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Smart Irrigation System Using Arduino and Soil Moisture Sensor

S . Venkatesh[1], Ch . Sumana[2], K. B . Akshaya[3], G . Sravani[4], K.Tarun[5]
[1,2,3,4,5]Department of ECE, CMR Technical campus, Hyderabad, India.
Corresponding Author mail id: venkatesh.ece@cmrtc.ac.in

Abstract:

Efficient water management is essential in modern agriculture because conventional irrigation methods commonly depend on manual operation or fixed schedules. Such approaches may cause overwatering or underwatering, resulting in water wastage, increased labour effort, and reduced crop productivity. This paper presents a Smart Irrigation System using an Arduino UNO, soil moisture sensor, relay module, water pump, and external power supply. The soil moisture sensor continuously monitors the moisture condition of the soil and provides an analog signal to the Arduino. The controller compares the sensed value with a predefined threshold. When the soil condition indicates dryness, the Arduino activates the relay and the water pump supplies water to the plants. When sufficient moisture is reached, the relay is deactivated and the pump is switched OFF automatically. The system therefore provides real-time irrigation control with minimal human intervention. Experimental testing described in the source project showed consistent operation for dry and wet soil conditions, with the pump turning ON for dry soil and OFF after sufficient moisture was reached. The proposed system is simple, low-cost, and suitable for small-scale applications such as gardens, greenhouses, and agricultural fields.

Keywords: Smart irrigation, Arduino UNO, soil moisture sensor, relay module, water pump, embedded system, automation

I. INTRODUCTION

Efficient resource management has become an important requirement in agriculture, particularly for water usage. Irrigation is essential for crop growth, but conventional irrigation practices often depend on manual supervision or fixed watering schedules. These methods do not directly consider the actual moisture condition of the soil and may therefore supply excess or insufficient water. The resulting water wastage, additional labour requirement, and
possible reduction in crop productivity motivate the development of automated irrigation systems.

A smart irrigation system monitors soil conditions and supplies water only when required. A soil moisture sensor can provide real-time information about the water sensor signal and controls an irrigation actuator. In the proposed system, an Arduino UNO receives the sensor reading, compares it with a predefined threshold, and controls a water pump through a relay module.

The system is designed as a simple embedded and real-time control application. The Arduino UNO acts as the processing unit, the soil moisture sensor provides the input, and the relay-controlled water pump forms the output stage. The continuous monitoring and automatic ON/OFF operation are intended to reduce water wastage, minimize manual intervention, and maintain suitable soil moisture.

II. PROBLEM STATEMENT AND OBJECTIVE

Water scarcity and inefficient water management are important challenges in agriculture. Traditional irrigation based on manual judgement or fixed schedules can result in overwatering or underwatering because the actual soil condition is not continuously considered. Regular field monitoring also increases time, effort, and labour requirements, particularly in larger or remote areas.

The objective of the proposed project is to design and implement an automated irrigation system using an Arduino UNO and soil moisture sensor. The system is intended to measure soil moisture, activate a water pump when the soil becomes dry, and switch the pump OFF when sufficient moisture is reached. The project also aims to provide a cost-effective and easy-to-implement solution for small-scale irrigation while reducing water wastage and human effort.

III. LITERATURE REVIEW

Previous work described in the project report shows a progression from manual and timer-based irrigation towards sensor-based automatic control. A simple automatic irrigation system using a soil moisture sensor and Arduino was reported to reduce manual effort by controlling a pump through a relay [1]. A low-cost approach using a soil moisture sensor, relay, and water pump was also reported, with automatic pump control according to soil moisture [2]. Microcontroller-based irrigation systems have further been proposed for small-scale farming and gardening, providing continuous

monitoring and automatic operation [3]. Another reported system included a display unit for real-time observation of soil moisture while automatically controlling the pump [4].

The literature survey indicates that sensor-based irrigation can improve on traditional and timer-based methods by using the actual soil condition for control. The project therefore adopts a simple architecture based on Arduino UNO, a soil moisture sensor, a relay module, and a water pump. Additional references listed in the project report cover Arduino-based automatic irrigation, moisture-based control, and related smart irrigation implementations [5]–[10].

IV. PROPOSED METHOD

The proposed Smart Irrigation System is an embedded real-time control system. The soil moisture sensor is inserted into the soil and continuously produces an analog signal representing the soil condition. The Arduino UNO receives this signal through analog pin A0 and processes it according to the programmed threshold. The relay module is connected to digital pin 9 and acts as the switching interface between the Arduino and the water pump.

