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IOT Enabled Automatic Plant Watering System for Efficient Water Management

[1]Avanti Dalimbkar, [2]Neha Dhotre, [3]Ghanshyam Sonawane, [4]Prof. Mayuri Narudkar

[1,2,3]Student, Artificial Intelligence and Machine Learning Engineering Diploma, Ajeenkya D. Y. Patil School of Engineering, Charholi, Pune, India

[4]Professor, Artificial Intelligence and Machine Learning Engineering Diploma, Ajeenkya D. Y. Patil School of Engineering, Charholi, Pune, India

***Abstract* - Agriculture and plant maintenance play a vital role in human life, yet traditional methods of watering plants are often inefficient, inconsistent, and highly dependent on human involvement. Manual watering can lead to several problems such as overwatering, underwatering, wastage of water, and neglect due to human error or unavailability. With the increasing demand for water conservation and smart resource management, automation in irrigation systems has become an essential area of research and development. This project presents the design and implementation of an IoT-based smart plant watering system using a microcontroller-based control unit and soil moisture sensing technology to ensure efficient and automated irrigation.**

The proposed system is designed to monitor soil moisture levels in real time and supply water to plants only when required. The core objective of this project is to reduce water wastage, improve plant health, and minimize manual intervention by using an intelligent decision-making mechanism. The system uses a soil moisture sensor to continuously measure the moisture content of the soil. These sensor readings are processed by the controller, which compares the measured values with predefined threshold levels. When the moisture level falls below the required threshold, the system automatically activates a water pump through a relay module, thereby supplying water to the plant. Once adequate moisture is restored, the pump is switched off automatically, ensuring optimal watering.

An important feature of the proposed system is the integration of Internet of Things (IoT) technology. By utilizing a WiFi-enabled controller, the system can transmit sensor data over the internet, enabling remote monitoring and control. This allows users to observe soil moisture conditions and system status from a remote location using a mobile device or web-based interface. Such connectivity enhances system reliability and provides flexibility to users, especially in scenarios where constant physical presence near plants is not possible, such as in home gardens, greenhouses, or small agricultural fields.

The hardware design of the system consists of a microcontroller board, a soil moisture sensor, a relay module, a DC water pump, and a suitable power supply unit. The soil moisture sensor acts as the primary input device, while the water pump functions as the output actuator. The relay module provides electrical isolation and safe switching between low-power control circuitry and high-power pump operation. The software logic is implemented using embedded programming techniques, where conditional decision-making ensures that watering occurs only when necessary. The system is programmed to operate continuously, providing real-time responsiveness to changing soil conditions.

The proposed smart plant watering system is cost-effective, easy to implement, and suitable for small-scale agricultural applications as well as domestic plant care. It provides a practical solution for efficient water management and demonstrates how modern technologies such as embedded systems and IoT can be applied to solve real-world problems. The modular design of the system allows for future enhancements, including the addition of temperature and humidity sensors, data logging, mobile application interfaces.

Keywords: Internet of Things (IoT), Smart Irrigation System, Automatic Plant Watering, Soil Moisture Sensor, Water Management, Arduino-Based Automation, Precision Agriculture, Environmental Monitoring, Wireless Sensor Network (WSN).

I. INTRODUCTION

Water is one of the most essential resources for agriculture and plant growth, yet its improper usage leads to significant wastage and reduced plant health. Traditional plant watering methods mainly depend on manual observation and

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human judgment, which are often inaccurate and inconsistent. Factors such as irregular watering schedules, lack of time, human negligence, and unawareness of actual soil moisture conditions can result in overwatering or underwatering of plants. These issues not only affect plant growth but also contribute to unnecessary water consumption. In the present scenario, where water conservation is becoming increasingly important, there is a strong need for efficient and automated irrigation solutions.

The advancement of embedded systems and Internet of Things (IoT) technology has opened new possibilities for smart agricultural and gardening applications. Automation in plant watering systems helps in delivering the right amount of water at the right time based on actual soil conditions rather than assumptions. A smart plant watering system uses sensors and controllers to continuously monitor soil moisture and control the water supply accordingly. Such systems reduce human effort, improve accuracy, and ensure optimal plant care.

