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Plant Monitoring System

Shreeya Dinesh Rajput[1*], Shrawani Mohan Patil[2]
[1,2]Student, Department of Computer Science, St. John College of Humanities and Sciences, Palghar, India

***Abstract*: The growing demand for efficient agricultural solutions has paved the way for smart plant monitoring systems. This research presents PMS—an IoT-based system that integrates the ESP8266 Wi-Fi module with soil moisture, temperature, and humidity sensors to enable real-time plant health monitoring. Data is stored in Google Firebase, while a mobile application provides farmers with remote access to plant conditions. A key feature of this system is its automated irrigation mechanism, which activates when soil moisture drops below a predefined threshold, thereby reducing water wastage and ensuring timely watering. This not only improves water efficiency but also minimizes human intervention in routine plant care. During implementation, challenges such as unstable connectivity and variations in sensor accuracy were observed. Despite these limitations, the results demonstrate that PMS can effectively automate irrigation, promote healthier plant growth, and enhance resource utilization. Its scalability and cost-effectiveness make it suitable for precision agriculture, while future enhancements may include AI-based predictive analytics and solar-powered operation for greater efficiency and sustainability.**

***Keywords*: Internet of Things (IoT), Smart Agriculture, Plant Monitoring System (PMS), ESP8266, Firebase, Soil Moisture Sensor, Automated Irrigation, Precision Agriculture, Smart Farming, Real-Time Monitoring.**

1. Introduction

As urbanization accelerates and modern lifestyles become increasingly hectic, the care and nurturing of plants often receive less attention. With concrete infrastructures replacing natural spaces, the challenge of sustaining green areas has grown significantly. This has amplified the importance of plant monitoring systems, particularly for urban residents engaged in rooftop or home gardening.

The rising interest in urban farming and the cultivation of Ayurvedic medicinal plants such as Tulsi, Aloe Vera, and Ashwagandha highlights the necessity of precision in plant care. Unlike conventional houseplants, these medicinal plants demand specific levels of temperature, humidity, and soil moisture to preserve their therapeutic value.

Manual monitoring, however, is often impractical. Many individuals' resort to routine watering without evaluating soil conditions, resulting in problems such as overwatering, nutrient loss, root rot, and fungal infections. These limitations call for an intelligent, automated solution.

To address this, we propose an IoT-based Plant Monitoring and Automated Irrigation System that employs sensors to track soil moisture, temperature, humidity, and water levels. The system integrates with an Android application, enabling real-time monitoring, automatic irrigation, and remote pump control with a single click. By reducing human dependency and maintaining optimal growth conditions, the system enhances the survival rate and quality of delicate Ayurvedic plants.

With its compact design, user-friendly interface, and real-time tracking capabilities, this system is particularly suited for rooftop farms, small-scale greenhouses, and indoor gardening setups.

2. Methods and Material

The proposed IoT-based Smart Plant Monitoring and Automated Irrigation System was developed using a combination of hardware and software resources. Each component was selected based on its functionality, efficiency, and suitability for real-time monitoring and automation.

A. Materials

1) ESP8266 Microcontroller

Serves as the core processing unit, providing built-in Wi-Fi communication and interfacing with all sensors and actuators. It collects data from the soil moisture, DHT11, and LDR sensors and controls the relay module for automated irrigation.

Fig. 1. ESP8266 (Wi-Fi Module)

2) Soil Moisture Sensor

Measures soil water content and provides analog data to the ESP8266 for irrigation decision-making.

3) DHT11 Sensor

Records temperature and humidity levels to monitor environmental conditions.

*Corresponding author: shreeyarajput1102@gmail.com

Fig. 2. Soil moisture sensor

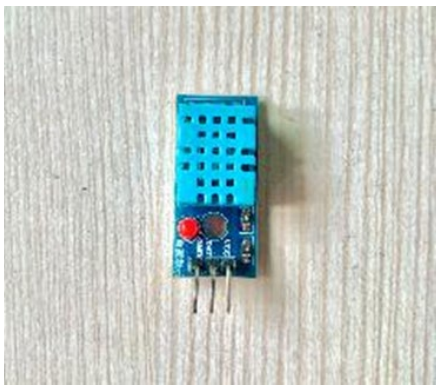

Fig. 3. DHT11 sensor

4) Light Dependent Resistor (LDR)

Detects light intensity to track sunlight exposure for plants.

