IoT-Based Smart Irrigation System Using Soil Moisture Sensor and ESP8266 NodeMCU

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Date: July 2025

Abstract

Water scarcity and increased demand for agricultural productivity have driven the adoption of smart irrigation technologies. This project introduces an IoT-based Smart Irrigation System that automates water flow based on real-time soil moisture readings. Using a soil moisture sensor and ESP8266 NodeMCU microcontroller, the system monitors soil conditions and controls a water pump accordingly. It ensures efficient water usage, reduces manual effort, and can optionally provide data monitoring through cloud platforms. This report outlines the system design, working, implementation, and future scope.

1 Introduction

Agriculture consumes nearly 70% of the world's freshwater. In regions with unpredictable rainfall or manual irrigation, water is often used inefficiently, harming both crops and the environment. Integrating the Internet of Things (IoT) into irrigation allows farmers to automate watering based on real-time data, conserving water and improving yield.

The proposed system uses a soil moisture sensor to detect the water level in soil and, depending on the value, triggers a water pump through the ESP8266 NodeMCU. The microcontroller is programmed to take threshold-based decisions, and can optionally push the data to an online platform such as Blynk or ThingSpeak for real-time visualization.

2 Objectives

- To build a cost-effective smart irrigation system using open-source hardware.
- To automate the irrigation process by detecting soil moisture levels.
- To conserve water by irrigating only when necessary.
- To reduce dependency on manual monitoring and labor.
- To provide the option for remote data monitoring via cloud-based IoT platforms.

3 Components Used

Component	**Description**
ESP8266 NodeMCU	Microcontroller with built-in Wi-Fi, acts as the brain of the system
Soil Moisture Sensor	Senses the volumetric water content in soil
Relay Module	Acts as a switch to control the pump
Water Pump	Delivers water to the plant when activated
Breadboard and Jumper Wires	Used for prototyping the circuit
Power Supply	Provides operating voltage to components

Table 1: List of Components Used

4 Circuit Overview

The soil moisture sensor's analog output is connected to pin A0 of the NodeMCU, and a relay module is connected to a digital pin (e.g., D1). When the sensor detects that the soil is dry, the NodeMCU sends a signal to the relay, activating the water pump.

- Dry soil → Low moisture reading → Pump ON
- Wet soil → High moisture reading → Pump OFF

Circuit Diagram:

5 Arduino Code and Explanation

The ESP8266 NodeMCU is programmed using Arduino IDE. The logic involves reading analog values from the soil moisture sensor and toggling the relay to control the water pump.

Sample Code

```
#define sensorPin A0
#define relayPin D1

int sensorValue = 0;
int threshold = 500; // Adjust based on calibration

void setup() {
  Serial.begin(9600);
  pinMode(sensorPin, INPUT);
  pinMode(relayPin, OUTPUT);
  digitalWrite(relayPin, HIGH); // Pump OFF initially
}

void loop() {
  sensorValue = analogRead(sensorPin);
  Serial.println(sensorValue);

  if (sensorValue < threshold) {
    digitalWrite(relayPin, LOW); // Turn ON pump
  } else {
    digitalWrite(relayPin, HIGH); // Turn OFF pump
  }

  delay(1000);
}
```

Explanation

- The analog soil moisture value is read from pin A0.
- A threshold is set based on dry/wet soil calibration.
- If the sensor value is below the threshold (dry soil), the pump is turned ON.
- If above threshold (wet soil), the pump is turned OFF.
- Serial Monitor is used to observe real-time values for debugging.

6 Cloud Integration (Optional)

For real-time remote monitoring and control, platforms such as **Blynk** or **ThingSpeak** can be integrated using Wi-Fi capabilities of the NodeMCU.

Features

- Real-time visualization of soil moisture on mobile app or web dashboard.
- Optional manual control over the pump.
- Historical data logs and alerts.

Blynk Integration (Example)

- Use Blynk library and app to link NodeMCU via Auth token.
- Send sensor values to Virtual Pins (e.g., V0) for real-time display.
- Add button widget to remotely turn pump ON/OFF.

7 Results and Observations

- The system successfully detects soil dryness and activates the pump automatically.
- Manual testing confirmed that the pump shuts off once the soil reaches adequate moisture.
- When integrated with Blynk, the real-time graph and control interface worked as expected.
- The threshold value needs to be tuned depending on the soil type and sensor used.

Observation Table:

Soil Moisture Reading	Condition	Pump Status
< 500	Dry	ON
≥ 500	Wet	OFF

Table 2: Sensor Response Table

8 Conclusion and Future Work

This project successfully demonstrates the potential of IoT in automating irrigation processes. Using simple components like ESP8266 and a soil moisture sensor, we built a working prototype that detects soil dryness and activates irrigation without manual intervention.

Future Enhancements

- Adding temperature/humidity sensors for improved environmental monitoring.
- Implementing solar-powered operation for off-grid deployments.
- Enhancing cloud integration for advanced analytics and mobile notifications.
- Adding multiple sensor nodes to monitor large-scale agricultural fields.

Overall, the system is cost-effective, scalable, and can significantly improve water conservation efforts in agriculture.

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