IoT- powered Real Time Smart Plant Surveillance System for Digital Gardening and Agriculture

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***Abstract*—This paper presents an IoT-enabled plant monitoring and automated watering system that leverages the power of sensors, wireless communication, and cloud computing to provide a scalable and cost-effective solution for precision agriculture. The proposed system consists of soil moisture, temperature and humidity sensors that collect real-time data on plant growth conditions and transmit it to a cloud-based platform for analysis and decision-making. The system's control unit receives commands from the cloud platform and activates the watering system when the soil moisture falls below a threshold value. The system also provides individuals with remote access to the plant growth data, enabling them to make informed decisions on crop management and resource allocation. The proposed system offers several benefits, such as water conservation, increased crop yields, and reduced labor costs, making it an attractive solution for precision agriculture. The experimental results demonstrate the system's effectiveness in maintaining optimal soil moisture levels, enhancing plant growth, and reducing water wastage. Overall, this paper provides a valuable contribution to the field of IoT-enabled precision agriculture and offers practical insights for designing a scalable and intelligent plant monitoring and watering system.**

Keywords—IoT, ESP8266, automated watering system, DHT11,Blynk , Soil moisture.

I. Introduction

We continue to grapple with the challenge of managing our natural resources, with water being a vital element for human survival. The rapid depletion of this precious resource poses a looming existential crisis, particularly for farmers residing in regions prone to droughts. To address this issue, modern irrigation systems offer a solution by efficiently providing water to plants when they need it most. Our project, titled "Plant Monitoring And Automated Watering System," has emerged from thorough research. Its goal is to regularly monitor the moisture levels in plants and notify caregivers when they reach critically low levels. By implementing an automated plant watering system in your garden or agricultural field, you not only support your plants in achieving their full potential but also contribute to water conservation.

II. Literature Survey

The Internet of Things (IoT) application in plant monitoring systems has gained significant attention in recent years for its potential to revolutionize traditional farming practices and boost agricultural yields. This section provides an in-depth examination of IoT-based plant monitoring devices in the literature and discusses recent advancements in the field.

In [1], a system is introduced to enable farmers to efficiently plan irrigation and monitor soil moisture at an affordable cost. This system comprises a commercially available soil moisture sensor (the Decagon EC-5), a lightweight wireless transmitter (the nRF24L01), and a locally developed microcontroller (the MPC82G516A). The EC-5 sensor node communicates soil moisture data to the coordinator via a 2.5GHz signal and further transmits this data to a computer using an RS232 interface. The MPC82G516A microcontroller processes analog data, employing a calibration curve tailored to the EC-5 sensor, given its low power consumption. The wireless network facilitates easy data transfer and storage, allowing efficient irrigation planning based on volumetric water content classifications.

To enhance transmission range and mitigate line-of-sight challenges, a repeater node is incorporated into the wireless

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sensor network (WSN). This system proves to be a valuable and viable choice for precision agriculture, thanks to its accuracy in assessing soil moisture content and its capacity to effectively plan irrigation in agricultural greenhouses. However, it's worth noting that the system's scalability may be limited due to the chosen communication protocol and technology. As the number of sensor nodes increases, managing data flow and ensuring timely communication could become more complex.

In [2], they present irrigation techniques that incorporate soil-embedded moisture sensors capable of detecting capacitance changes linked to variations in soil moisture levels. These sensors consist of insulated electrodes situated within a chamber filled with granules and enclosed within a water-permeable shell. These sensors are integrated into ground units, which include a high-frequency driver to activate the sensor and a detector circuit that generates moisture-related signals in response to capacitance changes. The innovation also features controllers that group the ground units to enable precise irrigation control, providing dependable moisture signals. These controllers offer the choice of shared or independent moisture adjusters for multi-zone operation. By adapting to real irrigation requirements, conserving water, accommodating weather fluctuations and tolerating soil treatments such as fertilizers and pesticides, this system aims to optimize the watering process. One limitation of this irrigation system is that the moisture sensors embedded in the ground may lose accuracy over time due to debris accumulation within the sensor chamber. Additionally, the system's reliance on intricate circuitry may lead to technical issues and interruptions in the irrigation control process.

