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IOT-Based Smart Plant Watering System

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Abstract

Effective water management in plant irrigation is essential for resource conservation and sustaining robust plant development in the age of smart technologies. This project introduces a NodeMCU microcontroller-based Internet of Things (IoT) smart plant pump control system designed to automate irrigation procedures based on real-time environmental data. A soil moisture sensor built within the system continuously checks the soil's moisture content. When the moisture level drops below a predetermined threshold, the NodeMCU activates the water pump to irrigate the plants until the required moisture level is restored. Through a web interface or mobile application, the system's Internet of Things functionality enables remote monitoring and control. Users can manually operate the pump if necessary and get real-time data on the soil moisture levels. By ensuring that plants receive the right amount of water, this smart irrigation system not only minimizes water waste but also encourages sustainable gardening techniques. Key features of the system include automatic irrigation based on soil moisture levels, remote monitoring and control via IoT, and low-cost, energy-efficient operation using the NodeMCU platform. This project demonstrates the integration of IoT in agriculture, offering a scalable, low-cost, and energy-efficient solution for both small-scale home gardens and larger agricultural setups, thus showcasing the impact of smart technology in modern farming.

Keywords: Smart irrigation, IoT plant watering, automated watering system, precision agriculture

INTRODUCTION

Imagine a system that takes care of your plants for you. This system knows when your plants are thirsty and waters them just the right amount. This idea forms the heart of the IoT-Based Smart Plant Watering System. "IoT" stands for the Internet of Things. This is a modern way of connecting everyday objects to the internet. For example, your phone, watch, or even your fridge might already be connected to the internet. You don't need to worry about checking the soil or guessing if the plants need water. You can even check on your plants from your phone, no matter where you are while making life more convenient. This smart watering system uses several components to function seamlessly. It starts with a moisture sensor placed in the soil. This sensor acts like a thermometer, but instead of measuring temperature.

Figure 1 shows the Smart Plant Watering System Design Framework Now, imagine a plant watering system that can do the same. It measures the soil's moisture content using sensors. The mechanism activates a tiny pump to water the plant if the soil becomes too dry. The device ceases watering the land once it has adequate water, guaranteeing.

The vegetation is content and thriving. This initiative aims to simplify and improve the intelligence of plant care. Regardless of the size of your outside farm or indoor garden, this system can adjust to meet your demands. Apart from saving time and effort, the intelligent technology also contributes to water conservation. The fact that

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water is a valuable resource that we must use responsibly makes this crucial. Watering plants is not the only thing that has to be done. It requires knowing how much water they require and when. A plant that receives too much water may have unhealthy roots. Underwatering, however, might dry out the plant and make it wilt. Finding the ideal balance can be challenging, particularly if you're busy or inexperienced with plants. Another important aspect is water conservation. In many parts of the world, people face severe water shortages. By watering plants only when needed, this system prevents waste and helps save water. It’s an excellent example of how technology can contribute to solving global problems You can even check on your plants from your phone, no matter where you are while making life more convenient. This smart watering system uses several components to function seamlessly. It starts with a moisture sensor placed in the soil.

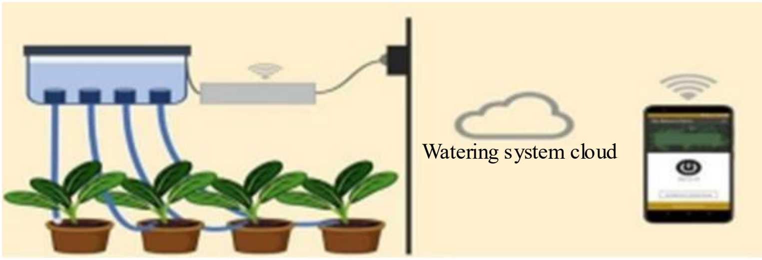

Figure 1. Smart plant watering system design framework.

This s mart watering system uses several components to function seamlessly. It starts with a moisture sensor placed in the soil. This sensor acts like a thermometer, but instead of measuring temperature, it checks how wet the soil is. If the sensor detects that the soil is too dry, It communicates with the NodeMCU, a tiny computer. This computer serves as the system's brain, determining when and how long to irrigate the plants. The smart plant watering system's capacity for independent operation is one of its most notable characteristics. This feature is especially beneficial for individuals who have busy schedules, frequently travel, or lack consistent access to their plants.

Advanced versions of the system are integrated with IoT (Internet of Things) technology, enabling users to monitor and control the irrigation process remotely through smartphone applications or web interfaces. These systems can provide real-time updates on soil moisture, ambient temperature, and humidity levels, offering valuable insights into the plant's environment. Customization options allow users to set specific watering schedules or adjust moisture thresholds based on the needs of different plant species.

RELATED WORKS

The water pump is activated when low moisture levels are detected, and the owner can monitor the condition of soil moisture through a mobile app [1]. The model reveals mathematical connections and enhances learning as data accumulates. The system uses four supervised machine learning algorithms and the Gradient Boosting Regression Trees method, with a test bed for system performance analysis [2]. The Arduino Uno microcontroller implements the system control unit, and IoT keeps garden owners updated on sprinkler status on a ThinSpeack IoT cloud. Sensor readings are also transmitted to a ThingSpeak channel for analysis [3]. This is also used to assess the health of the plants and notify the farmer or other relevant party via email. Thus, technology avoids the need for constant human supervision while conserving water when irrigating the plants [4]. Devices are sensors.

