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Research Paper

Automatic irrigation system-2

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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 Library+1 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.

Components Required**Soil Moisture Sensor**

The soil moisture sensor measures the amount of moisture present in the soil. The sensor generates an electrical signal that can be read by the microcontroller.

Two common types are:

- Resistive soil moisture sensors.
- Capacitive soil moisture sensors.

Capacitive sensors can be preferable for longer-term deployment because they avoid direct dependence on electrical conductivity between exposed electrodes.

Microcontroller

An Arduino, ESP32, or similar microcontroller can be used as the main control unit.

The controller:

- Reads sensor values.
- Compares the measured moisture with a threshold.
- Controls the irrigation pump.
- Can transmit data to an IoT platform.

Relay Module

The microcontroller generally cannot directly operate a high-power pump. A relay or suitable motor driver provides electrical isolation and switching between the low-voltage controller and the pump circuit.

Water Pump

The pump supplies water from a tank, well, reservoir, or other source to the crop through pipes or drip lines.

Power Supply

The system may use:

- AC mains power,
- rechargeable batteries,
- solar panels, or
- a combination of solar power and batteries.

IoT Module

An ESP32 or another network-enabled controller can transmit sensor data through Wi-Fi or another communication technology. More advanced agricultural installations can use LoRa, GSM, or cellular networks.

Working Principle

The operation of the proposed system can be summarized as follows:

1. The soil moisture sensor is placed near the root zone of the crop.
2. The sensor continuously measures soil moisture.
3. The microcontroller receives the sensor reading.
4. The measured value is compared with a predefined threshold.
5. If the soil moisture is below the lower threshold, the controller activates the relay.
6. The relay switches on the water pump.
7. Water is supplied to the crop.
8. The sensor continues monitoring the soil.
9. When the moisture reaches the required upper threshold, the controller switches off the pump.
10. The cycle repeats automatically.

Using separate ON and OFF thresholds, rather than one threshold, can reduce rapid pump switching. This approach is commonly referred to as hysteresis control.

Control Algorithm

A basic control algorithm can be expressed as:

START

Initialize soil moisture sensor

Initialize relay/pump

Set moisture threshold

Read soil moisture

IF soil moisture < lower threshold:

 Turn ON water pump

ELSE IF soil moisture > upper threshold:

 Turn OFF water pump

ELSE:

 Maintain previous pump state

Repeat continuously

STOP

For a more advanced IoT system, additional parameters can be incorporated:

Read:

Soil moisture
Temperature
Humidity
Rainfall/weather forecast
Water tank level

Calculate irrigation requirement

IF irrigation is required AND
water is available AND
rainfall is not expected:
Start irrigation

Monitor soil moisture

Stop irrigation when target moisture is reached

Upload data to cloud/mobile application

Advantages

The major advantages of an automatic irrigation system include:

1. Water conservation: Water is supplied according to soil conditions.
2. Reduced labor: Continuous manual observation is minimized.
3. Automatic operation: The system can operate without constant human intervention.
4. Improved crop management: More consistent soil moisture can support healthy crop growth.
5. Remote monitoring: IoT systems allow farmers to observe conditions remotely.
6. Reduced over-irrigation: Irrigation can stop once the target moisture level is reached.
7. Scalability: The system can be implemented for small gardens or larger agricultural fields.
8. Data collection: Historical sensor data can support future irrigation planning.
9. Energy optimization: Pumps can operate only when irrigation is necessary, enabling remote monitoring, data storage, alerts, and control. Research has demonstrated that sensor-based automation can improve irrigation efficiency, while newer systems are increasingly incorporating weather information, cloud
10. Integration with precision agriculture: Weather forecasting and machine learning can be incorporated.

Limitations

Despite its advantages, the system has several limitations:

- Initial installation costs can be higher than conventional manual irrigation.
- Sensors require calibration and maintenance.
- Sensor readings can vary with soil type and installation conditions.
- Electrical components require protection from moisture and weather.
- IoT systems depend on communication network availability.

- Pumps require reliable energy sources.
- Incorrect moisture thresholds can result in over- or under-irrigation.
- Large fields require multiple sensors to represent spatial variation adequately.

Consequently, automatic irrigation should be designed according to local soil, crop, climate, and water-resource conditions.

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