Root Check: Real-time Plant Health Monitoring and Irrigation Control

SALIM, SOURAV DIWANIA, SUMIT SHARMA, NATWAR SINGH RATHORE, JYOTI SRIVASTAVA, RUCHIKA SINGH
Department of Electrical and Electronics Engineering
Dr. A. P. J. Abdul Kalam Technical University
KIET GROUP OF INSTITUTIONS DELHI-NCR, GHAZIABAD
INDIA

Abstract: - Ensuring the stability and profitability of aquatic plants is a critical concern in modern agriculture. This research seeks to develop an intelligent communication system for monitoring plant health. Despite the advanced data visualization and forecasting capabilities of existing technologies, many farmers are not fully utilizing them. Our innovative technology analyzes key factors like temperature and humidity to make informed decisions about water pumping from the generator. System reduces the complexity of managing plant health, converting sensor data into meaningful visuals in platforms like Adafruit Cloud and IoT interfaces. Additionally, the system sends emails to notify farmers about the real time status of the farm. (Saving water and avoiding regular maintenance). Combining ancient farming methods with modern innovations is the goal of the Trans Agriculture technique.

Key-Words: - ESP 8266, Smart Agriculture, IoT, DHT 11.

Received: September 23, 2023. Revised: March 11, 2024. Accepted: May 14, 2024. Published: July 9, 2024.

1 Introduction

In developing nations, including India, water scarcity is a serious issue especially in north India. Our study aims to solve this by coming up with innovative ways to conserve water and reduce the need of human intervention for maintenance purpose. The proposed idea is to replace water-intensive plants with low-water, low-maintenance alternatives. Additionally, utilizing sensor data to monitor plant health and determine optimal watering schedules can significantly improve water efficiency and plant care. This approach not only conserves water but also ensures plants receive the precise amount of water for growth, enhancing their health and resilience. We recommend using soil and environmental condition measurement equipment to accomplish this [1]. Using this data, a decision-making model will determine when to water the plants most effectively, saving water and cutting down on waste. Using the model to forecast plant health and supply crucial data, we also intend to design a specific growing environment for these water-saving plants. Our system is designed to automatically manage the water pump according to soil moisture content, promoting efficient water usage. It also incorporates safety features, such as a fire detection buzzer. Unlike other research that primarily emphasizes temperature, our approach considers the overall health of the plants and provides a visualization of sensor data. In our approach, we take into account both the ambient temperature around the plant and the plant's own temperature. Additionally, our system will send email alerts about plant health, allowing for timely intervention and maintenance.

2 Literature Survey

An in-depth analysis of existing smart buildings showing progress within the water management and irrigation category. For example, a smart home irrigation system based on Wireless Sensor Network (WSN) and actuation proposed to adjust water delivery according to the specific demands of different plants [2]. Wireless sensor network combined with a mobile data acquisition system effectively measures soil moisture and conveys real-time information useful in planning the best times for irrigation of rice crops. They developed real-time soil moisture sensors and irrigation control systems in California, using their XBEE wireless communication module to transmit sensor data wirelessly back to a central computer for cloud irrigation solutions with water scarcity areas [3]. In this study author states that the development of a comprehensive IoT-based system, dubbed "Root Check," that aims to streamline and optimize these critical agricultural processes [4]. The study focused on different objectives: first, to develop a hydroponic system that can effectively monitor and regulate key parameters such as air temperature, root temperature, humidity, and pH. Secondly, to support IoT technology to provide real-time control and monitoring capabilities, enabling farmers to oversee and manage their hydroponic operations remotely [5]. A system was created to measure soil pH, temperature, and moisture content using sensors like LM35, pH 100, and HS-220, providing farmers with critical soil information for maintaining plant health [6]. Study proposed a system to simplify water management by monitoring tank water level and accurately calculating the water required for irrigation in the field [7]. According to the article given innovation is a GPS-enabled, remote-controlled robot designed for tasks such as moisture detection, temperature detection, spraying, and insect control. This system includes real-time monitoring of humidity and temperature to facilitate intelligent decision-making [8]. These advancements focus on leveraging technology to improve water management practices [9]. A smart water system to meet pipeline energy needs, promote environmental protection through water conservation, and reduce carbon dioxide emissions Proposed [10]. While these advancements demonstrate progress in water-saving irrigation technology, most existing systems lack user-friendly platforms for communicating and predicting plant health based on environmental conditions or visual data. Addressing these limitations, our proposed smart plant watering system aims to integrate comprehensive monitoring and predictive capabilities for enhanced plant health management.

