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Design and Implementation of a Smart Irrigation System Using Arduino and IoT

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Abstract :

This paper presents the design and implementation of a cost-effective and efficient Smart Irrigation System aimed at optimizing water usage in agricultural and gardening applications. The system utilizes an Arduino uno microcontroller as its central processing unit, interfaced with a soil moisture sensor (FC-28) to monitor real-time soil conditions. When the moisture level falls below a predefined threshold, the system automatically activates a water pump via a relay module, ensuring precise irrigation only when necessary. The prototype demonstrates significant water conservation compared to traditional timer -based methods. The system is scalable and can be integrated with IoT modules for remote monitoring and control, making it a viable solution for modern sustainable agriculture.

Keywords: **Smart Irrigation, Arduino, Soil Moisture Sensor, Water Conservation, IoT, Automation, Agriculture**

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I.INTRODUCTION

This paper details the development of an automated Smart Irrigation System designed to enhance water use efficiency. The core objective is to create a system that monitors soil moisture in real-time and triggers irrigation automatically, thereby eliminating human intervention and reducing water consumption. The system is built around an Arduino uno microcontroller, which processes data from a soil moisture sensor and controls a water pump through a relay module. The proposed solution is low-cost, easy to implement, and suitable for small-scale farms, gardens, and urban agriculture. Future enhancements can include IoT connectivity for remote data access and control via mobile applications.

II. SYSTEM ARCHITECTURE

- **Soil Moisture Sensing Module** This module continuously monitors soil moisture levels using the FC-28 soil moisture sensor. The sensor measures the volumetric water content in the soil and provides analogy readings to the microcontroller. When moisture levels drop below the predefined threshold, it triggers the irrigation process.
- **Water Pump Control Module** This module controls the water pump through a relay module based on commands from the Arduino. The relay acts as a switch that can handle the high current requirements of the water pump, ensuring safe operation of the low-voltage control circuit.
- **Central Processing Module (Arduino Microcontroller)**

This module acts as the brain of the system. It processes data from the soil moisture sensor, compares it with the threshold value, and controls the relay module to activate or deactivate the water pump. It also manages the system timing and provides status updates.

❖ **Power Supply Module**

The system is powered by a combination of sources. The Arduino and sensors operate on 5V DC, while the water pump requires an external power source (typically 12V). The relay module provides electrical isolation between the low-voltage control circuit and high-voltage pump circuit.

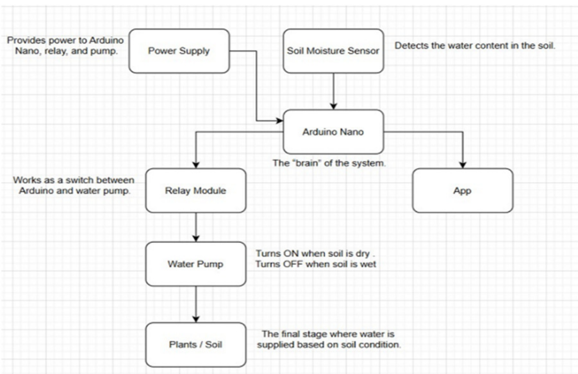

Figure 1: Architecture diagram

III.RELATED WORK

Several research studies and prototypes have explored automated irrigation systems using various technologies and approaches:

3.1.Timer-Based Irrigation Systems – Traditional automated systems use predetermined schedules for irrigation, operating at fixed time intervals. However, these often lead to significant water wastage as they don't account for actual soil moisture conditions, rainfall, or seasonal variations. This approach fails to adapt to changing environmental factors.

3.2.Commercial Sensor-Based Systems – Advanced agricultural systems from companies like Netafim and Jain Irrigation use sophisticated soil moisture sensors and weather stations. While effective, these systems are often cost-prohibitive for small-scale farmers and home gardeners, limiting their widespread adoption in developing regions.

3.3.Arduino-Based Academic Prototypes – Various academic projects have demonstrated the effectiveness of Arduino microcontrollers in agricultural automation. While these prototypes show promising results in controlled environments, many lack the reliability, weatherproofing, and scalability required for real-world agricultural applications.

3.4.IoT-Enabled Precision Agriculture – Emerging solutions integrate cloud platforms and data analytics for farm management. These systems offer comprehensive monitoring but often involve high operational costs, complex maintenance, and dependency on multiple technologies, making them impractical for small to medium-scale applications.

a. Thus, while existing solutions provide various levels of automation, there is a significant gap in providing cost-effective, reliable, and easily implementable irrigation systems that can automatically respond to real-time soil.

IV.PROPOSED METHODOLOGY

The architecture of the Smart Irrigation System is divided into four core modules:

4.1.Soil Moisture Monitoring Module

- Uses FC-28 soil moisture sensor to measure the volumetric water content in soil through electrical conductivity principles.

4.2.Central Processing and Decision Module

- Arduino microcontroller serves as the brain, processing real-time sensor data and making irrigation decisions

- Manages system hysteresis to avoid rapid on/off switching near the threshold point

4.3.Water Pump Control Module

- Utilizes relay module to safely control high-power water pump using low-voltage Arduino signals
- Provides electrical isolation between the 5V control circuit and 12V pump power supply.

