Smart Plant Watering System*

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***Abstract*—The Smart Plant Watering System is a cost-effective and efficient solution aimed at automating the irrigation process for small-scale gardens and plant setups. This project utilizes an Arduino Uno microcontroller as the central control unit, paired with a soil moisture sensor to continuously monitor the moisture content in the soil. When the sensor detects that the soil has dried beyond a predefined threshold, the system activates a water pump through a relay module to supply water to the plant via a connected water pipe. A 16x2 LCD module is included to display real-time status updates such as moisture levels and pump activity, providing users with valuable feedback on the system's operations. All components are integrated on a breadboard using jumper wires and powered by a battery, making the system portable and easy to assemble. This automated system eliminates the need for manual watering and ensures that plants receive adequate moisture, especially useful for users who are unable to tend to their plants regularly. By preventing both overwatering and underwatering, this project promotes healthier plant growth and contributes to water conservation in domestic gardening applications.**

***Index Terms*—component, formatting, style, styling, insert**

I. Introduction

The increasing global demand for food and greenery has made efficient water usage a critical concern in both agriculture and home gardening. Traditional irrigation methods often result in either overwatering or underwatering, which can harm plant health and waste precious water resources. With rapid advancements in embedded systems and automation technologies, smart irrigation solutions are becoming increasingly feasible and necessary. A smart plant watering system offers a practical approach to address these challenges by automating the irrigation process based on real-time soil conditions.

This project focuses on building a low-cost and user-friendly system for automating plant irrigation, especially suited for households, indoor gardens, and small agricultural setups. The motivation behind this project is to reduce manual labor, prevent water wastage, and ensure healthy plant growth through timely watering. By integrating basic electronic components with a microcontroller, the system intelligently determines when plants require water and responds accordingly. In the following sections, the design, implementation, and benefits of the proposed system are discussed in detail.

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II. Literature Review

In this paper An automated plant watering system designed to reduce manual intervention and optimize water usage for home gardens and agricultural fields. The system is built around an ATmega328 microcontroller, which monitors real-time soil moisture using a sensor and controls a water pump through a relay module.

When the moisture level drops below a defined threshold, the pump is triggered to water the plant. Additionally, the system includes a mobile application that notifies users about the system's status and alerts them to refill the water tank when needed. With its scheduled watering capability and sensor-based control, the system ensures efficient irrigation while maintaining plant health and minimizing water wastage. [1]

In this paper An automated plant watering system designed to improve irrigation efficiency and reduce manual labor. The system utilizes an Arduino UNO R3 and a soil moisture sensor to monitor soil moisture levels in real-time. When the soil dries out, a relay-controlled submersible pump is triggered to irrigate the plants. The system can target specific areas of a field using multiple sensors and includes a rain detection feature to prevent unnecessary watering during rainfall. Additionally, a mobile interface allows farmers to control and monitor the system, promoting water conservation and smarter farming practices, particularly in areas with labor shortages or inconsistent rainfall. [2]

In this paper An Arduino Nano-based automated gardening system using a soil moisture sensor, relay module, and water pump to maintain optimal soil moisture. The system automatically waters the plant when dryness is detected and stops when sufficient moisture is reached. Simulation in Proteus ensured system reliability, and the authors emphasized its potential for sustainable agriculture and future integration with AI. [3]

III. Components Used

This section details the hardware components utilized in the Smart Plant Watering System. Each component has been carefully selected to ensure that the system operates efficiently and effectively.

Arduino Uno: The central microcontroller of the system, the Arduino Uno processes the signals from the soil moisture sensor and controls the operation of the relay module and water pump based on the moisture levels detected in the soil.