3 Proposed Smart Plant Monitoring System

Our smart plant-monitoring system utilizes various sensors to gather crucial data on soil pH, temperature, and moisture levels, all aimed at assessing plant water requirements. These sensors continuously monitor the soil conditions unless manually deactivated by the user, these sensors continuously monitor soil conditions. The decision tree method then uses the collected data to evaluate the overall health of the plant. To provide users with easy access to this data, we offer a cloud platform that displays sensor information and assesses plant health. Farmers receive email notifications containing updated plant health information once the assessment is complete. At the core of our hardware is the Arduino UNO board, which interfaces with essential sensors via specific pins (e.g., flame, pH, and DHT sensors connected to pins 4, 2, and A0, respectively). The DHT sensors specifically detect both pH and temperature levels. Pin 5 connects to a buzzer for alert notifications. Pins 0 and 1 connect the WiFi module to the cloud platform for communication. A 16x2 LCD is used to show real-time actions and sensor outputs, providing immediate feedback of system performance. To interface the LCD with the Arduino the I2C protocol is used, which simplifies wiring by using just two pins: SDA (Serial Data) and SCL (Serial Clock). These pins facilitate communication between the Arduino and the LCD. Additionally, pins 7, 8, 9, and 10 on the Arduino are connected to the LCD screen to handle display messages effectively. Pin 6 is connected to the ULN2003 IC, which is utilized for driving special bits that control various operations within the system. This integrated setup ensures accurate monitoring and management of plant health by optimizing water usage and providing essential real-time data to the user.

4 Material and Methods

4.1 Soil Moisture Sensor

A soil moisture sensor measures the volumetric water content in the soil by utilizing properties like

resistivity, dielectric constant, or interaction with neutrons. This measurement is crucial for understanding soil moisture levels without the need for manual gravimetric measurements, which involve removing, drying, and weighing soil samples.
Specifications of the Old Soil Moisture Sensor:

Operating voltage: 3.3V–5V dual output mode, with analog output being more accurate includes a fixed bolt hole for easy installation. Features a power indicator (red) and a digital switching output indicator (green). Equipped with an LM393 comparator chip for stability

- Panel PCB Dimension: 3cm x 15cm
- Soil Probe Dimension: 6cm x 3cm
- Cable Length: Approximately 21cm
- VCC: 3.3V–5V
- GND: Ground

4.2 Jumper Wire

A jumper wire is a simple wire with two male connector pins used to connect two components without soldering. When needed, we often use it with breadboards and other prototyping equipment to facilitate easy circuit modification.

4.3 Node MCU

For the ESP8266 WiFi chip, Node MCU is an open-source firmware based on LUA. It provides a development board (also known as a kit) for exploring the capabilities of the ESP8266 chip. The ESP8266 chip is a low-cost WiFi module that supports the TCP/IP protocol, and it serves as the core of the Node MCU development kit and board.

4.4 Relay

A single-channel relay module is a board used to control high-voltage and high-current devices such as motors, solenoid valves, lights, and AC loads. Microcontrollers such as Arduino and Node MCU can interface with it. Screw terminals can connect the relay terminals (COM, NO, and NC), while LEDs display the relay's status.

4.5 Humidity and Temperature Sensor

The DHT11 sensor combines temperature and humidity sensing capabilities with calibrated digital signal output. It features a built-in 8-bit microprocessor for reliable performance and long-term stability. Additionally, it includes an NTC temperature measurement sensor for wet conditions.

4.6 PIR Motion Sensor

Passive infrared (PIR) sensors detect human or animal movement by sensing infrared radiation levels. They consist of pyroelectric sensors that passively receive infrared radiation from the environment. When a human or animal passes by, their body heat causes a change in the sensor's infrared radiation levels, triggering the sensor to generate an electrical signal.

