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Plant Monitoring and Automatic Irrigation Using IOT Technology

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ABSTRACT –

Smart agriculture is really picking up steam as a way to meet the growing demands for food production, conserve resources, and enhance farming efficiency. This paper introduces a Plant Monitoring and Automated Irrigation System powered by IoT, designed to optimize water usage and keep an eye on plant health in real-time. The system brings together various environmental sensors, including those for soil moisture, temperature, humidity, and CO_2, along with a camera module to assess plant conditions. An AI-driven decision-making algorithm analyzes the sensor data to activate irrigation exactly when it's needed. The ESP32 microcontroller acts as the central hub, connecting with the sensors and controlling a water pump. Real-time monitoring and control are facilitated through the Blynk IoT platform and MQTT protocol, while alerts and updates are communicated via an LCD module and SMS notifications. This comprehensive solution supports sustainable agriculture by cutting down on water waste, enhancing crop health, and reducing the need for manual intervention.

Keywords: IoT, smart farming, automated irrigation, plant health monitoring, ESP32, soil sensors, Blynk, AI-based irrigation.

INTRODUCTION

Agriculture is essential for both our economy and our daily lives. Yet, modern farming faces significant hurdles like limited resources, a shortage of workers, and unpredictable weather patterns. One major issue is the inefficient use of water, often stemming from outdated manual irrigation methods and a lack of timely monitoring of crops and environmental conditions. This can lead to either over-watering or under-watering, which ultimately reduces crop yields, wastes water, and drives up costs.

Fortunately, the rise of Internet of Things (IoT) technologies has opened the door to smart agriculture systems that can automatically oversee and manage farming tasks. By incorporating sensors and automation, farmers can now get real-time updates on soil and plant health, enabling them to make informed decisions and optimize their resources. In this project, we've developed a Plant Monitoring and automated irrigation System using the ESP32 microcontroller, various environmental sensors, and a camera module. This system keeps track of important factors like soil moisture, temperature, humidity, and CO_2 levels. It automatically turns on the irrigation system when the soil moisture falls below a set threshold. Plus, the camera module offers a visual check on plant health, while AI-driven logic helps with smart irrigation scheduling.

Data is sent wirelessly through the Blynk IoT platform and the MQTT protocol, allowing farmers to check the system's status from their mobile app or web interface. Alerts come through SMS and are also shown on an LCD, so users stay informed even when they're offline. This smart irrigation system is designed to cut down on manual work, boost crop yields, save water, and promote sustainable farming practices. It also keeps a record of historical sensor data for later analysis and visualization, which can help with decision-making for future irrigation cycles. With its modular and scalable design, it can easily be tailored to fit different types of crops and farm sizes, whether it's a small home garden or a vast agricultural field.

LITERATURE REVIEW

Smart Irrigation System Using ESP32 and Blynk Cloud (@2023 IEEE): This paper proposes the development of an automated irrigation system using the ESP32 microcontroller integrated with soil moisture and temperature sensors. The system connects wirelessly to the Blynk cloud to allow users to remotely monitor the soil condition and activate irrigation. The use of IoT simplifies data collection and automates watering based on real-time feedback. The implementation ensures efficient water usage while minimizing manual intervention by the farmer. Our proposed system builds on this concept by incorporating additional sensors and AI-based decision logic to enhance irrigation precision. The system in the referenced paper primarily focuses on the binary response of irrigation based on threshold values. In contrast, our system applies machine learning techniques to learn from sensor trends over time, enabling smarter irrigation scheduling. Additionally, the cited design lacks integrated alert mechanisms like SMS or LCD display, which our model incorporates for local and remote communication. Their approach demonstrates strong feasibility for low-cost smart farming, which we further enhance with scalability and visual plant health assessment.

