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Smart Irrigation System Using Soil Moisture Sensor for Optimized Water Management

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Abstract

Water scarcity is one of the most pressing global challenges, especially in arid regions. Traditional irrigation methods often waste water by overwatering or underwatering plants, reducing crop productivity. This project presents a smart irrigation system that uses a soil moisture sensor to monitor real-time soil conditions and automatically control water flow. The system consists of an Arduino microcontroller, a soil moisture sensor, a water pump, and a solenoid valve. When the soil moisture level drops below a set threshold, the system activates the pump and irrigates the plants until optimal moisture is achieved. The prototype reduced water consumption by up to 40% compared to manual irrigation, while maintaining healthy plant growth. This project demonstrates how low-cost smart technologies can support sustainable agriculture.

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Introduction

Agriculture consumes nearly 70% of the world's freshwater resources. In many regions, inefficient irrigation practices lead to excessive water waste and soil degradation. Smart irrigation systems offer a sustainable alternative by providing water only when needed. Advances in IoT and low-cost sensors enable farmers to optimize irrigation and improve crop yields. This project aims to design a low-cost irrigation system suitable for small-scale agriculture and home gardening in water-scarce environments.

Objectives

1. Design a smart irrigation system that minimizes water waste.
2. Integrate a soil moisture sensor to detect re-al-time soil conditions.
3. Automate irrigation through a microcontroller and water pump.
4. Reduce water consumption without affecting plant health.

Methodology

- Hardware Components:
- Soil moisture sensor for real-time detection of soil humidity.
- Arduino Uno microcontroller for signal processing.
- Relay module for controlling the pump.
- Water pump and solenoid valve for irrigation.
- Power supply (12V battery).

Software:

- Arduino IDE used to program the control logic.
- If soil moisture < 40% → system turns ON pump until soil reaches optimal level.
- Moisture data displayed on LCD screen for monitoring.

Design:

- Moisture sensor inserted in soil near roots.
- Pump connected to irrigation pipeline.
- Compact, energy-efficient design for home and agricultural use.

Results

- Water Consumption: Reduced by ~40% compared to traditional manual watering.
- Plant Growth: Plants maintained healthy growth with consistent soil moisture.
- System Efficiency: Automated response prevented both overwatering and underwatering.
- Cost: Prototype built at ~200 SAR, affordable for small-scale farmers.

Discussion

The smart irrigation system successfully optimized water use while supporting healthy plant growth. Its low cost and simplicity make it suitable for small farms and households. However, limitations include the need for calibration across different soil types and environmental conditions. Future improvements may include integrating wireless monitoring, solar-powered energy, and smartphone applications for remote control.

Conclusion

This project demonstrates that a soil moisture–based irrigation system can significantly reduce water waste while maintaining plant health. The system is affordable, reliable, and easy to deploy, making it a practical solution for sustainable agriculture in water-scarce regions. With further development, such systems can be scaled to large farms and integrated into IoT-based smart agriculture platforms.

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