

Review of Automatic Irrigation System

Vikas Arjun¹, Mahesh Khandekar², Rushikesh Magar³, S.K. Godase^{4*}

Abstract

The automatic irrigation system is a contemporary technological innovation aimed at improving water efficiency in farming and landscaping uses. This system guarantees that water reaches plants according to real-time data including soil moisture, weather conditions, and set irrigation schedules by combining sensors, microcontrollers, and automated valves or pumps. The main objective of an automated irrigation system is to increase water efficiency, decrease waste, and boost crop production while limiting human involvement. This setup generally comprises elements like soil moisture sensors, weather monitoring stations, and a main controller such as an Arduino Uno or programmable logic controller, in addition to irrigation equipment (sprinklers, drip lines, or valves). The sensors assess soil conditions and environmental elements, sending data to the controller, which analyses the information and initiates the suitable irrigation response. Furthermore, IOT-driven solutions are progressively integrated into automated irrigation systems, enabling remote supervision and management through mobile applications or online platforms. Additionally, the system aids in preserving water resources, which is vital in areas experiencing water shortages. It lowers labor expenses by automating the irrigation system and removes the risks of overwatering or underwatering. The system can be set to function at designated times, guaranteeing effective irrigation even when the user is not present. It encourages sustainable farming methods by preserving optimal soil quality. Enhanced models might incorporate data recording capabilities for performance evaluation and future enhancements. In general, the system boosts efficiency while promoting eco-friendly agricultural practices.

Keywords: Water conservation, internet of things (IOT), Arduino microcontroller, smart irrigation, and soil moisture sensing

INTRODUCTION

Agriculture serves as the foundation of the economy, and efficient water resource management is essential for increasing agricultural productivity. With growing concerns such as water scarcity and labor shortages, modern technologies such as automatic irrigation systems have become important solutions for farmers [1].

An Automatic Water Plant System was developed to automate field irrigation using sensors and controllers, ensuring that plants receive the right amount of water at the right time without manual involvement.

This system generally uses soil moisture sensors, temperature sensors, or timers to determine when irrigation is needed and how much water should be provided to the crops [2].

The primary objective of this system is to improve water-use efficiency, reduce wastage, and enhance agricultural productivity. By minimizing manual work, farmers can save time and effort, allowing them to focus on other important farming activities. In addition, the system can be integrated with the Internet of Things (IOT) for real-time monitoring and control, making it highly efficient and adaptable to different farming practices [3].

*Author for Correspondence

S.K. Godase

E-mail: Sonali.karche@sknscoe.ac.in

¹⁻³UG Students, Department of Electronics and Telecommunication Engineering, SKN Sinhgad College of Engineering, Pandharpur, Maharashtra, India

⁴Assistant Professor, Department of Electronics and Telecommunication Engineering, SKN Sinhgad College of Engineering, Pandharpur, Maharashtra, India

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This project aims to design and implement a user-friendly Automatic Water Plant System that promotes the sustainable use of resources and improves operational efficiency. Water is a crucial component of agriculture, and its proper management is necessary for sustainable and productive farming. Traditional irrigation methods often depend on manual operation and can lead to significant water wastage due to over-or insufficient watering. In contrast, the Automatic Water Plant System provides a smart and reliable solution that automates irrigation, reduces water loss, and supports healthier plant growth [4].

Furthermore, the system is cost-effective and suitable for both small- and large-scale farming. It can be easily adjusted based on the crop type, soil conditions, and climatic factors. The use of a microcontroller, such as Arduino Uno, makes the system easy to implement and maintain. It also increases irrigation accuracy by ensuring an even water distribution across the field. Additionally, the system improves energy efficiency by operating only when required. Overall, it promotes smart farming practices and contributes to long-term agricultural sustainability [5].

LITERATURE REVIEW

IoT-Based Smart Irrigation and Precision Agriculture

Research in smart irrigation and precision agriculture has evolved from traditional irrigation systems to intelligent IoT-enabled and data-driven frameworks. Recent studies have focused on fuzzy-logic-based irrigation control, precision irrigation management, machine learning-assisted irrigation scheduling, autonomous irrigation systems, multisensor fusion, greenhouse monitoring, and smart farming architectures [6–8]. IoT-enabled agricultural applications such as Agri-Bot-based smart farming, automatic drip irrigation systems, pomegranate farming monitoring, solar-powered irrigation systems, sprinkler irrigation automation, and real-time agricultural monitoring have been reported in the literature. These systems significantly improve water-use efficiency, crop productivity, environmental monitoring, and sustainable agricultural practices through real-time sensing and automated decision making [9–11].

IoT Monitoring and Industrial IoT Systems

Several researchers have developed IoT-based monitoring systems for industrial, environmental, educational, and public service applications. Secure Industrial IoT (IIoT) frameworks, smart school bus tracking systems, environmental parameter monitoring, healthcare resource management, cloud-based IoT solutions, and water resource optimization platforms have been investigated. These studies demonstrate the increasing adoption of IoT technologies for real-time monitoring, resource management, predictive maintenance, and operational efficiency across diverse application domains [12–14].

