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IoT-Based Smart Garden Monitoring and Automated Irrigation System Using NodeMCU

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***Abstract*—This paper describes the development of a monitoring and controlling system for a garden using the Internet of Things (IoT). The system is designed to assist users in managing their plants and gardens remotely and effectively. Soil moisture levels are difficult to assess and manage, and achieving their target levels can be challenging. Therefore, an automatic water pump system is the optimal solution for this situation. The soil moisture sensor measures the moisture content in the soil, and the system automatically turns on the water pump when the moisture level is insufficient for healthy plant growth. A Light Emitting Diode (LED) is used to notify the user when the water pump is operating. A NodeMCU is used as the microcontroller for this project, which has a built-in Wi-Fi module, making it easier to interface with the Blynk software on a smartphone. The input is a soil moisture sensor, and the outputs are a water pump and an LED. The system successfully demonstrated real-time monitoring and automated control of soil moisture, ensuring optimal plant health. The integration of NodeMCU with Blynk enabled seamless remote access and notifications, enhancing user convenience. Experimental results confirmed the system's reliability in maintaining soil moisture levels within the desired range, reducing manual intervention, and improving water efficiency. This IoT-based approach provides a practical and scalable solution for smart gardening applications.**

***Index Terms*—IoT, NodeMCU, soil moisture sensor, water pump**

I. INTRODUCTION

Human civilization has relied on agriculture since its inception, recognizing water as a vital nutrient for plant growth. Traditional irrigation methods such as overhead sprinklers and flood systems have proven ineffective, resulting in water wastage and soil disease [1]. The inadequacy of water supply poses significant challenges, including stress, reduced plant quality, and even plant death [2].

To address these issues, the agricultural sector has transitioned to automation, leveraging advancements in technology to enhance productivity and reduce human intervention [3]-[6]. The integration of automatic systems with the Internet of Things (IoT) has revolutionized agriculture, enabling remote monitoring and control without human intervention. A plethora of research has explored the potential of IoT and sensors in agriculture, highlighting their role in irrigation management and soil monitoring. Various studies have demonstrated the effectiveness of wireless sensor networks in optimizing irrigation practices, utilizing real-time data on soil conditions and weather [7]-[10]. For instance, researchers have developed control systems utilizing node sensors, smartphone data management, and web applications for monitoring and analyzing crop conditions [11]-[12]. Others have implemented automated watering systems based on soil moisture content, utilizing microcontrollers and Wi-Fi modules for remote operation [13]-[15].

Jirapond et al. designed and developed a control system for crop fields using node sensors, smartphone data management, and a web application, comprising hardware, web, and mobile components for monitoring, analyzing, and controlling crop conditions [16]. K. Taneja and S. Bhatia demonstrated an automated watering and irrigation system that can supply water to crops as needed based on soil moisture content. The system uses an Arduino Uno microcontroller as its core control system, two soil moisture sensors (EC-1258), and a Wi-Fi module (ESP-8266). For IoT applications, this project used ThingSpeak and API to store and retrieve data from things using the HTTP and MQTT protocol over the Internet or a Local Area Network [17]. R.Karthikamani and Harikumar Rajaguru use Raspberry Pi to develop an IoT-based Smart Irrigation System using Raspberry Pi for their plant. This proposed process is designed to automatically operate a water pump and the soil moisture sensor to detect sufficient water in a plant. Thing Speak is used to monitor information and notify the users about the moisture level using an internet connection [18]. J. Karpagam et al. utilize a soil moisture sensor to detect moisture levels, transmitting this information to a microcontroller. The microcontroller then regulates the flow of water to the plants accordingly.

Additionally, an ESP8266 board is employed for remote control functionality, allowing the system to be operated via the Internet [19]. M. Monica et al. designed an IoT-based automated irrigation system that integrates soil moisture, luminosity, temperature, and humidity sensors with an Arduino and a GSM module. The system updates the parameters to the cloud, allowing for real-time monitoring and tracking of the field status using the sensors [20]. The Blynk IoT platform has also gained significant popularity and widespread usage in the

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realm of smart irrigation systems. Blynk offers a user-friendly and versatile platform that enables seamless integration and control of various IoT devices, including those utilized in irrigation systems. It provides a range of features and functionalities that allow users to remotely monitor and manage their irrigation systems through a smartphone or web application [21]–[25].

Hence, in this context, this project aims to enhance plant and garden management by enabling remote monitoring and control, ultimately improving efficiency and convenience. By integrating a soil moisture sensor with an automatic water pump and LED indicator, coupled with smartphone interfacing via a nodeMCU microcontroller and Blynk software, we strive to achieve optimal moisture levels for robust plant growth. Through our work, we aim to address the limitations of traditional irrigation systems and provide a reliable and efficient solution for plant care and management.