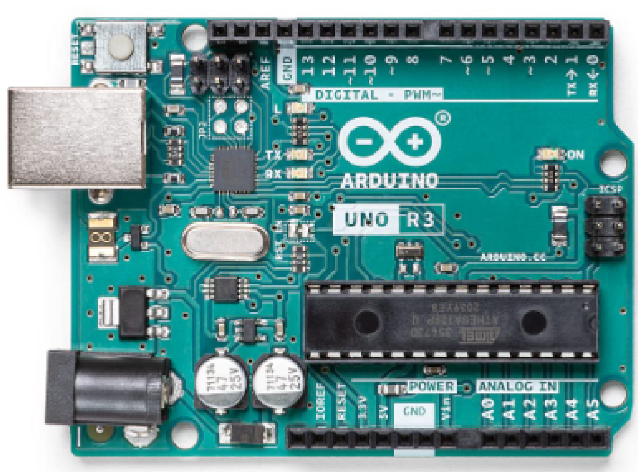

Fig. 1. Arduino Uno Microcontroller

Soil Moisture Sensor: This sensor monitors the moisture level in the soil and sends the data to the Arduino. If the soil moisture level falls below a predefined threshold, the Arduino triggers the water pump to irrigate the plant.

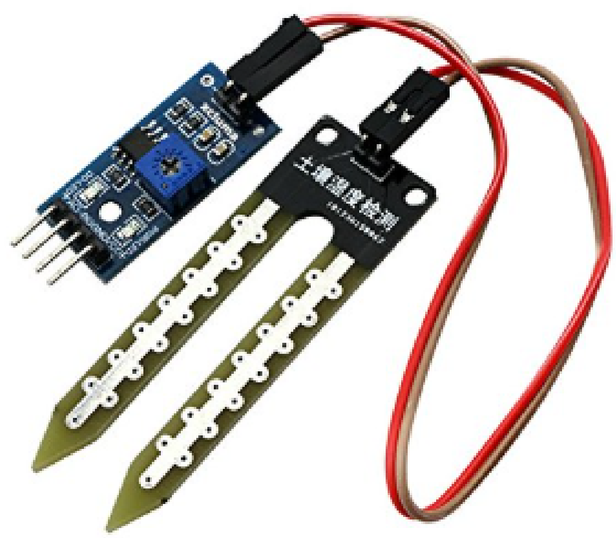

Fig. 2. Soil Moisture Sensor

Relay Module: The relay module acts as a switch, controlled by the Arduino. It enables the Arduino to turn the 5V water pump ON or OFF, depending on the soil moisture level.

Fig. 3. Relay Module

LCD Module with I2C: The 16x2 LCD display with I2C interface shows real-time system information, such as current soil moisture levels and the operational status of the water pump, providing easy monitoring of the system.

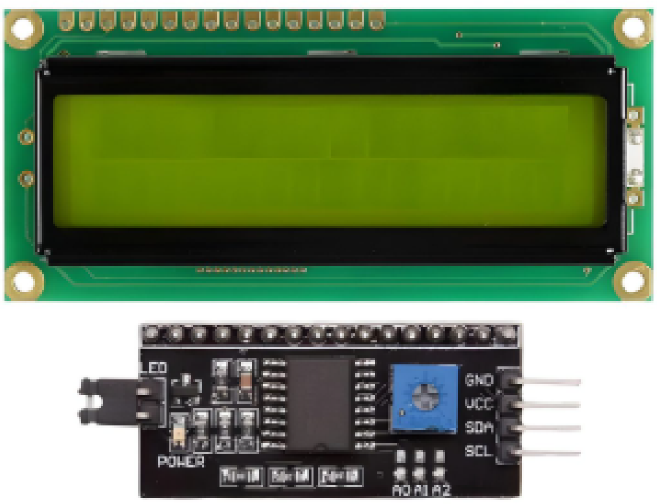

Fig. 4. LCD Module with I2C

5V WaterPump: The water pump, activated by the relay module, delivers water through the connected water pipe to irrigate the plant when the soil moisture is insufficient.

Fig. 5. 5V Water Pump

Jumper Wires and Breadboard: Jumper wires and a breadboard are used to make temporary connections between components without the need for soldering, facilitating easy prototyping and testing.