4.4.Status Monitoring Module

- Visual LED indicators provide immediate system status - LED ON during pump operation, OFF during monitoring

4.5.System integration & Communication module

- Uses serial communication protocol to enable data exchange between Arduino, sensors, and optional external display modules
- Implements USB connectivity for real-time monitoring and parameter configuration through computer interface
- Provides expansion capability for additional sensors and modules, allowing system upgrades without hardware modifications

V.SYSTEM WORKFLOW:

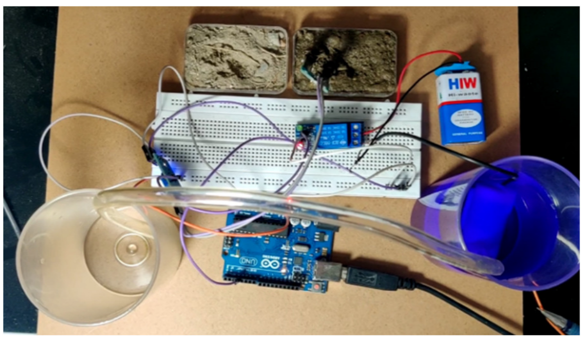

Figure 3: prototype

- Soil moisture sensor continuously monitors soil conditions → Arduino reads analogy values and compares with threshold → If moisture below threshold, activate relay to start water pump → Pump runs for predefined duration → System deactivates pump and resumes monitoring.

5.1. Power Supply Module

- The power supply module provides stable power to all system components. The Arduino Uno operates on 5V DC supplied via USB or external 7-12V adapter. The soil moisture sensor draws power from the Arduino's 5V pin, while the relay module is powered through the Arduino's digital pins. For the water pump, a separate 12V DC power supply is used, controlled through the relay to ensure electrical isolation between low-voltage control circuits and high-power pump operation.

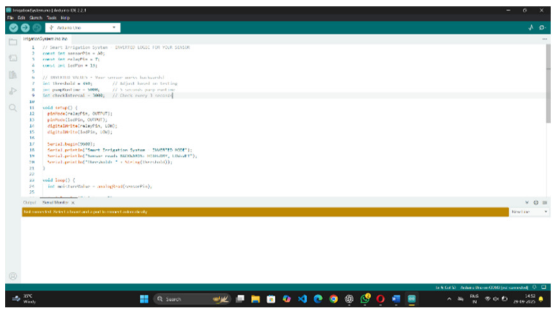

Figure 2: Arduino ide screenshot

5.2. Soil Moisture Sensing Module

- The soil moisture sensing module uses an FC-28 sensor to measure soil water content through electrical conductivity principles. The sensor's two probes inserted into the soil measure resistance which inversely correlates with moisture levels. The sensor provides analogy readings from 0-1023, with lower values indicating drier soil and higher values indicating wetter conditions.

5.3. Water Pump Control Module

- The water pump control module manages irrigation through a relay switch. When soil moisture drops below the threshold, the Arduino sends a HIGH signal to the relay module.

5.4. Central Processing & Control Module

- The Arduino Uno microcontroller serves as the system's brain, continuously processing sensor data and making irrigation decisions. It reads analogy values from the moisture sensor, compares them with the predefined threshold, and controls the relay accordingly.

5.5. System Timing & Coordinates Module

- The timing module manages intervals between system operations. It implements configurable delays between moisture readings (typically 3-30 seconds) to allow proper water absorption.

VI. FUTURE WORK

- **IoT Integration:** Extend the system with cloud platforms (Blynk, Firebase, Things Board) to store irrigation logs, monitor system performance, and enable remote control and diagnostics through web interfaces.
- **Mobile Application:** Develop a dedicated Android/iOS application to provide real-time soil moisture monitoring, irrigation scheduling, water usage statistics, and manual pump control from smartphones.
- **Weather Integration:** Incorporate weather forecasting APIs and rain sensors to adjust irrigation schedules based on predicted rainfall, temperature, and humidity conditions for optimal water conservation
- **Multi-Zone Expansion:** Scale the system to support multiple irrigation zones with independent soil moisture sensors and relay controls, allowing customized watering for different plant types and garden sections.
- **Solar Power Integration:** Implement solar panels with battery storage to create a completely self-sufficient system, making it ideal for remote agricultural applications and reducing operational costs.
- **Water Quality Monitoring:** Integrate pH and nutrient sensors to monitor soil health and provide insights for fertilizer application, creating a comprehensive plant care system.

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AUTHOR PROFILE

S. PARTHIBAN is working as an Assistant Professor at Kongunadu College of Engineering and Technology, with thirteen years of teaching experience. He pursued his Bachelor of Engineering – Computer Science Engineering at Kurunji College of Engineering and Technology in 2009. Subsequently, he pursued his Master of Engineering with a Specialization in Computer Science and Engineering at JJ college of Engineering and Technology in 2013. He is currently pursuing his Ph.D. with a focus on Data Mining

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