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Research Paper

Automatic irrigation system-1

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Abstract

Agriculture is one of the major consumers of freshwater, and inefficient irrigation can result in significant water loss. Traditional irrigation methods often depend on manual observation and fixed watering schedules, which may lead to over-irrigation or under-irrigation. An automatic irrigation system provides a technological solution by monitoring soil moisture and automatically supplying water according to the requirements of the crop.

This research paper presents the design and working principle of an automatic irrigation system based on soil-moisture sensing, a microcontroller, a relay, and a water pump. The proposed system continuously measures the moisture level of the soil. When the moisture falls below a predefined threshold, the controller activates the water pump. Once sufficient moisture is restored, the pump is automatically switched off. The system can additionally incorporate Internet of Things (IoT) technology, allowing farmers to monitor soil and environmental conditions remotely through a mobile or web interface.

Previous research has demonstrated the potential of sensor-based irrigation automation to improve water-use efficiency. For example, a soil-moisture-based automated basin irrigation system reported irrigation application efficiency of up to 86.6%. More recent systems combine soil moisture, temperature, humidity, weather information, IoT connectivity, and machine learning to improve irrigation scheduling. Wiley Online Library¹ The proposed system is therefore a low-cost and scalable approach toward precision agriculture, water conservation, reduced labor requirements, and sustainable agricultural production.

Keywords: Automatic irrigation, soil moisture sensor, IoT, microcontroller, water conservation, smart agriculture, precision irrigation.

1. Introduction

Agriculture plays an important role in food production and economic development. Adequate water availability is essential for crop growth; however, inappropriate irrigation practices can waste water and negatively affect crop productivity. Conventional irrigation commonly depends on farmers manually deciding when and how much water should be applied. Such practices can result in irrigation at inappropriate times, excessive water application, and unnecessary labor.

Automation provides an opportunity to improve this situation. An automatic irrigation system uses sensors to monitor the condition of the soil and a controller to make irrigation decisions. The most common approach is to use a soil moisture sensor that determines whether the soil

is sufficiently wet. When the soil becomes dry, the controller activates a pump or valve; when the required moisture level is reached, irrigation is stopped.

Recent research has extended this concept by incorporating IoT technologies, wireless communication, cloud platforms, weather information, and machine learning. A review published in *Agronomy Journal* identified soil moisture, weather conditions, communication technologies, hardware modules, cloud storage, and machine learning as important components of modern smart irrigation systems. Wiley Online Library

Automatic irrigation is particularly useful in areas where water availability is limited and agricultural labor is costly. It can also support greenhouse farming, nurseries, gardens, plantations, and precision agriculture.

2. Problem Statement

Traditional irrigation systems face several challenges:

- Excessive or insufficient water application.
- Dependence on manual labor.
- Irrigation based on fixed schedules rather than actual soil conditions.
- Water loss through evaporation, runoff, and deep percolation.
- Difficulty in continuously monitoring large agricultural fields.
- Limited information about soil and environmental conditions.
- Increased labor and operational costs.

Therefore, there is a need for an irrigation system that can automatically determine when irrigation is required and control water delivery accordingly.

3. Objectives

The main objectives of the proposed automatic irrigation system are:

1. To monitor soil moisture continuously.
2. To automatically start irrigation when soil moisture falls below a predetermined level.
3. To automatically stop irrigation when sufficient moisture is restored.
4. To reduce unnecessary water consumption.
5. To reduce human intervention and labor requirements.
6. To improve irrigation efficiency and crop management.
7. To provide a low-cost and easily deployable system.
8. To provide the possibility of remote monitoring using IoT technology.
9. To create a foundation for future integration of weather forecasting and machine learning.

4. Literature Review

Research into automatic irrigation has progressed from simple timer-based systems to sensor-driven and IoT-based systems.

Pramanik et al. developed an automatic soil-moisture-based basin irrigation system using wireless communication between soil-moisture sensors and an automatic check gate. Their system used LoRa and GSM communication and achieved irrigation application efficiency of up to 86.6% during testing. DOI

Bowlekar et al. developed and evaluated an automatic irrigation system using a Raspberry Pi controller and soil-moisture sensors. The system controlled a motor and solenoid valve based on soil moisture, with defined upper and lower moisture thresholds determining when irrigation should stop or start. AGRICultural Information System

Jain et al. investigated an IoT-based soil monitoring system for automatic drip irrigation. Their system used soil-moisture, temperature, and humidity sensing together with a microcontroller, pump, wireless communication, and cloud storage. The research

demonstrated the potential of IoT-based monitoring for automated irrigation. Wiley Online Library

Goyal et al. proposed an IoT-based automatic irrigation control system that incorporated environmental sensor information and weather forecasts. Machine learning was used to predict soil moisture and estimate irrigation requirements. Taylor & Francis Online

Recent research is moving toward AIoT-based irrigation systems. A 2026 IEEE conference paper describes a system for Indian agricultural conditions that combines soil moisture, pH, weather data, IoT sensing, and AI-based scheduling. IEEE Xplore

The literature therefore indicates that automatic irrigation can evolve from a simple moisture-controlled pump into a complete precision-agriculture platform.

5. Proposed System

The proposed automatic irrigation system consists of five major stages:

Soil → Sensors → Microcontroller → Relay/Driver → Water Pump

An optional IoT layer can be added:

Sensors → Microcontroller → Wi-Fi/Internet → Cloud/Mobile Application

Methodology

The proposed research methodology consists of the following stages.

Stage 1: Sensor Installation

Soil moisture sensors are installed in representative locations within the crop root zone. Sensor placement is important because soil moisture can vary spatially across a field.

Stage 2: Sensor Calibration

The raw sensor output is calibrated against known soil moisture conditions. Calibration improves the reliability of irrigation decisions. Recent research on IoT-enabled soil moisture sensors has demonstrated the importance of laboratory calibration and field validation before using sensors for irrigation management. Indian Journals

Stage 3: Data Acquisition

The microcontroller periodically records soil moisture. Additional sensors may measure temperature, relative humidity, rainfall, water level, and other environmental parameters.

Stage 4: Decision Making

The controller compares the measured soil moisture against predefined crop-specific limits.

Stage 5: Irrigation Control

If the soil is too dry, the controller activates the pump. When sufficient moisture is restored, irrigation is stopped.

Stage 6: IoT Monitoring

In an IoT-enabled version, sensor measurements can be uploaded to a cloud platform. Farmers can monitor the field using a smartphone or computer.

Stage 7: Performance Evaluation

The system can be evaluated using:

- Water consumption.
- Soil moisture stability.
- Pump operating time.
- Irrigation efficiency.
- Crop growth.
- Labor requirements.
- Energy consumption.
- System reliability.

Applications

Automatic irrigation systems can be used in:

- Agricultural farms.
- Greenhouses.
- Vegetable cultivation.
- Fruit orchards.
- Nurseries.
- Home gardens.
- Parks and lawns.
- Vertical farming.
- Polyhouses.
- Drip irrigation systems.
- Precision agriculture projects.

IoT-enabled systems are particularly useful where farmers need remote access to field information.

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