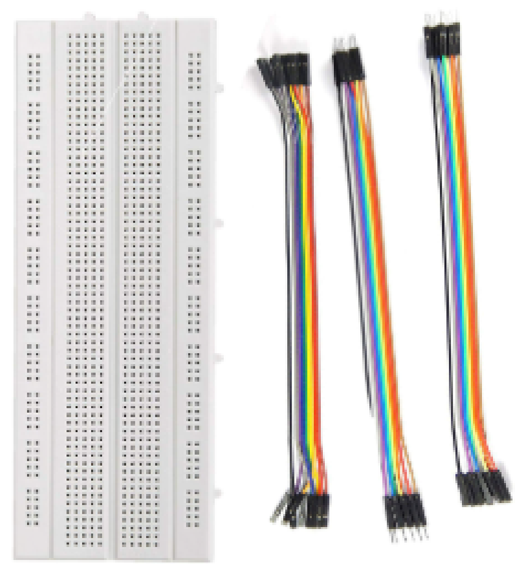

Fig. 6. Jumper Wires and Breadboard

Water Pipe: A flexible water pipe is used to deliver water from the pump to the plants, ensuring efficient irrigation.

Fig. 7. Water Pipe

IV. Methodology

The Smart Plant Watering System is designed to automatically water plants based on soil moisture levels. The system utilizes an Arduino Uno microcontroller for processing sensor data, and a relay module to control the water pump. The methodology for building the system involves the following steps:

- **Sensor Selection and Threshold Setup:** The key sensor used in this system is a soil moisture sensor that provides an analog output based on the moisture content in the soil. The sensor's reading is mapped to a threshold to determine the need for irrigation. The thresholds are set as:
  - **Dry (Moisture Value** > 950**):** Indicates that the soil is dry, and the system needs to water the plant.
  - **Wet (Moisture Value** < 500**):** Indicates that the soil has enough moisture, so the system will not water the plant.
  - **Medium** ($500 \geq$ **Moisture Value** ≤ 900 **):** Indicates that the moisture is in a moderate range, and the pump will operate briefly to ensure sufficient moisture.
- **System Control Logic:** Based on the moisture data from the sensor, the Arduino Uno processes this input and makes decisions:
  - If the moisture is dry (greater than 800), the pump is turned on.
  - If the moisture is wet (below 500), the pump remains off.
  - If the moisture is in the medium range (between 500 and 800), the pump is activated for a short period (2 seconds) to add water.
- **User Interface:** The system provides real-time feedback to the user using a 16x2 LCD module with I2C. This LCD continuously displays the current moisture level, the status of the pump (ON/OFF), and whether the system is watering the plant.

The approach is designed to optimize water usage and ensure that the plant receives the right amount of water at the right time, without human intervention.

A. Circuit Connections

The Smart Plant Watering System's components are connected as follows:

- **Soil Moisture Sensor:**
  - VCC $\rightarrow$ 5V on Arduino Uno
  - GND $\rightarrow$ GND on Arduino Uno
  - Analog Output $\rightarrow$ A0 on Arduino Uno
- **Relay Module:**
  - IN $\rightarrow$ Digital Pin 7 on Arduino Uno
  - VCC $\rightarrow$ 5V on Arduino Uno
  - GND $\rightarrow$ GND on Arduino Uno
  - Common (COM) $\rightarrow$ One terminal of the water pump
  - Normally Open (NO) $\rightarrow$ 5V power supply (from external source or Arduino)
- **Water Pump:**
  - Connected between the relay's NO terminal and GND of the power supply
  - Controlled by the relay to turn ON/OFF based on sensor readings
- **LCD Display with I2C:**
  - SDA $\rightarrow$ A4 on Arduino Uno
  - SCL $\rightarrow$ A5 on Arduino Uno
  - VCC $\rightarrow$ 5V on Arduino Uno
  - GND $\rightarrow$ GND on Arduino Uno

All components share a common ground, and jumper wires and a breadboard are used for connecting the modules during prototyping. The relay acts as a switch that isolates the low-power logic of the Arduino from the higher-power motor.

V. Implementation

The Smart Plant Watering System was implemented using the Arduino Uno, connected with various components, and programmed to automate the irrigation process. Below is the breakdown of the system's hardware and software implementation.