All system functions, including plant watering system monitoring, will be managed by an Arduino Uno. The outcome is a system for watering plants. De-sign for Small Garden at Homes [5]. Oftentimes persons forget to water their plants throughout their daily duties, making it a difficult chore to keep their plants healthy and strong. To overcome these issues and promote plant development, an automatic watering system can be an optimum choice. Irrigation is a conventional technique that employs a greater percentage of workers in the agricultural industry on a daily basis. Sensors and microcontrollers would be used to detect once the crops have to be watered periodically [6]. Embracing IoT capabilities, this system automates rooftop plant watering, optimizing water use and fostering healthy growth. Preliminary trials showcased a remarkable 30% water consumption reduction compared to traditional methods, emphasizing its efficiency and sustainability in conserving urban water resources anticipated. To overcome these issues and promote plant development, an automatic watering system can be an optimum choice. Irrigation is a conventional technique that employs a greater percentage of workers in the agricultural industry on a daily basis.

Urban green cover may be increased by 25% through implementations, which would greatly support ecologically conscious urban ecosystems.

Growing your own organic plants at home is becoming more and more popular these days as a health and safety measure [7]. Some of them, meanwhile, lack the time necessary to care for the plants. As a result, this project presents an Internet of Things backyard system as a gardening tool to track and regulate irrigation for plants cultivated at home. We apply the Internet of things (IoT) and affordable technology and focus on soil-based plant with a water tank and tap [8]. We use inexpensive technologies and the Internet of Things (IoT) to concentrate on soil-based plants that have a water tank and a tap. There are three components to the system: (1) NodeMCU V3 microcontroller system composites for data transmission and reception to and from the Firebase, and data transfer to Arduino UNO for watering sensor control, (2) Firebase functions as a NoSQL database system to gather and store monitoring sensor data and user-defined plant profiles, Additionally, customers can monitor water sensor data, select or add plant profiles to crops, and turn on or off the automated watering plant using the IoT Backyard smartphone application [9]. By use of voice instructions, farmers can remotely operate the water pump, offering a hands-free solution that is not only convenient but also practical in scenarios where manual intervention may be challenging [9]. An extra degree of accessibility is added with the use of Google Assistant. Farmers may remotely control the water pump with voice commands, providing a simple hands-free option. database system to gather and store user-defined plant profiles and monitoring sensor data, and (3) IoT Backyard mobile application, which allows users to select or add plant profiles to crops, track water sensor data, and turn on or off but also useful in situations when manual intervention could be difficult [10]. In addition to improving plant health, the combination of IoT and AI highlights how technology may promote ecologically friendly behavior [11]. The system is set up to detect the plant's soil moisture content and activate the motor to water it when necessary. By watering itself, this technique increases the plant's independence [12]. Software controls the system, enabling the user to select the type of plant, assess the soil's current condition, calculate the amount of water needed, and assess the likelihood of incorporating additional features and plant species into the program library [13]. The user is then notified of this value via the mobile application. People will enjoy gardening more because they won't have to worry about the health of their plants thanks to this solution [14]. The goal is to develop a low-cost system that relies on embedded technology for the framework of a water irrigation system. To determine the amount of water in the soil, this device makes use of a soil moisture sensor. The project processes data using an Arduino Uno controller [15].

PROPOSED WORK

The proposed IoT-based Smart Plant Watering System is a revolutionary solution designed to overcome the inefficiencies of traditional plant care methods by automating irrigation and optimizing resource utilization. The system employs a range of advanced sensors to monitor and respond to the needs of plants in real time. Soil moisture sensors detect water levels, ensuring plants receive precise hydration, which conserves water by watering only when necessary and addresses the growing global concern of water scarcity. Temperature and humidity sensors provide insights into environmental conditions that influence soil water retention, while light sensors track sunlight exposure, aligning irrigation schedules with the photosynthesis process. These sensors feed data to a microcontroller (e.g., Arduino Uno, ESP8266, or ESP32), which processes the information and coordinates the operation of the system's components. Water is delivered through a submersible pump, solenoid valve, and drip irrigation tubes, ensuring precise delivery directly to the roots. This efficient system design minimizes water wastage and promotes optimal plant growth. The system is powered by rechargeable lithium-ion or LiPo batteries and is equipped with a Wi-Fi module for cloud-based communication.

Through a web interface or mobile application, users can remotely monitor and control the system. Sensor data are transmitted in real time to the cloud, displayed on an easy-to-use dashboard. Users are notified and alerted when important occurrences, such as low water levels, sensor malfunctions, or unusual system circumstances, arise. The substantial reduction in manual involvement, achieved through this degree of automation and monitoring, makes the system convenient and easy to operate. Users can adjust irrigation thresholds, activate the system manually, and monitor plant health from any location, thereby providing a seamless and efficient gardening experience. The system also sends alerts if it is unable to water due to a pump or sensor issue.