Plant Health Monitoring with Deep Learning and Camera Modules (@2023 IEEE Access): This paper introduces a framework for detecting diseases in plants using images and deep convolutional neural networks (CNN) to classify their health status. The authors utilize leaf image datasets taken in natural settings and employ transfer learning with models like EfficientNet and Mobilenet. This approach enables early identification of plant diseases without the need for human inspection, ultimately enhancing farming results. We've taken this concept a step further by incorporating a camera module into our system, allowing us to monitor plant health in real time. This addition creates an AI-driven visual diagnosis layer within our automated irrigation system. The authors highlighted that classification accuracy improves significantly when images are captured in natural lighting, which supports our choice to use live camera feeds rather than relying on static datasets. Furthermore, the paper stresses the importance of choosing the right model architectures to strike a balance between accuracy and computational efficiency, aligning perfectly with our aim to implement lightweight models on embedded hardware like the ESP32. Their research illustrates how visual cues can boost decision-making when paired with sensor data, making it an ideal match for environmental monitoring. Our system enhances this by linking visual alerts with automated irrigation control, resulting in a fully intelligent agriculture assistant.

Smart Agriculture Monitoring and Control System Using IoT and Cloud (@2022 IEEE): This paper introduces a smart farming solution powered by IoT technology, designed to keep an eye on soil moisture, temperature, humidity, and pH levels. It utilizes a microcontroller that connects via GSM and Wi-Fi. The collected data is then sent to a cloud server, where it can be viewed on a mobile-friendly dashboard. While the system excels at gathering data and providing remote access, it falls short in offering real-time control features. Our enhanced system addresses this gap by incorporating dynamic irrigation logic, SMS and LCD alerts, and quick communication through MQTT. This upgrade boosts responsiveness, particularly in areas with unreliable networks, and lays the groundwork for future smart farming advancements. Plus, our system enables real-time local actions even without internet access, which is a game-changer for reliability in rural settings. Its modular design also ensures it can easily integrate with other agricultural technologies, like pest detection or nutrient management systems.

PROBLEM STATEMENT

Traditional irrigation methods often fall short, lacking real-time monitoring and leading to unnecessary water waste and lower crop yields. This project aims to tackle these issues by introducing an automated IoT-based system designed to enhance irrigation efficiency and improve plant health management.

OBJECTIVES

- To keep an eye on soil moisture, temperature, humidity, and CO_2 levels, we can use a variety of sensors.
- To automate irrigation based on real-time data from these sensors, ensuring we use water efficiently.
- To allow for remote monitoring and control through IoT platforms like Blynk and MQTT.
- To send user alerts via SMS and show data on an LCD screen.
- To create a smart irrigation system that is scalable, energy-efficient, and budget-friendly.
- To incorporate AI-driven analysis for better irrigation scheduling and monitoring of plant health.

METHODOLOGY

The system is built around an ESP32 microcontroller that connects to sensors measuring soil moisture, temperature, humidity, and CO_2 levels, allowing for real-time environmental monitoring. A camera module takes pictures of the plants to assess their health.

The ESP32 processes the sensor data and triggers a water pump through a relay when the soil moisture dips below set thresholds. It also uses smart algorithms to fine-tune watering schedules, helping to minimize water waste. Users can stay connected through the Blynk IoT platform and MQTT protocol, which allows for real-time remote monitoring and control via mobile apps and web interfaces. An LCD screen shows the local system status, giving users instant feedback.

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The methodology is divided into three parts.

The first part is on the design structure, followed by hardware setup description and the finally on the software programming design All these three parts were assembled together and experiments were then performed to build a system

SYSTEM DESIGN

The system is built around the ESP32, which acts as the central microcontroller—the brain behind the whole operation. It gathers data from all the connected sensors and runs the control logic for irrigation. You'll find sensors like soil moisture, a DHT11 for temperature and humidity, CO_2 sensors, and even a camera module hooked up to the ESP32. When the sensors pick up low soil moisture or signs of plant stress, the ESP32 activates a relay that turns on the water pump for irrigation.