III. EXISTING SYSTEM

India is the world's second-largest irrigated nation after China, with only one-third of its cropland benefiting from irrigation. This highlights the crucial role of irrigation in Indian agriculture, especially in a country with a tropical monsoon climate like India, where rainfall is unpredictable, unreliable and variable. To further advance agriculture in India, it is essential to expand irrigation coverage to over half of the cultivated land.

Various irrigation methods are employed, including drip irrigation and spray irrigation. Farmers also utilize center pivot irrigation and canal irrigation. However, it's important to note that the installation process for these methods can be time-consuming and costly when applied in fields. Improper execution, particularly with drip irrigation, can lead to wastage of time, water and energy. Additionally, the use of plastic tubes can affect soil fertility and other factors.

It's clear that other countries are making progress in developing modern equipment and technology for irrigation. This highlights the importance of India staying updated with advancements in this crucial agricultural sector.

IV. PROPOSED SYSTEM

Instead of traveling to each field separately, the technology came up with the notion of regulating the irrigation system directly from the mobile app. In this project, a soil moisture sensor measures the moisture content and transmits that information to the user via the Blynk app. As a result, users receive notifications when the pump should be turned on or off. So that farmers won't have to spend as much time watering and collecting soil moisture data.

The primary focus of the contemporary agricultural sector is to enhance efficiency. If modern agriculture is widely adopted, millions of farmers will benefit from real-time agricultural information. Mobile technologies play a significant role in monitoring and managing crop irrigation systems. Moisture sensors embedded in the ground provide information about the amount of moisture present at different soil depths.

By avoiding unnecessary water usage, a substantial amount of water is saved. This approach is cost-effective, improves productivity, reduces water waste, simplifies monitoring, saves labor costs, and is environmentally friendly. It ensures the maintenance of gardens with aesthetic value and enables effective irrigation. Our suggested technique can be utilized for agriculture, commercial gardenscapes, and small backyard gardens. The current area of focus is the design and development of an IoT-based soil moisture monitoring system.

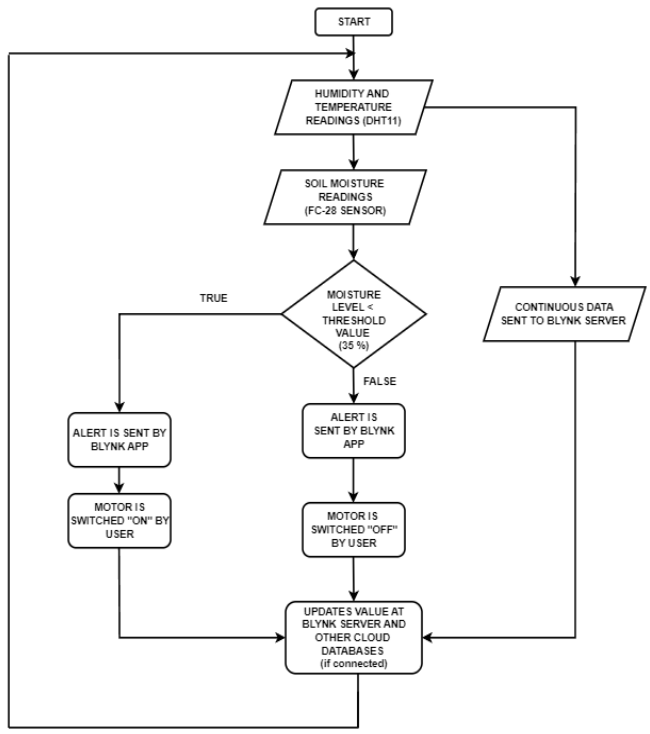

Fig 1 - Flowchart of the Proposed System

A. Components Used :

a) NodeMCU :

NodeMCU is an IoT-focused development board and open-source firmware. It is designed to cater to IoT applications and is built around the ESP8266 Wi-Fi SoC by Espressif Systems. The firmware is developed using Lua, while the hardware is dependent on the ESP-12 module.