- **Hardware Implementation:**
  - The **Soil Moisture Sensor** was connected to the analog pin A0 on the Arduino to measure the soil moisture. The sensor reads the moisture level and outputs an analog signal that the Arduino processes.
  - The **Relay Module** was connected to pin 7 of the Arduino. It controls the state of the 5V water pump. When the soil is dry, the relay is triggered to allow the pump to activate.
  - The **Water Pump** was connected to the relay, which controls whether the pump is on or off. The pump is activated when the soil is dry or when the moisture level is medium.
  - The **LCD Display** was connected via I2C to the Arduino to show the moisture level and pump status on a 16x2 display. This allows users to monitor the system's performance.
- **Software Implementation:**
  - The program starts by initializing the LCD display and setting the relay pin as an output.
  - The Arduino then continuously reads the soil moisture sensor and calculates an average moisture level from multiple readings for better accuracy.
  - Based on the average moisture level, the system compares the readings to the predefined thresholds:
    - If the moisture value is above the dry threshold (950), the pump is activated.
    - If the moisture value is below the wet threshold (500), the pump is turned off.
    - If the moisture is in the medium range (500-900), the pump is briefly activated to water the plant for 2 seconds.

  - The LCD is updated every second to show the current moisture level and the pump's status.
- **System Behavior:** The system operates in a continuous loop. It constantly reads the moisture levels and makes decisions based on the conditions. If the soil is dry, the system waters the plant; if the soil is wet, no action is taken. The LCD serves as a user-friendly interface to display real-time data.

This integration of hardware and software ensures that the plant receives the right amount of water at the right time, making the system fully automated and efficient.

VI. Results Analysis

The proposed system employs a threshold-based control mechanism to regulate soil moisture levels through autonomous irrigation. The hardware implementation operates as follows:

- When the soil moisture sensor detects dry conditions (readings > 950), the control circuit activates the water pump continuously until moisture levels improve.
- For moderately dry soil ($500 \leq$ reading ≤ 950), the system engages the pump for a fixed 2-second duration before automatically deactivating, providing measured hydration while preventing waterlogging.
- The pump remains inactive when sensor readings indicate adequately moist soil (readings < 500), completing the control loop.

This deterministic approach ensures efficient water utilization while maintaining optimal soil hydration levels. The system's binary decision-making, based on clearly defined moisture thresholds, provides reliable operation with minimal computational overhead.

The implementation demonstrates effective closed-loop control through:

- Real-time soil moisture monitoring
- Threshold-based actuation logic
- Direct pump control via electromechanical relay
- Continuous status feedback through LCD and serial interfaces

VII. Conclusion

In this paper, we have presented the design and implementation of a Smart Plant Watering System that automates the process of watering plants based on soil moisture levels. The system, built around an Arduino Uno, utilizes a soil moisture sensor to measure the soil's moisture content and activates a water pump when the soil is dry or moderately moist. The system successfully categorizes the soil moisture into three states: Dry, Medium, and Wet, and responds by either turning the pump on or off as required.

The system was tested under different conditions, and the results demonstrated its effectiveness in providing optimal irrigation. The LCD module displayed the moisture readings in real-time, ensuring users are informed of the system's current status. The relay module controlled the pump accurately, preventing overwatering by turning off the pump when the soil was wet.

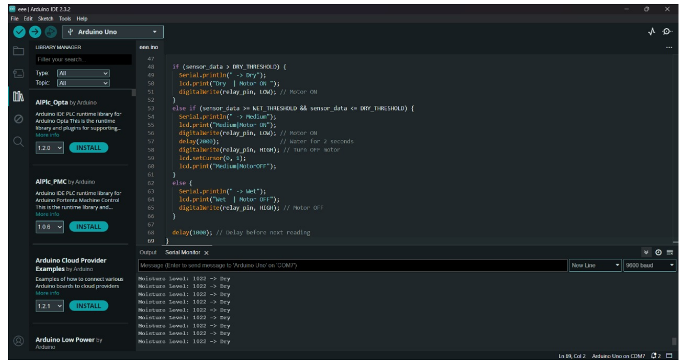

Fig. 8. Moisture levels for dry soil

Overall, the Smart Plant Watering System provides an efficient solution for automated plant care, ensuring the plants receive the right amount of water without the need for constant manual intervention. The system achieved its objectives and offers a practical, low-cost approach to smart irrigation.

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