CW8: IoT-Based Soil Moisture Controlled Irrigation System

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1. Introduction

Smart irrigation systems leverage Internet of Things (IoT) technologies to optimize water usage in agriculture. By integrating soil moisture sensing, automated control, and cloud-based monitoring, farmers can irrigate crops more efficiently, reduce water wastage, and improve productivity. This project demonstrates a practical implementation using an ESP32, a soil moisture sensor, and the ThingSpeak cloud platform.

2. Problem Statement

Traditional irrigation methods rely heavily on manual observation or fixed schedules, often resulting in over-irrigation or under-irrigation. This leads to water wastage, increased costs, and poor crop yield. Smallholder farmers in Uganda frequently struggle with inconsistent watering due to limited monitoring tools. There is therefore a need for an automated, data-driven irrigation solution.

3. Proposed Solution

This project implements an IoT-based soil moisture controlled irrigation system using an ESP32 microcontroller, a soil moisture sensor, and a relay-controlled water pump (simulated with an LED in Wokwi). The system continuously monitors soil conditions and automatically activates irrigation when the soil is dry while stopping it when the soil is sufficiently wet. All sensor data is uploaded to ThingSpeak for real-time visualization and historical analysis.

4. System Architecture

The system consists of a soil moisture sensor connected to an ESP32. The ESP32 processes sensor data and transmits it via Wi-Fi using HTTP to the ThingSpeak cloud platform. ThingSpeak stores the data in Field 1 (Soil Moisture) and provides live charts and analytics. The farmer can remotely view trends and irrigation status from any internet-enabled device.

5. Hardware Components

- ESP32 Microcontroller
- Soil Moisture Sensor (Analog)
- Relay Module
- Water Pump (simulated with LED in Wokwi)
- Wi-Fi Network

6. Communication and Cloud Integration (ThingSpeak)

Data communication is implemented using HTTP POST requests to the ThingSpeak API. The ESP32 uploads soil moisture values to Field 1 of a ThingSpeak channel every 5 seconds. ThingSpeak provides live visualization through line charts and allows export of historical data for further analysis. This approach eliminates the need for a local server and enables remote monitoring from anywhere.

7. Results

In simulation, the pump automatically turns ON when soil moisture readings indicate dry conditions and turns OFF when adequate moisture is detected. Live data is successfully transmitted to ThingSpeak, where clear trends can be observed showing moisture variations over time. This validates the effectiveness of the automated control logic.

8. Key Benefits

- Reduced water wastage
- Lower labor requirements
- Improved crop health and yield
- Real-time remote monitoring
- Historical data for decision making

9. Conclusion

The smart irrigation system demonstrates how IoT can improve agricultural efficiency through automation and cloud-based monitoring. By integrating ESP32 sensing with ThingSpeak analytics, the system conserves water, reduces manual effort, and supports data-driven farming. This project is scalable and can be extended to include weather data, multiple sensors, or mobile alerts in future work.