The smart plant watering system presented in this project is designed to automatically monitor soil moisture levels and provide water only when required. The system mainly consists of a soil moisture sensor, a microcontroller-based control unit, a relay module, and a water pump. The soil moisture sensor measures the water content present in the soil and sends the data to the controller. Based on predefined threshold values, the controller decides whether watering is necessary. If the soil is dry, the controller activates the water pump through the relay module, supplying water to the plant. Once sufficient moisture is detected, the pump is turned off automatically.

An important aspect of this system is its ability to operate with minimal human intervention. By using a WiFi-enabled controller or IoT platform, the system can also provide real-time monitoring of soil conditions and system status. This allows users to observe and manage plant watering remotely using a mobile phone or web interface. Such functionality is especially useful for home gardens, small farms, greenhouses, and indoor plants where continuous physical monitoring is not practical.

The proposed system aims to improve water efficiency, reduce wastage, and ensure healthy plant growth. It provides a low-cost, reliable, and easy-to-implement solution suitable for small-scale applications. Compared to conventional irrigation methods, the smart watering system offers better control, consistency, and sustainability. This project demonstrates how simple electronic components and IoT concepts can be effectively combined to solve real-world agricultural problems and contribute toward smarter and more sustainable plant care practices.

II. LITERATURE SURVEY

In recent years, several studies and projects have been carried out to improve irrigation techniques using automation and smart technologies. Traditional irrigation systems such as manual watering and time-based sprinkler systems are simple to use but lack accuracy and efficiency. These methods often supply water without considering the actual moisture content of the soil, leading to water wastage and unhealthy plant growth. To overcome these limitations, researchers have proposed automated irrigation systems based on sensors and microcontroller technology.

Many existing automated plant watering systems use soil moisture sensors to determine the water requirement of plants. These systems operate by continuously monitoring soil conditions and activating a water pump when the moisture level falls below a predefined limit. Studies have shown that sensor-based irrigation systems significantly reduce water consumption compared to manual watering methods. Microcontrollers such as Arduino and other embedded control units are commonly used to process sensor data and control irrigation components.

With the development of Internet of Things (IoT) technology, researchers have further enhanced irrigation systems by enabling remote monitoring and control. IoT-based smart irrigation systems allow users to observe soil moisture levels, temperature, and humidity through mobile applications or web platforms. Some studies have integrated cloud-based data storage to record sensor readings over time, which helps in analyzing watering patterns and improving system efficiency. These systems provide better flexibility and convenience, especially for users managing plants in remote locations.

Several researchers have also explored the use of environmental sensors such as temperature and humidity sensors along with soil moisture sensors to make irrigation decisions more accurate. Advanced systems use weather data and predictive algorithms to estimate plant water requirements. Although these systems offer high efficiency, they often increase system complexity and cost, making them less suitable for small-scale or domestic applications.

From the literature reviewed, it is observed that most smart irrigation systems focus on reducing water wastage and minimizing human intervention. However, many existing solutions are either expensive, complex, or designed mainly for large-scale agricultural use. There is a need for a simple, low-cost, and reliable smart plant watering system that can be easily implemented for home gardens and small farms.

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The proposed system in this project is developed by considering the limitations of existing methods. It uses a basic soil moisture sensing approach combined with a microcontroller-based control unit to automate watering. The inclusion of IoT functionality provides remote monitoring without significantly increasing system cost or complexity. Thus, this project aims to bridge the gap between simple manual irrigation and complex large-scale smart farming systems.

III. METHODOLOGY

The methodology of the proposed smart plant watering system describes the systematic approach followed for the design, development, and implementation of the automated irrigation solution. The system is developed using a combination of hardware components and embedded software logic to monitor soil moisture and control water supply efficiently. The methodology is divided into sequential stages to ensure proper functioning and reliable performance of the system.

The first stage involves the selection and integration of hardware components required for the system. A soil moisture sensor is used as the primary sensing element to measure the moisture content of the soil. The sensor is placed near the root zone of the plant to obtain accurate readings. A microcontroller-based control unit is used to receive and process sensor data. A relay module is connected between the controller and the water pump to safely control high-power operation using low-power signals. A DC water pump is used to supply water to the plant, and a suitable power supply is provided to ensure stable operation of all components.