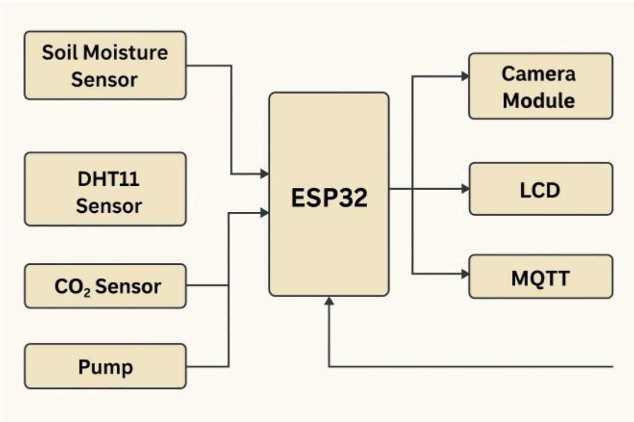

Figure 1: Block Diagram

To keep you informed, a LCD module displays real-time sensor readings, system status, and alerts. Plus, the ESP32 connects to the Blynk IoT platform and an MQTT broker to upload sensor data and receive control commands. If any critical values are detected, SMS notifications are sent out through a GSM module to keep users in the loop.

The whole system is powered by a 12V adapter, which is regulated down to safe levels for the ESP32 and its connected sensors. The modular wiring design makes maintenance a breeze and allows for easy scalability. This complete hardware setup enables real-time monitoring, automates irrigation, tracks plant health visually, and provides remote access through a mobile app.

RESULT AND DISCUSSIONS

This project focuses on creating a Plant Monitoring and Automated Irrigation System that utilizes an ESP32 microcontroller. It has been successfully tested to keep track of soil moisture, temperature, humidity, and CO_2 levels in real time.

Experimental work has been carried out carefully.

The system smartly manages irrigation by turning on a relay-controlled water pump whenever the soil moisture dips below a certain level. Users can easily keep track of real-time sensor data and system status on the LCD display.

Sensor information is sent to the Blynk IoT platform using MQTT, allowing for remote monitoring. Plus, SMS alerts keep users informed about critical conditions through the GSM module, ensuring they can respond quickly, even when they're not online.

The system has proven to be dependable, cost-effective, and scalable. It helps conserve water, cuts down on manual labor, and guarantees timely irrigation. Plus, the inclusion of a camera module offers extra insights into plant health. All in all, this model enhances agricultural efficiency and aligns with the goal of sustainable farming through automation and smart monitoring.

The Following figure shows the hardware setup of the proposed system:

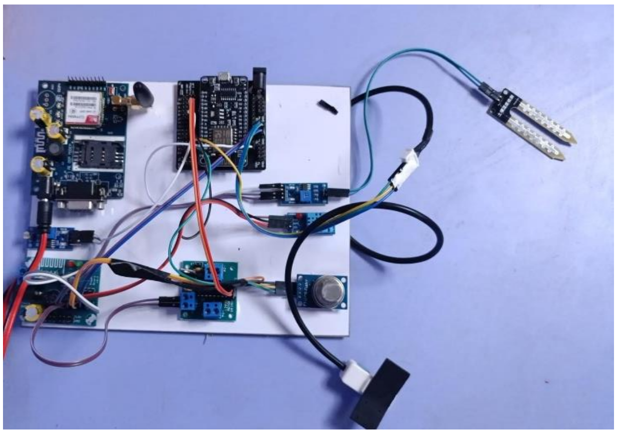

Figure 2: Result of Hardware

CONCLUSION

This project introduces a cutting-edge automated irrigation system that requires very little human oversight, all aimed at boosting agricultural efficiency. The system effectively keeps track of essential environmental factors like soil moisture, temperature, humidity, and CO_2 levels through IoT sensors. It automatically activates irrigation based on real-time data, which helps to minimize water waste and enhances the reliability of crop yields.

Remote monitoring and control are made possible through the Blynk IoT platform and the MQTT protocol. Critical alerts are sent via SMS and shown on an LCD screen. Plus, with the addition of a camera module, you can visually check on the health of your plants, which really helps with smart farm management. All in all, this system is scalable, energy-efficient, and budget-friendly, making it a great fit for both small and large farming operations.

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