Artificial Intelligence and Machine Learning Applications

Artificial intelligence and machine learning techniques have been extensively applied in agriculture, healthcare, and automation systems. The research contributions include machine learning-assisted irrigation systems, blood glucose estimation using noninvasive devices, epilepsy identification using hybrid deep learning models, environmental parameter monitoring using machine learning, and intelligent greenhouse management systems. These studies highlight the transformative impact of AI-driven technologies on improving prediction accuracy, automation efficiency, healthcare diagnostics, and precision agriculture applications.

Image Processing, Watermarking, and Security

A significant body of research has focused on image processing, digital watermarking, image authentication and multimedia security. Various approaches, including cryptography-based image authentication, FPGA-based watermarking, DWT-PCA watermarking, secure digital watermarking, video watermarking, and image quality analysis, have been presented. These methods contribute to secure multimedia transmission, copyright protection, data integrity verification, and robust image-processing applications [15–18].

FPGA, VLSI and Reconfigurable Computing

Research on FPGA-based systems and reconfigurable computing platforms has focused on image authentication, watermarking systems, convolutional encoders, Viterbi decoder implementations, and hardware-efficient architectures. Significant contributions have been made to this field. These studies emphasize area optimization, hardware efficiency, high-speed processing, and the reliable implementation of digital communication and security systems.

Robotics and Automation

Robotic and automation systems have been widely investigated for agricultural, surveillance, and intelligent-control applications. Bluetooth-controlled robotic cars, obstacle-avoidance systems, ultrasonic radar systems, hand-gesture-controlled robots, and Agri-Bot-based smart-farming systems have been developed. These systems demonstrate the growing role of robotics in autonomous operations, intelligent navigation, agricultural automation, and real-time environmental interaction [19].

Face Recognition, Biometrics and Computer Vision

Numerous studies have explored facial recognition, image retrieval, computer vision, and intelligent image analysis techniques. Research on scalable face image retrieval, image authentication, image quality assessment, and vision-based agricultural monitoring has been reported. These contributions advance the fields of pattern recognition, computer vision and intelligent multimedia processing.

Healthcare, Biomedical and Assistive Systems

Healthcare-oriented research has focused on IoT-enabled monitoring systems, disease diagnosis, medical resource management and AI-assisted healthcare analytics. Applications such as medical resource storage management, blood glucose monitoring, epilepsy detection, and healthcare automation have been explored. These studies illustrate the convergence of IoT, AI, and biomedical engineering to improve healthcare services, diagnosis accuracy, and patient support systems.

Communication, Networking and Sensor-Based Systems

Research in communication and networking has emphasized wireless sensor networks, greenhouse monitoring systems, vehicular communication networks, and secure Internet of Things (IoT) communications. Greenhouse monitoring using ZigBee wireless sensor networks, vehicular ad hoc network (VANET)-based secure irrigation systems, and efficient routing techniques have been reported. These studies have focused on improving communication reliability, energy efficiency, scalability, and real-time data transmission in distributed monitoring environments.

Smart Energy, Water Management and Renewable Energy Systems

Several studies have explored renewable-energy-supported agricultural systems, smart water management, PLC-based automation, and energy-efficient infrastructures. Solar-powered irrigation systems, smart solar irrigation platforms, PLC-assisted water distribution systems, leakage detection mechanisms, smart energy management in manufacturing plants, and water resource optimization frameworks have been investigated. These studies contribute to sustainable resource utilization, intelligent infrastructure management, and energy-efficient agricultural operations.

Although extensive research has been conducted on IoT-based irrigation, precision agriculture, environmental monitoring, AI-assisted prediction, smart water management, renewable-energy-supported farming, and agricultural automation, most existing solutions address specific functionalities independently. An integrated framework combining IoT sensing, machine learning-based prediction, cloud analytics, renewable energy support, autonomous decision-making, water resource optimization, and security mechanisms remains a significant challenge. Such a comprehensive smart agriculture platform can enhance water conservation, crop productivity, sustainability, scalability, and intelligent farm management, while enabling next-generation precision agriculture systems.

PROPOSED METHODOLOGY

Figure 1 shows that the proposed system employs an Arduino Uno interfaced with a soil moisture detector to constantly assess the soil status and independently regulate a water pump through a relay module when the moisture falls below a predefined threshold. This closed-loop approach ensures efficient water usage, minimizes human intervention, and maintains optimal soil moisture for plant growth in the greenhouse. When the moisture level drops below a predefined threshold, the system automatically activates the water pump through a relay module. Once the desired moisture level was restored, the pump was turned off. This closed-loop control mechanism ensures efficient water utilization, reduces the need for manual intervention, and maintains optimal soil conditions for healthy growth.

Additionally, the system can be calibrated according to different soil types and crop requirements by adjusting threshold values. The moisture readings can be displayed on a serial monitor or LCD module for easy monitoring. Power consumption is kept minimal, making the system suitable for long-term operation in agricultural fields.

The relay module provides electrical isolation, ensuring the safe switching of the water pump. The system was designed to operate in real time and respond to changes in soil conditions. It can also be extended by integrating wireless communication modules for remote monitoring and controls. Overall, the proposed methodology offers a cost-effective, reliable, and scalable solution for automated irrigation.