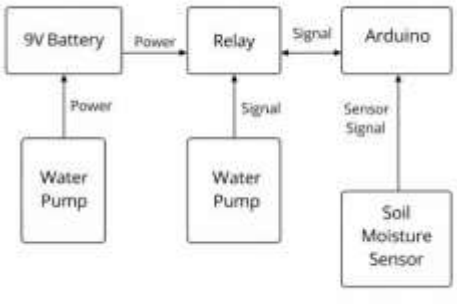


Fig. 1. System block diagram of the Smart Irrigation System.

The operating sequence begins with sensing. The Arduino reads the soil moisture value and compares it with the predefined threshold. If the soil is dry, the controller sends a HIGH signal to the relay, which activates the water pump. Water is supplied to the soil through a pipe. As the soil absorbs water, the sensor value changes. When the required moisture condition is reached, the Arduino sends a LOW signal to the relay and the pump is switched OFF. This loop continues during operation, enabling automatic irrigation.

A. System Components

Component	Role	Project Connection / Detail
Arduino UNO	Processing and control unit	A0 reads the sensor; digital pin 9 controls the relay
Soil moisture sensor	Measures soil moisture condition	Analog output connected to Arduino A0
Relay module	Electrical switching interface	Controlled from Arduino digital pin 9
DC water pump	Supplies water to the soil	Powered through the relay using an external supply
9V battery / DC supply	Provides pump power	Used as external source for the pump
Arduino IDE	Software development environment	Embedded C/C++ program uploaded through USB

Table 1. Main components and their functions.

B. Soil Moisture Sensing

The soil moisture sensor estimates the water content of soil through changes in electrical conductivity. Wet soil provides higher conductivity and lower resistance, whereas dry soil provides lower conductivity and higher resistance. The sensor provides analog data to the Arduino, enabling continuous monitoring of the soil condition. The project report identifies VCC, GND, A0, and D0 connections on the sensor module and uses the analog A0 output for the Arduino input.

C. Processing and Control

The Arduino UNO is based on the ATmega328P and provides the processing required for the control logic. The sensor signal is read using analogRead(), while digitalWrite() is used to control the relay output. The software continuously executes a loop in which the moisture value is read, compared with the threshold, and used to determine the pump state. The threshold can be adjusted according to soil and plant requirements as described in the project report.

D. Relay and Water Pump

The relay module provides the interface between the low-power Arduino control signal and the water pump. When the soil is dry, the Arduino activates the relay and the pump receives power from the external supply. When sufficient moisture is reached, the Arduino deactivates the relay and the pump stops. The project uses separate power for the pump so that the Arduino is not overloaded.

V. IMPLEMENTATION AND METHODOLOGY

The hardware implementation integrates the Arduino UNO, soil moisture sensor, relay module, water pump, external power supply, and connecting wires. The

sensor is placed in the soil and its analog output is connected to A0. The relay input is connected to digital pin 9. The pump is connected through the relay and powered by a 9V battery or external DC source. The Arduino and relay share a common ground, while the pump is supplied separately.

The software is developed using the Arduino IDE in Embedded C/C++. During initialization, the sensor input and relay output pins are configured. In the main loop, the Arduino continuously reads the sensor value. A value below the programmed threshold represents a dry condition and causes the relay to be activated. When the moisture reaches or exceeds the threshold, the relay is deactivated. The loop then repeats, providing continuous real-time control.

A. Working Algorithm

- Place the soil moisture sensor in the soil.
- Read the analog moisture signal through Arduino analog pin A0.
- Compare the sensed value with the predefined moisture threshold.
- If the soil is dry, activate the relay and turn ON the water pump.
- Continue monitoring the soil while water is supplied.
- When sufficient moisture is reached, deactivate the relay and turn OFF the pump.
- Repeat the sensing and control process continuously.

B. Real-Time Operation

The system is designed to respond to changes in soil moisture during continuous operation. When dryness is detected, the control action is initiated without manual intervention. As water is supplied and absorbed by the soil, the sensor updates the Arduino with the changing condition. The pump is stopped once the required moisture condition is reached. This real-time feedback loop is the main operating principle of the proposed system.

C. Applications

The project report identifies several application areas for the proposed system, including agricultural and farming fields, home gardens and lawns, greenhouses, plant nurseries, parks and landscaped areas, smart farming systems, and remote irrigation areas. The same architecture can be adapted to these applications by changing the installation and control requirements.

VI. RESULTS AND ANALYSIS

The Smart Irrigation System was implemented and tested using a practical setup consisting of an Arduino UNO, soil moisture sensor placed in a soil container, relay module, water pump, water container, connecting pipe, and external power source. The testing focused on observing the pump response under dry and wet soil conditions.



Fig. 2. Experimental setup showing irrigation operation under a dry-soil condition.