However, initial setup costs for hardware and cloud services may pose a limitation. The system's reliance on consistent power and connectivity highlights the need for robust infrastructure, including solar power backups and resilient internet connectivity. Innovative enhancements can further elevate the system's performance and utility. Machine learning algorithms can forecast plant requirements and dynamically modify watering schedules by evaluating past data and environmental variables. Energy optimization with solar panels improves sustainability by reducing dependency on traditional power sources. Adding cameras with image processing capabilities allows the system to monitor plant growth visually and detect potential issues.

The system integrates with a weather API (such as OpenWeatherMap) to fetch real-time weather data, allowing it to consider external environmental factors. For instance, if rain is expected, the system postpones watering to conserve water and prevent overwatering. Conversely, if a hot spell is predicted, the system might increase watering frequency to ensure plants do not dry out. When low soil moisture is detected and it is an appropriate time to water, the microcontroller activates a water pump connected to a reservoir. The system can be programmed to water for a specific time or until an optimal moisture level is reached, ensuring precise hydration and avoiding common problems like underwatering and overwatering.

Its flexibility extends to its power supply, which can be a battery, solar panel, or direct mains connection, ideal for various environments like self-sustaining outdoor applications. The energy-efficient design reduces environmental impact and ensures operational longevity. A significant advantage is its scalability and customization, allowing users to customize watering schedules, moisture thresholds, and parameters for different plant types, from houseplants to agricultural fields. Furthermore, multi-user access via its connectivity makes it suitable for shared gardening spaces or professional horticulture. Voice assistant integration (e.g., Alexa or Google Assistant) can further enhance user interaction. This IoT-based smart watering system, combining real-time data, automation, and remote monitoring, offers an efficient, user-friendly solution for healthy, thriving plants with minimal user effort, while also contributing to water conservation.

In a transformer's circuit, every component receives power from the power supply. Its purpose is to change AC voltage into DC voltage. A transformer converts 230V to 12V AC. The diode is supplied with 12V AC. A diode rectifies AC voltage into pulsating DC voltage. Capacitors are used to smooth the pulsating DC voltage. An LM7805 regulator is utilized to keep the voltage constant before sending the signal to a subsequent capacitor, which filters out undesirable AC components. The NodeMCU power port is connected to the power supply unit. NodeMCU port D5 is connected to input port 1 of the ULN2003. Next, a voltage regulator (LM7805) is employed to ensure a constant 5V DC output, which is essential for powering the NodeMCU and other components. Another capacitor is placed after the regulator to further filter out any remaining AC components, ensuring a clean and stable voltage supply. The 5V DC output is then connected to the power port of the NodeMCU, enabling it to function properly. In this project, a NodeMCU is used to monitor inputs and display information on a webpage.

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Through Wi-Fi, the plant pump can be turned on and off by a user interacting with a button on an Android mobile phone. The MCU controls the load using a driver circuit. The driver used is a ULN2003. It is connected to loads via a relay. The driver IC acts as a switch. When the relay is closed, the load will be ON; otherwise, it will be OFF. The ULN2003, which acts as an interface between the microcontroller and high-power devices, is connected to the load through a relay module, which functions as an electronic switch. When the NodeMCU sends a signal to the ULN2003 driver, it activates the relay, closing the circuit and turning on the pump. Conversely, when the relay is open, the pump remains off. This system ensures efficient automation, enabling users to control plant watering remotely and conveniently. The NodeMCU connects to a web interface, allowing users to remotely operate the pump via a Wi-Fi-enabled Android mobile phone. When the user presses the button on the web interface, a signal is sent to the NodeMCU, which then activates the pump accordingly.

EXPERIMENTAL RESULTS

Figure 2 depicts the Smart Plant Watering System. The result image showcases the functioning of the IoT-based Smart Plant Watering System. A soil moisture sensor is placed in the soil to monitor moisture levels, sending real-time data to the microcontroller. When the moisture drops below the threshold, the water pump is automatically activated, delivering water precisely through drip irrigation tubes. Once the desired moisture level is reached, the pump turns off, ensuring water efficiency. The image may also feature LED indicators or displays showing the system's status, such as active watering or low water alerts. Additionally, a user interface on a mobile or web dashboard displays live data and allows remote monitoring and control.

Figure 2. Smart plant watering system.

CONCLUSION

The implementation of the IoT-based smart plant pump control system using NodeMCU represents a transformative advancement in automated irrigation technology. This innovative solution combines reliability, scalability, and cost-effectiveness, offering an accessible pathway for users to automate and optimize their plant care routines. By leveraging the Internet of Things (IoT), the system facilitates real-time data collection, remote monitoring, and control, enabling users to manage irrigation systems seamlessly from any location, at any time. A core advantage of this system is its integration with cloud storage and edge computing, which allows the storage of historical data for detailed analysis. This feature empowers users to track and analyze trends in water usage, plant health, and environmental conditions over time. Consequently, the system can adapt watering schedules dynamically, informed by real-time data and historical insights. This cost-effective and energy-efficient solution supports sustainable gardening and is scalable for both small home gardens.

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