II. Methodology

Fig. 1 shows the proposed system of the project. NodeMCU controls the water pump based on the value of soil moisture. The smartphone is connected to NodeMCU through an internet connection to monitor the system remotely.

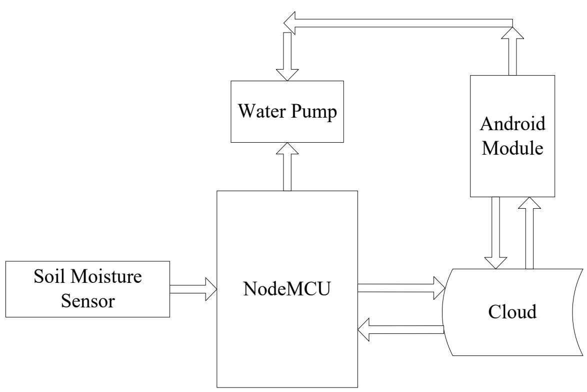

Fig. 1. Proposed system design.

The measured moisture levels are updated on the IoT cloud and the data is transferred to the user's smartphone. This modern technology system for gardens can be monitored and controlled using IoT (Internet of Things), allowing busy individuals to care for their gardens without the need to visit the garden site directly. This system minimizes the energy required by humans and reduces the time needed to maintain the garden.

Referring to Fig. 2, the process begins when the capacitive soil moisture sensor measures the moisture content of the soil. If the sensor reading exceeds a threshold value of 500, indicating that the soil is too dry, the relay is activated to power the water pump. Conversely, if the moisture value is equal to or below 500, the relay remains inactive and the pump stays off. An LED is included in the system as an indicator to alert users in the event of technical issues with the water pump. Additionally, the soil moisture data is transmitted to the user's smartphone via the Blynk application for real-time monitoring.

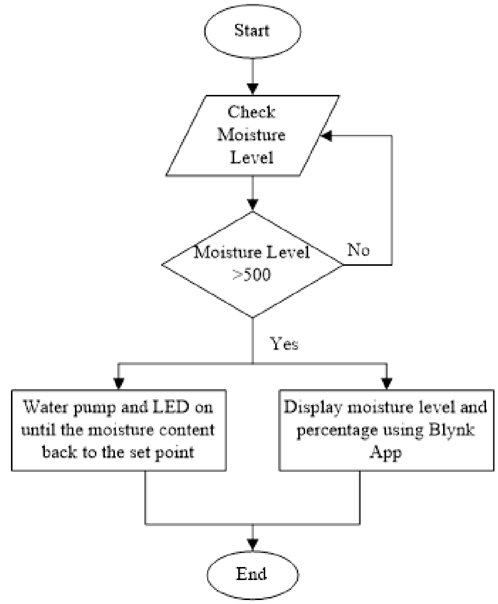

Fig. 2. Flowchart of monitoring and controlling system for garden.

A. NodeMCU

NodeMCU is an open-source platform based on the ESP8266 designed to enable object connectivity and wireless data transfer via Wi-Fi. It was selected for this project due to its compact size, low cost, and built-in Wi-Fi capabilities, which are ideal for IoT-based applications. Additionally, its compatibility with the Arduino IDE and seamless integration with Blynk further streamline development. Fig. 3 shows the NodeMCU module used in this system.

Fig. 3. NodeMCU

B. Soil Moisture Sensor

A capacitive soil moisture sensor, illustrated in Fig. 4, operates by detecting change in capacitance, which refers to the amount of electrical charge stored across an electrical potential. Unlike resistive sensors, capacitive sensors are more resistant to corrosion and environmental wear, improving them suited for long-term deployment in outdoor environments. This sensor provides the primary input for the system to assess soil conditions and trigger automated irrigation.

Fig. 4. Capacitive soil moisture sensor

C. Blynk Application

The Blynk mobile application is utilized as the IoT interface for real-time monitoring and control. It was chosen for its user-friendly interface, cross-platform compatibility, and seamless integration with the NodeMCU via cloud connectivity. Fig. 5 shows the Blynk interface displaying soil moisture level and percentage scale.