When the sensor was placed in dry soil, it detected a low moisture condition. The Arduino processed the input and activated the relay, which turned ON the water pump. Water was then delivered from the container to the soil through the pipe. As water was supplied, the soil moisture increased and the sensor continuously updated the controller.



Fig. 3. Experimental setup after the soil reached a sufficiently wet condition.

When the soil reached the required moisture condition, the Arduino deactivated the relay and the water pump stopped. The project report states that the system was tested multiple times under different conditions and produced consistent operation, with the pump turning ON for dry soil and turning OFF for wet or sufficiently moist soil.

Soil condition	Sensor condition	Relay state	Pump state
Dry	Moisture below threshold	ON	ON
Sufficiently wet	Moisture reaches/exceeds threshold	OFF	OFF

Table 2. Observed control response reported during testing.

The analysis in the source project indicates that the Arduino UNO, soil moisture sensor, relay module, water pump, and 9V battery worked together effectively. The system demonstrated automatic irrigation, reduced the need for manual monitoring, and supplied water only when required. The reported performance was considered suitable for small-scale applications.

Advantages

- Reduces water wastage by supplying water according to soil moisture condition.
- Minimizes manual monitoring and labour effort.
- Provides real-time response to changes in soil moisture.
- Uses simple and commonly available components.
- Provides a low-cost implementation for small-scale irrigation.
- Can be applied to gardens, greenhouses, and agricultural use.

A. Limitations

- The implemented system is primarily suitable for small-scale applications and requires modification for large agricultural fields.
- Performance depends on the quality and calibration of the soil moisture sensor.
- Sensor readings may be affected by soil type, temperature, and corrosion over time.
- Continuous power is required for operation, particularly for the pump.
- The present implementation does not include remote monitoring, weather prediction, or additional environmental sensors.

VII. CONCLUSION AND FUTURE SCOPE

The Smart Irrigation System using Arduino was successfully designed, implemented, and tested for automatic irrigation based on soil moisture. The system continuously monitors soil condition using a moisture sensor and controls the water pump through a relay. The experimental observations reported in the project show that the pump turns ON under dry conditions and turns OFF after sufficient moisture is reached. The architecture therefore provides automatic irrigation with reduced manual intervention and improved water-use control.

The system uses simple and low-cost components and is suitable for applications such as small farms, home gardens, greenhouses, nurseries, and landscaping. Its embedded real-time operation provides a practical foundation for further development of automated irrigation.

Future development described in the project includes IoT-based remote monitoring and control through a mobile application or web interface, integration of temperature and humidity sensors, solar power for remote operation, weather-based irrigation using rainfall prediction, multiple sensors for large agricultural areas, and data logging and analysis for long-term crop-management decisions.

VIII. REFERENCES

[1] V. Divya and G. Meena, “Automatic Irrigation System Using Arduino,” International Journal of Engineering Research & Technology (IJERT), Vol. 6, Issue 5, 2017.

[2] S. R. Kumbhar and Arjun P. Ghatule, “Low Cost Automatic Irrigation System Using Soil Moisture Sensor,” International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering (IJIREEICE), Vol. 5, Issue 4, 2017.

[3] N. Suma and S. R. Samson, “Microcontroller Based Automated Irrigation System,” International Journal of Research in Engineering and Technology (IJRET), Vol. 2, Issue 8, 2013.

[4] K. Lakshmisudha and S. Hegde, “Automatic Plant Watering System Using Soil Moisture Sensor with Display,” International Journal of Scientific & Engineering Research (IJSER), Vol. 8, Issue 4, 2017.

[5] M. Riyad Ariwibowo, “Design of Irrigation System Based on Arduino UNO Using Soil Moisture Sensor,” ELPER-Tech Journal, 2025.

[6] Kavya Monisha K., Aishwarya D., and Krupaleni K., “Smart Irrigation System Using Arduino UNO,” International Journal of Advance Research, Ideas and Innovations in Technology (IJARIIT), Vol. 4, Issue 5, 2018.

[7] S. B. Arun, K. B. Nandan, and P. Harsha Vardhan, “Arduino Based Automatic Irrigation Control System by Utilizing Moisture Content,” Journal of Mines, Metals and Fuels, 2022.

[8] Shruti Satra, Avinash Agrawal, and Sanyukta Gogate, “Design and Implementation of Arduino-based Automatic Irrigation with Moisture Sensor,” SSRN, 2023.

[9] Warji, Siti Suharyatun, and Ahmad Tusi, “Development of Automatic Irrigation System Using Arduino UNO,” International Journal of Design & Nature and Ecodynamics, 2024.

[10] Saleh Babaa and Muneer Ahmed, “Smart Irrigation System Using Arduino with Soil Moisture Sensor,” International Journal of Engineering Research, 2020.