4.7 16x2 Display

The 16x2 LCD (Liquid Crystal Display) can display up to 16 characters per line and 2 lines. Electronic projects commonly use it to display text or information. The LCD includes a built-in controller that interprets and executes commands for tasks such as adjusting cursor position, displaying images, and controlling screen on/off status.

4.7 Water Pump

The Node MCU's 5V output directly powers the water pumps used in this context due to their low operating currents. This simplicity makes them ideal for use in automatic irrigation systems, facilitating easy and rapid prototyping.

5 Result and Discussion

The system measures soil and environmental parameters around plant roots, displaying the data graphs on the Adafruit Io cloud platform. The monitor output identifies the highest values from these readings. Users also receive an email report regarding the health of the facility. The article uses the sensor data output as an input for their search algorithm.

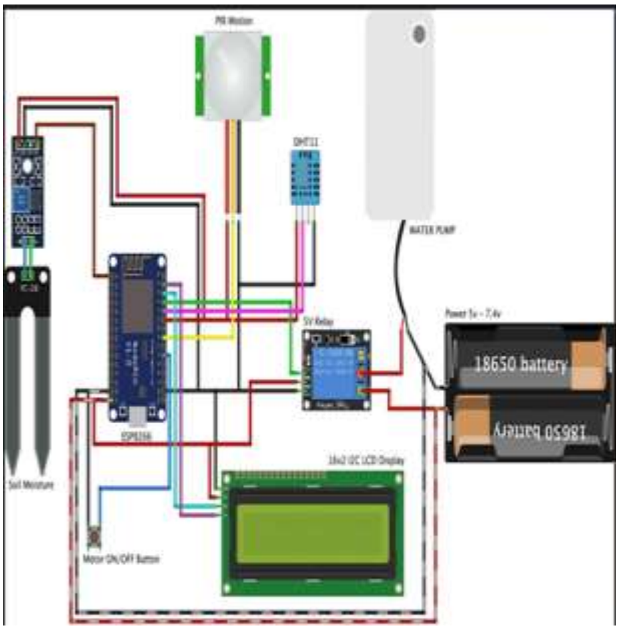

Fig. 1. Circuit diagram.

The ESP8266 reads sensor data periodically and displays it on the LCD or sends it to a web server or mobile app. It can also control the water pump based on soil moisture, activating the pump when moisture is low.

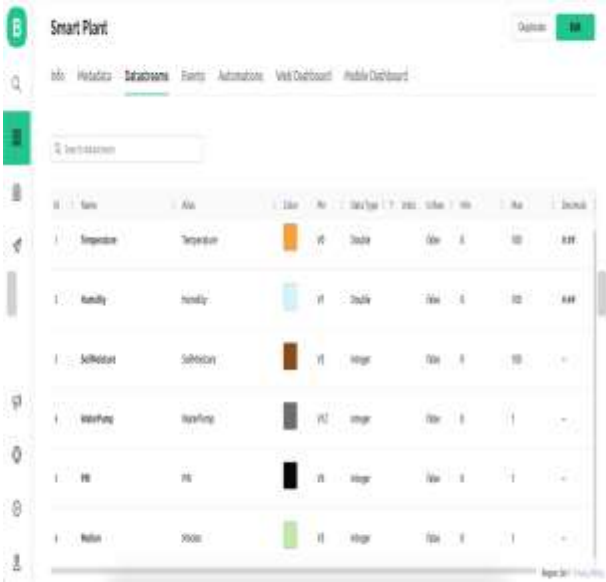

Fig. 2. Blynk IoT Platform.

The dashboard's features include:

Plant List:
On the left side, a list of monitored plants is displayed. Although the image only displays one plant, you can add multiple plants to the dashboard.

Sensor Readings:
The center of the dashboard displays sensor readings for the selected plant. The specific readings shown depend on the connected sensors. The image shows a temperature sensor reading of 100, but we can also include other sensors such as soil moisture and light sensors.

Data History:
Graphs at the bottom show the history of sensor readings over time, aiding in identifying trends in plant health.