Fig. 5. Blynk App

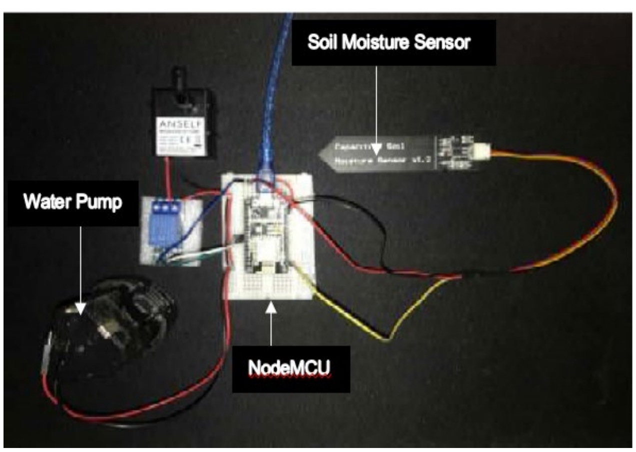

Fig. 6. Connection setup

Fig. 6 shows the connection setup of the automatic irrigation system. Wires are used to make the connection and carry the current flow and signal by using three pins on the capacitive soil moisture sensor which are VCC (Power), GND (Ground) and AO (Analog Output). The VIN pin on the relay is connected to a digital output of the NodeMCU which is a D5 pin, the GND pin on the relay is connected to the GND pin of the NodeMCU, and the VCC pin on the relay is connected to the VIN pin of the NodeMCU board. The positive terminal of the water pump is connected to the terminal block COM on the relay and the negative terminal of the water pump is connected to the negative terminal of the 12V power supply. Hence, the positive terminal of the 12V power supply is connected to the normally opened (NO) terminal block of the relay. D5 pin is used to trigger the relay, the signal comes out from the capacitive soil moisture sensor is LOW. Therefore, no current flow through the coil caused the coil de-energized, the armature is held away from the core by spring tension. It causes the motor to turn off since there is no current flow from the relay as the connection on the relay switches from a normally closed to an open condition. Besides, when the capacitive soil moisture sensor transmitted a HIGH signal to the relay, the contact inside the relay change from normally opened to a closed condition. As a result, the water pump turns ON and supplies water to the system. This project is also based on a closed loop control system where there is a feedback element to make sure the desired output will be equally the same as a set point. The percentage scale and soil moisture level are displayed using the Blynk app on a smartphone.

III. Experimental Result and Analysis

This project uses a capacitive soil moisture sensor as an input, a water pump and an LED as an output that is triggered by a relay. This experiment operates when the capacitive soil moisture sensor dips into the soil, which has a moisture level of more than 500, the sensor gives an analog signal to the NodeMCU. The analog signals are converted into digital signals to trigger the relay position and allow the current to flow so the water pump is turned on.

Besides, when the capacitive soil moisture sensor dipped into soil that has a moisture level below 500, the sensor also transmitted the signal to trigger the relay to be opened circuit which the contact on the relay de-energize and the water pump turns off. Fig. 7 shows the Blynk interface for moisture level and its percentage for moisture conditions below 500.

This test is conducted to examine the time required for dry soil to dry every two hours after 500 ml of water has been supplied. Table I shows the sensor value read by the soil moisture sensor using 15 inch diameter pot and 500 g of soil. Pot 1 is kept indoors or out of direct sunlight, whereas Pot 2 is kept outside or in direct sunlight. Pot 1 required 20 hours and Pot 2 required 8 hours to reach a moisture level of more than 500 as shown in Table II.

Fig. 7. Blynk interface for moisture level and its percentage for moisture condition below than 500.

TABLE I. SOIL MOISTURE VALUE FOR 24 HOURS

Time Taken (Hour)	POT 1	POT2
0	> 500	> 500
2	> 500	> 500
4	> 500	> 500
6	> 500	> 500
8	> 500	> 500
10	> 500	< 500
12	> 500	< 500
14	> 500	< 500
16	> 500	< 500
18	> 500	< 500
20	> 500	< 500
22	< 500	< 500
24	< 500	< 500

TABLE II. TIME REQUIRED FOR SOIL TO DRY INDOOR AND OUTDOOR

Pot Location	Initial Condition Of Soil	Amount of Water Supplied	Time Taken For Soil To Dry
1 (Indoor)	DRY	500 ml	20hours
2(Outdoor)	DRY	500 ml	8 hours

IV. CONCLUSION

This system is designed to automatically operate the water pump based on soil moisture levels detected by a capacitive soil moisture sensor. The automated controller replaces the conventional manual watering process traditionally carried out by farmers. When the soil moisture level drops below the desired threshold, the sensor sends a signal to the NodeMCU, which then activates the water pump to irrigate the plants. Real-time monitoring is facilitated through the Blynk mobile application, allowing farmers to track soil conditions remotely. This approach helps to minimize water wastage, reduce manual labor costs, and ease the workload for farmers. However, the system has some limitations. It currently focuses solely on soil moisture and does not account for other critical parameters such as soil pH, nutrient levels, or environmental conditions like rainfall. To address these limitations, future enhancements will include the integration of a pH sensor and an automatic fertilizer injection system. This would enable a more comprehensive and intelligent irrigation management system, further improving efficiency and crop health.

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