In the second stage, the system is programmed to continuously monitor soil moisture levels. The sensor generates an analog or digital signal proportional to the moisture present in the soil. This signal is read by the microcontroller and compared with predefined threshold values stored in the program. These threshold values represent the minimum moisture level required for healthy plant growth. If the measured moisture level is found to be below the threshold, the controller generates a control signal to activate the relay module.

The third stage involves automated water control. When the relay module is activated, the water pump is switched on and supplies water to the plant. The pump continues to operate until the soil moisture level reaches the desired range. Once adequate moisture is detected, the controller automatically deactivates the relay, turning off the water pump. This closed-loop operation ensures that watering is performed only when necessary and prevents overwatering.

In the next stage, IoT functionality is incorporated to enable remote monitoring of the system. A WiFi-enabled controller is used to transmit soil moisture data and system status over the internet. The collected data can be viewed on a mobile device or web-based interface, allowing users to monitor plant conditions remotely. This feature enhances user convenience and ensures better system supervision without physical presence.

Finally, the system is tested under different soil conditions to evaluate its performance. Sensor calibration is performed to ensure accurate moisture detection. The system response is observed for dry and wet soil conditions to verify proper pump activation and deactivation. The results obtained during testing confirm that the system operates reliably and efficiently, providing an effective solution for automated plant watering.

IV. SYSTEM IMPLEMENTATION

The system implementation phase focuses on the practical realization of the smart plant watering system by assembling hardware components and deploying the control logic. This phase transforms the system design and methodology into a working model capable of automatically monitoring soil moisture and controlling the water supply.

The implementation begins with hardware setup and circuit assembly. The soil moisture sensor is inserted into the soil near the plant roots to accurately detect moisture levels. The sensor output is connected to the input pins of the microcontroller. A relay module is interfaced with the controller to enable safe switching of the water pump. The DC water pump is connected to the relay and water source using appropriate tubing to ensure controlled water flow. All components are powered using a regulated power supply to maintain stable operation and prevent voltage fluctuations.

After completing the hardware connections, the control program is developed and uploaded to the microcontroller. The program is written using embedded programming techniques to continuously read soil moisture sensor values. These values are compared with predefined threshold levels defined during calibration. Conditional logic is implemented to control the relay module based on the sensor readings. Proper delays and safety checks are included in the program to avoid frequent switching of the pump and to ensure smooth operation.

Once the program is uploaded, system calibration is performed. The soil moisture sensor is tested in dry and wet soil conditions to determine appropriate threshold values. These values are adjusted in the program to match actual soil behavior. Calibration ensures accurate moisture detection and

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prevents false triggering of the water pump. The relay operation and pump response are verified to ensure correct activation and deactivation.

IoT connectivity is then configured as part of the implementation. The WiFi module or WiFi-enabled controller is connected to a local network to enable data transmission. Soil moisture data and system status are sent to a cloud platform or web interface. This allows users to monitor real-time moisture levels and pump status using a mobile phone or browser. Remote access improves usability and system monitoring efficiency.

Finally, the fully assembled system is tested under real operating conditions. The system is observed over multiple watering cycles to evaluate reliability and performance. The implementation results show that the system operates automatically with minimal human intervention, supplies water only when required, and reduces water wastage. The successful implementation confirms the practicality and effectiveness of the smart plant watering system for small-scale applications.