Controls:
The dashboard may include controls for connected devices, such as a water pump. However, no controls are visible in the image.

Blynk dashboards are accessible via web browsers or mobile apps, enabling remote monitoring of plants from anywhere.

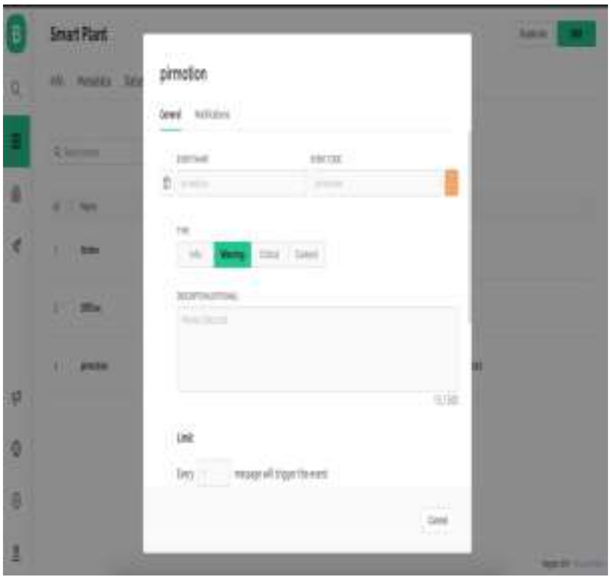

Fig. 3. Input Configuration on Blynk Platform.

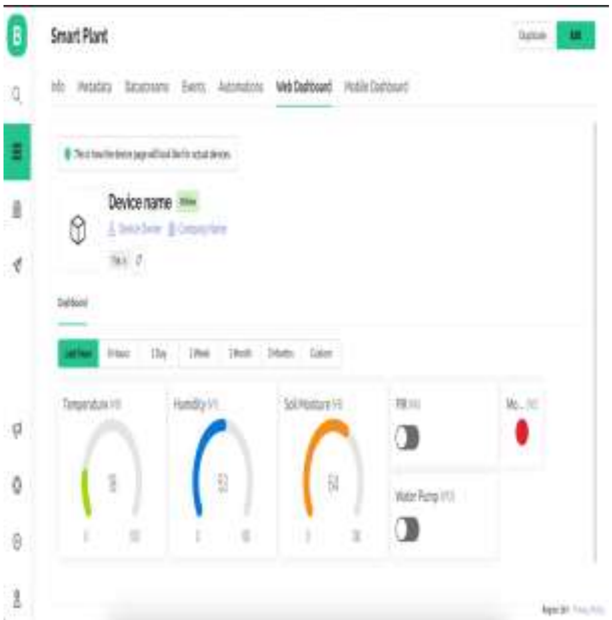

Fig. 4. Control Configuration on Blynk Platform.

Fig. 5. Smartphone layout of Blynk Platform.

The app appears to be monitoring the following:

- **Temperature:** The temperature is currently reading 29.20 degrees Celsius.
- **Humidity:** The humidity is currently at 65.00%.
- **Soil Moisture: The app does not display the soil moisture numerically, but it does have a gauge that appears to be half full, suggesting moderate moisture levels.**
- **PIR Sensor:** The PIR sensor is currently reading "ON," which means it has detected motion.
- **Motion:** Motion is also listed as "ON," which corroborates the PIR sensor reading.
- **Water Pump:** The water pump is currently reading "ON.".

Here are some of the possible benefits of using a smart plant monitoring system:

- **It helps to prevent over-watering and under-watering.** By monitoring the soil moisture, you can water your plants only when they need it. This can help prevent root rot and other problems caused by over-watering.
- **Helps identify potential problems:** By monitoring the temperature, humidity, and other factors, you can identify potential problems early on, such as if your plant is getting too hot or too cold.
- **Some smart plant monitoring systems are capable of controlling other devices, like grow lights or irrigation systems.**

4 Conclusion

Our smart watering system utilizes an array of sensors and employs advanced algorithms to optimize water usage and monitor tree health effectively. By analyzing tree patterns, the system can intelligently determine the optimal watering schedule, conserving water while promoting plant growth. The system autonomously evaluates plant health, sending email alerts to farmers and displaying detailed information on a cloud platform for prompt action. These innovations signify a significant leap in permaculture practices and precision agriculture, potentially revolutionizing agricultural water management and facility maintenance.