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Fig 2 - NodeMCU Board

b) FC-28 Soil Moisture Sensor :

The soil moisture sensor module is designed to monitor soil moisture levels. It measures the volumetric amount of water present in the soil and provides the moisture level as output. The module is equipped with both digital and analog outputs, allowing for versatile usage. Additionally, it features a potentiometer that can be used to regulate the threshold level.The moisture in the soil must be calibrated, as it can vary depending on environmental conditions such as soil nature, temperature, or electric conductivity.In hydrology and agriculture, reflected energy from microwaves is utilized for remote sensing of soil moisture. Gardening and farming enthusiasts can benefit from portable probing tools that utilize these principles to assess soil moisture levels.

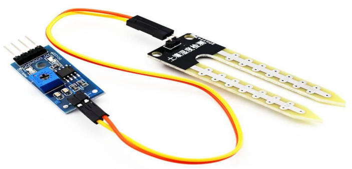

Fig 3 - FC-28 Soil Moisture Sensor

c) DC Water Pump :

The 3-6V Mini water pump is extremely easy and intuitive to use. To begin pumping water, just immerse the pump in water, connect a suitable pipe to the result, and power the motor with 3-6V. It has an internal capacity of 120 liters per hour and a comparatively small current draw of 220mA. Simply attach the tube pipes to the motor outlet, immerse it in water, and switch it on. Keep a water level that is constantly in excess of the motor.

Fig 4 - DC Water Pump

d) Power Relay :

An electrical switch powered by an electromagnet is termed as a power relay module. An independent low-power signal via the microcontroller powers the electromagnet's coil. Acting as a switch, it manages the circuit's activation and deactivation, making it ideal for controlling multiple circuits with a single signal.

Fig 5 - Power Relay

Deactivation connects the external circuit to the normally closed terminals, while activation connects it to the normally open and common terminals, ensuring precise circuit control. Power relay is a beneficial circuit it could potentially employ for regulating a motor's maximum voltage and extreme current load, and power from the AC.

e) DHT11-Digital Humidity and Temperature sensor :

The DHT11 temperature sensor efficiently monitors soil temperature, providing timely updates on soil temperature's impact on moisture levels. This versatile sensor, designed for measuring both relative humidity and air temperature, is cost-effective and compatible with microcontrollers like Arduino and NodeMCU. It employs a capacitive element for humidity measurement and a thermistor for temperature measurement, with changes in humidity affecting capacitance and subsequent resistance, allowing for digital temperature readings within the 0 to 50 degrees Celsius range and a humidity range of 20% to 80%.

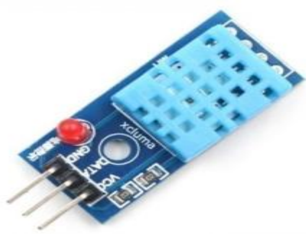

Fig 6 - DHT 11

B. Software Used :

a) Blynk :

The Blynk platform was used in conjunction with the Blynk Cloud platform. An open-source, web-based platform called Blynk was created exclusively for Internet of Things (IoT) gadgets. It offers a user interface for creating interactive dashboards for remote data visualization and system monitoring, as well as for controlling distant devices via the internet. Blynk is made up of three main modules:

<u>Blynk Server</u>: This component is in charge of enabling online communication between the gadget and a smartphone. It can support a variety of IoT devices, including Raspberry Pi. Users have the option of using an open Blynk host or establishing their own private Blynk host.

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Blynk App: Provides a range of user interfaces to interact with the system, enabling remote control and monitoring from a smartphone or other devices.

Blynk Libraries: These libraries play a crucial role in establishing communication between the device and the Blynk platform. They facilitate the exchange of input and output commands, enabling seamless interaction with the IoT device.