Water Pump

Water pumps play an important role in supplying water from the main source to the storage tank. It operates automatically when it receives a signal from the control unit, thereby fully automating the irrigation process. The pump generates the required pressure and flow for adequate watering. It switches ON when the soil becomes dry and turns OFF once the desired moisture level is reached, thereby helping to reduce water and energy wastage. This component ensures a steady and sufficient water supply for plants; without it, the automatic watering system would not function effectively.

Storage Tank

The storage tank acts as a reservoir that stores water pumped from the main source before distribution to the irrigation field. This helps maintain a continuous supply of water, even when the pump is temporarily turned off. The tank also stabilizes the water pressure and regulates the flow during irrigation. In some setups, water-level sensors are installed to monitor and maintain appropriate water levels in the tank. By serving as a buffer between the pump and irrigation field, the storage tank improves system reliability and overall efficiency.

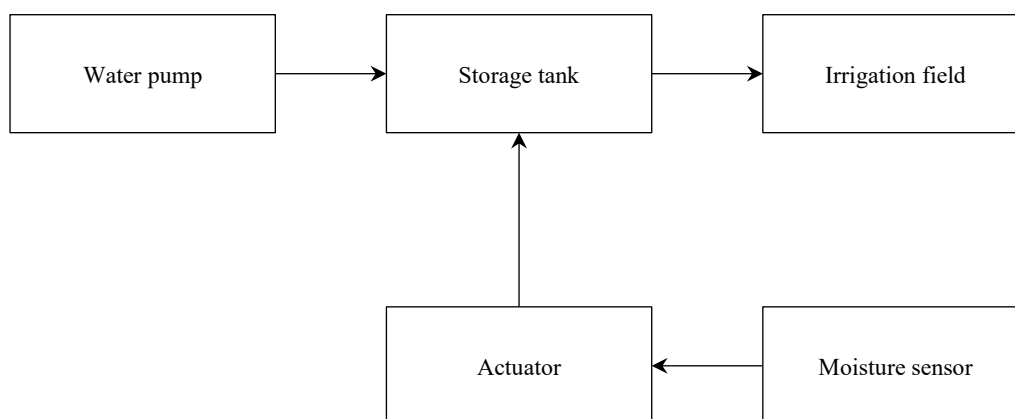


Figure 1. Block diagram of automatic irrigation system.

Irrigation Field

An irrigation field is an area where crops or plants are grown and watered. Water from the storage tank is delivered to the area through pipelines, sprinklers, or drip irrigation systems. The system automatically controls the amount and timing of the water supply based on the soil moisture levels. Proper irrigation promotes healthy plant growth and ensures that plants receive adequate hydration. Automation prevents both overwatering and underwatering, resulting in improved crop yield and efficient water use. This makes the irrigation field the final and most essential part of this system.

Moisture Sensor

A moisture sensor is a crucial component that measures the moisture level in the soil. It continuously monitors the soil conditions and sends real-time data to the control unit. When the soil becomes dry, the sensor signals the system to initiate watering. Once the required moisture level is achieved, it sends another signal to stop the pump operation. This helps to conserve water and prevent unnecessary irrigation. The sensor is typically placed near the plant roots for accurate readings, making the system more efficient and fully automatic.

Actuator/Control Unit

The actuator, also known as the control unit, functions as the brain of an automatic watering system. It receives input from the moisture sensor and processes information to decide whether the water pump should be turned on or off. The actuator ensures that water is supplied only when necessary, thereby maintaining appropriate soil moisture levels. It coordinates the operation of the pump, storage tank, and sensors, enabling the entire system to operate automatically. By continuously managing and monitoring the system, the actuator improves the reliability, efficiency, and overall automation of the watering process.

CONCLUSION

The developed automatic irrigation system demonstrated its ability to maintain soil moisture within a suitable range for healthy plant growth, while eliminating the need for frequent manual watering. By continuously monitoring the moisture content of the soil using sensors, the system supplied water only when the moisture level dropped below a predefined threshold. This intelligent operation reduces unnecessary water consumption, making the irrigation process more efficient and environmentally sustainable. The automated approach significantly reduces the need for human intervention, allowing users to maintain plants with minimal effort. This feature is especially valuable for homeowners, gardeners, and individuals with busy schedules or those who travel frequently, as the system ensures that plants receive adequate water even in the absence of the owner. In addition to improving convenience, the controlled irrigation process promotes stronger root development and healthier plant growth by preventing over- and underwatering. The system was designed using low-cost, readily available electronic components, making it affordable and practical for small-scale agricultural applications, kitchen gardens, nurseries, and household plants. Its simple architecture also enables easy installation, operation and maintenance. Future enhancements could further improve the reliability and functionality of the system. The integration of a rechargeable battery or solar power backup would ensure uninterrupted operation during power outages. Additionally, incorporating IoT-based remote monitoring and mobile application support would enable users to monitor soil conditions and control irrigation from anywhere, making the system smarter, more efficient, and suitable for modern precision agriculture applications.

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