improve crop productivity. Advanced data analytics can provide detailed insights and suggestions for better decision-making. Moreover, the system can be integrated with other smart farming technologies to develop a fully automated and efficient agricultural solution.

VII. CONCLUSION

In conclusion, this project successfully demonstrates the development of a smart irrigation and weather monitoring system using IoT technology. By using the ESP32 microcontroller along with various sensors, the system is able to monitor environmental conditions like temperature, humidity, soil moisture, and gas levels in real time. The automatic irrigation feature ensures that plants receive the right amount of water based on soil conditions, which helps in reducing water wastage and improving plant growth.

The system also provides the flexibility of manual control through a mobile application, allowing users to operate it from anywhere. With the integration of cloud platforms and MATLAB, the collected data can be stored, analyzed, and visualized effectively. Overall, this project offers a simple, cost-effective, and reliable solution for smart agriculture. It reduces manual effort, saves resources, and shows how modern technology can be used to make farming more efficient and sustainable.

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