By integrating the Blynk platform into the monitoring system, it became possible to operate the setup without the necessity of a tethered computer, enhancing its autonomy and accessibility for remote control and monitoring.

b) Arduino IDE :

Arduino is a versatile open-source platform encompassing both software and hardware components, easily accessible online. To program the microcontroller, an integrated development environment (IDE) is employed, facilitating code writing and its subsequent attachment to the circuit embedded within the microcontroller. This IDE supports programming languages like C and C++, each with its distinct code structure rules. In this project, we have opted for the NodeMCU board and the Arduino IDE due to their compatibility with a wide range of circuit boards, making them ideal choices for our application.

The modeled image demonstrated in Figure 7 has been employed to design a setup for experimentation, while the microcontroller that was embedded had been configured to run and transmit data directly to the computer. It subsequently endured through carefully planned testing on plants. Afterwards the testing configuration is successfully built up, the configuration of the system is modified to ensure it could operate independently without the aid of a computer to enable it to yield outcome.

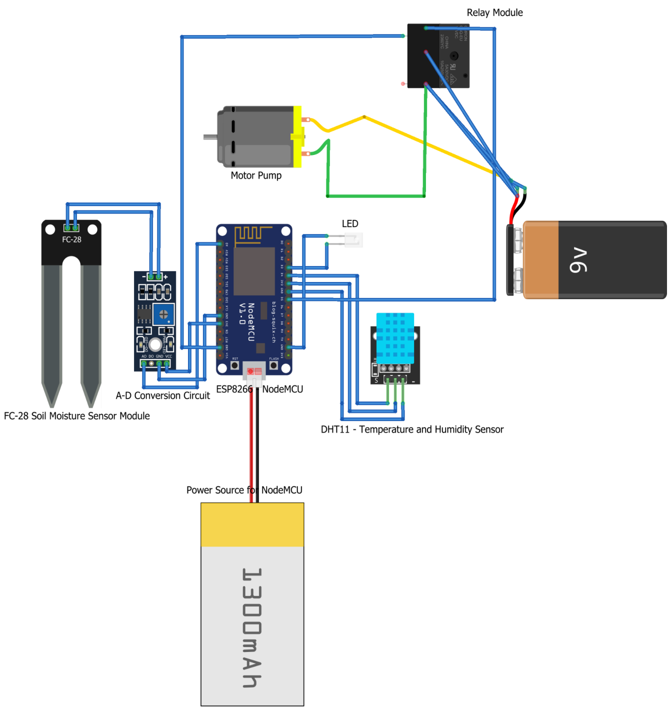

Fig 7 - Schematic Diagram

This is the key configuration needed before you can utilize the NodeMCU via the Blynk App. Install the Arduino IDE. You can get it from the Arduino website.Install the ESP8266 WiFi chip's Arduino core. Install the Blynk library for the Arduino IDE and the Blynk App for your smartphone. All of the information can be viewed on the Blynk webpage.

C. Calculations :

As soil moisture is generally expressed as a percentage, the sensor outputs analog values in the range of 0 to 1023. This equation is then utilized in converting these values to a scale from 0 to 100 percent:

$$S_{final} = (S_{initial} * 100) / Q \quad (1)$$

Here, In Eq.1 , $S_{initial}$ corresponds to the readings from the soil moisture sensor, and Q is the 1024 quantization levels available in a 10-bit Analog to Digital Converter (ADC) of the NodeMCU. S_{final} is the percentage that represents the value of the soil moisture sensor.

V. Discussion of Results

The outcome of the experiment exhibits that switching regulation from a sensing device to a motor right after the circuitry has been effectively implemented depends on the possibilities that the organic matter in the soil complies with the particular needs of the field. Figure 8 displays the monitored output that the Blynk software programme on the client's equipment observed during this changeover. Additionally, apart from assessing soil moisture levels, the system also gauges the moisture levels within the external environment and records the prevailing temperature conditions. There is also a bulb present for monitoring the plants at night .