Acknowledgement:
We would like to thank the IEC Club, Department of Electrical and Electronics for their invaluable technical support at the KIET Group of Institutions. Their assistance has been instrumental in the development of our project.

Declaration of Generative AI and AI-assisted technologies in the writing process.
During the preparation of this work, the authors used ChatGPT, a generative AI tool developed by OpenAI, to enhance clarity and coherence in the writing process. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

References:

[1] G.C. “wireless smart garden watering system” The 9th ACM International Symposium on Mobility Management and Wireless Sensor Networks, Mobiwac 11 Proceedings reach, 167–170, 2010.

[2] Boutraa T, Atta R, “A Wise Watering System for Wheat in Saudi Arabia Through Wireless Sensor Network Technology,” Akhkha A. International Journal of Arid Environments and Water Resources 1(6): 478–482, 2011.

[3] Touati F, Al-Hitmi M, Benhmed K, Tabish R “A fuzzy logic based irrigation system enhanced with wireless data logging applied to the state of Qatar”, Computers and Electronics in Agriculture, 98: 233-24, 2013.

[4] Kumar A, Kamal K, Arshad M.O., Mathavan S, Vadamala T. "Smart irrigation using XBee based communication and low-cost moisture sensors"

[5] IEEE Global Conference on Humanitarian Technology (GHTC 2014)

[6] Gain- war, S.D., and Rojatkar, D.V. "Automated Irrigation System for Monitoring Soil Parameters" was published in the International Journal of Science, Engineering, and Technology Research (IJSETR), volume 4, issue 11, pages 3817–3820, 2015.

[7] Kansara, K., Zaveri, V., Shah, S., Delwadkar, S., and Jani, K. "Sensor Based Automated Irrigation System with IOT: A technical review" International Journal of Computer Science and Information Technologies (IJCSIT), 6(6): 5331- 5333, 2015.

[8] Gondchawar N, Kawitkar. R.S. "IOT Based Smart Agriculture" International Journal of Advanced Re- search in Computer and Communication Engineering (IJAR- CCE), 5(6): 838:842, 2016.

[9] Roopaei M, Rad P and Choo K.K.R "Cloud of Things in Smart Agriculture: Intelligent Irrigation Monitoring by Thermal Imaging", IEEE Cloud Computing, 4(1): 10-15, 2017.

[10] Rawal S "IOT Based Smart irrigation system", International Journal of Computer Applications, 159(8): 7-11, 2017.

[11] Garcia. A.M, Garcia. I.F, Poyato. E.C, Barrios. P.M, Diaz. J.A.R, "Coupling irrigation scheduling with solar energy production in a smart irrigation management system", Journal of Cleaner Production, 175: 670-682, 2018.

[12] Salim, Jyoti Ohri, "Controlling of Solar Powered S.E DC Motor using IMC Controller," WSEAS Transactions on Power Systems, vol. 14, pp. 65-69, 2019.

[13] Ohri, J. "Study of aging effect on solar panel performance using LabVIEW." In Recent Trends in Communication and Electronics, pp. 299-304. CRC Press, 2021.

[14] Salim, and Jyoti Ohri. "Performance Study of LabVIEW Modelled PV Panel and Its Hardware Implementation." Wireless Personal Communications 123, no. 3 (2022): 2759-2774.

Contribution of Individual Authors to the Creation of a Scientific Article

SALIM – Hardware integration and Simulation
Dr. Sourav Diwania - Simulations
Dr. Sumit Sharma – Literature Survey
Dr. Natwar Singh Rathore - Drafting
Dr. Jyoti Srivastava - Drafting
Dr. Ruchika Singh - Drafting

Sources of Funding for Research Presented in a Scientific Article or Scientific Article Itself

No funding was received for conducting this study.

Conflict of Interest

The authors have no conflicts of interest to declare that are relevant to the content of this article.