V. RESULTS AND IMAGE OF THE SYSTEM

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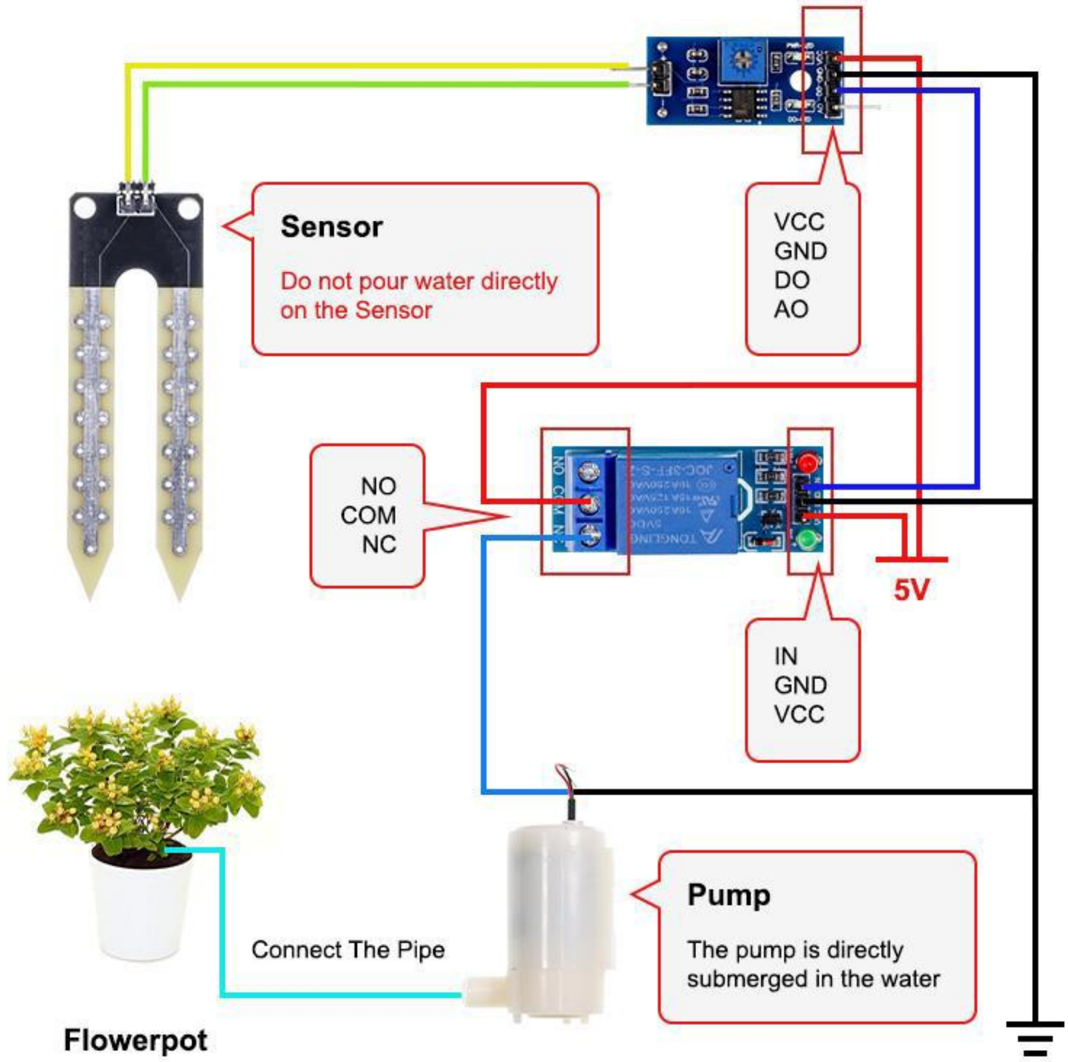

VI. CONCLUSION

The smart plant watering system developed in this project successfully demonstrates an automated and efficient approach to plant irrigation using soil moisture sensing and embedded control technology. The system continuously monitors the moisture content of the soil and supplies water only when required, thereby reducing water wastage and minimizing human intervention. This approach addresses the major drawbacks of traditional manual watering methods, such as overwatering, underwatering, and dependency on human availability.

The implementation of a microcontroller-based control unit along with a soil moisture sensor and relay-controlled water pump ensures reliable and accurate operation. The system responds effectively to varying soil conditions and maintains optimal moisture levels for healthy plant growth. The integration of IoT functionality further enhances the system by enabling remote monitoring of soil moisture and system status, making it suitable for modern smart gardening and small-scale agricultural applications.

Testing and observation of the system under different conditions confirmed its stable performance and practical usability. The automated operation helped maintain consistent watering cycles and reduced unnecessary water usage. Although minor challenges such as sensor calibration and network dependency were observed, these issues can be managed through proper setup and configuration.

Overall, the project achieves its objectives of designing a low-cost, reliable, and user-friendly smart plant watering system. It demonstrates how basic electronic components and IoT concepts can be effectively applied to solve real-world problems related to water management and plant care. The system has good potential for further enhancement and can be adapted for larger-scale agricultural applications, contributing to sustainable and efficient irrigation practices.

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