A button is provided to the user to turn the water pump on and off. If the soil moisture falls below the predetermined level, the user will receive a reminder to water their plant. The user can then start watering the plants by switching on the DC pump. Once it has been determined that the soil is sufficiently wet, the user can turn off the motor.

Table I : Temperature, Humidity and Soil Moisture values recorded at various parts of the day

Time	Temperature	Humidity	Soil Moisture
7 : 00	24 ℃	91%	68%
10 : 00	28 ℃	87%	60%
13 : 00	31 ℃	71%	51%
16 : 00	28 ℃	72%	43%
19 : 00	26 ℃	80%	36%
22 : 00	25℃	86%	93%
1 : 00	24 ℃	89%	85%

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By analyzing the plotted graphs like Fig.9 and Fig.10, future requirements can be estimated. This would be highly beneficial for individuals who are unable to care for their plants at home.

A range of sensor results at different points in time are presented in Table 1. Both humidity and temperature are recorded by the DTH11 sensor, and the soil moisture level is evaluated by the soil moisture sensor. The information in the table indicates that relative humidity reduces as temperatures go up. Also water flows to the plant when the soil moisture falls under the 35% threshold. This technique aids in bringing the soil moisture level back beyond permitted limits.

Fig 8 - Blynk App Interface With Set-Parameters

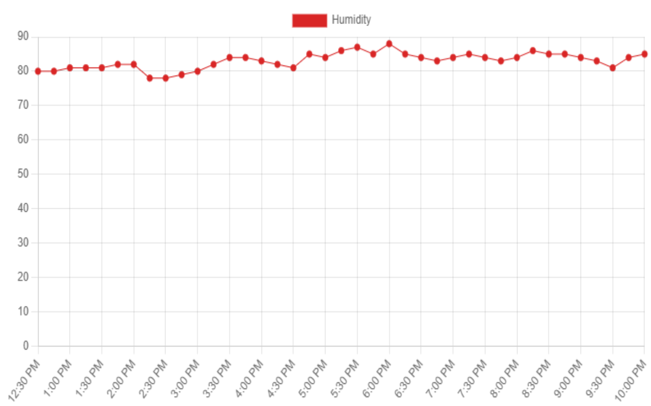

Fig 9 - Humidity Levels measured in a day (Humidity Percentage Vs Time)

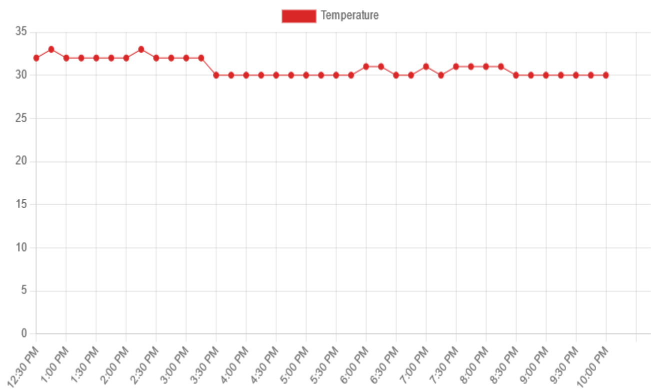

Fig 10 - Temperature Levels measured in a day (Temperature in Celsius Vs Time)

VI. Conclusion

With the above-discussed principle in consideration, watering plants becomes simple, precise and efficient. The output is primarily determined by the moisture sensor's output. As a result, the "Plant Monitoring And Automated Watering System" has been successfully developed and evaluated. It developed by combining all of the aforementioned hardware components. Each module's inclusion has been completely examined and justified accordingly in order to ensure the optimum operation of the unit. A simple and efficient irrigation technique is the Arduino-based autonomous irrigation system. An electronic database can be constructed using the numerous recorded parameters, facilitating the analysis of optimal conditions for a harvest in specific geographic areas. Therefore, this technology is very beneficial as it reduces the farmers' manual labor and aids in the effective utilization of resources. It gets rid of the manual switch whereby farmers used to turn on and off the irrigation system.

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