5) Relay Module

Acts as an electronic switch that enables the ESP8266 to control the high-voltage water pump safely.

Fig. 4. Relay module

6) Water Pump

Facilitates irrigation by delivering water when triggered by the relay.

7) Breadboard

Provides a solderless platform for circuit assembly and testing.

8) Jumper Wires

Establish electrical connections between the ESP8266, sensors, relay, and breadboard.

9) Software Tools

Arduino IDE was used for coding and programming, while Firebase was integrated for real-time data storage and Android app connectivity.

10) Buzzer

Provides an audio alert when soil moisture levels drop below the threshold. It acts as an early warning signal for the user before the automated irrigation process is activated.

Fig. 5. Water pump

B. Methods

The system workflow is designed to automate irrigation based on sensor readings and to provide real-time monitoring via a mobile interface.

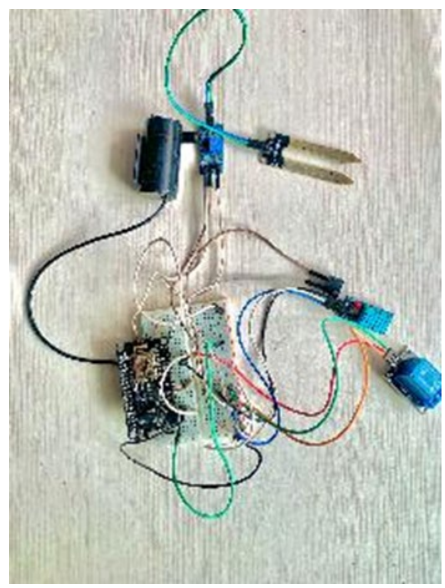

Fig. 6. Circuit system

The operational flow follows four stages:

1. *Sensing*: The soil moisture sensor records soil water levels. The DHT11 sensor measures temperature and humidity. The LDR detects the intensity of light falling on the plants.
2. *Processing*: The ESP8266 microcontroller collects and processes data from all sensors. Pre-defined thresholds for soil moisture are compared against the sensor input to determine whether irrigation is required.
3. *Actuation*: When soil moisture falls below the set threshold, the ESP8266 triggers the buzzer and the

relay module. The buzzer produces an audible alert to signal low soil moisture. The relay activates the water pump to irrigate the soil. Once the required moisture level is reached, the ESP8266 deactivates both the buzzer and the relay, turning OFF the pump to prevent overwatering.

4. *Monitoring and Control*: Sensor data and irrigation status are uploaded to the Firebase cloud in real time. Users can view plant conditions and control irrigation manually via an Android application.

This integrated approach ensures efficient water usage, reduces manual intervention, and maintains optimal conditions for plant growth.

3. Results and Discussion

The proposed IoT-based plant monitoring and irrigation system was implemented and tested under different environmental conditions to evaluate its performance. The results demonstrate that the system successfully automated irrigation while providing accurate and real-time environmental data.

A. System Performance

The ESP8266 microcontroller reliably processed sensor data and controlled the water pump through the relay module. The integration with Firebase enabled seamless real-time data logging and remote access through the Android application. Sensor readings, including soil moisture, temperature, humidity, and light intensity, were consistent with expected ranges, validating the effectiveness of the hardware–software integration.

B. Irrigation Accuracy

The soil moisture sensor effectively triggered irrigation when moisture levels dropped below the calibrated threshold. The pump operated until optimal levels were restored, preventing both overwatering and underwatering. While precise quantitative water savings were not measured during this implementation, qualitative observations indicated that the system minimized unnecessary irrigation and ensured more consistent soil moisture compared to manual watering. This confirms the system's potential to improve efficiency in precision agriculture.

C. User Interface and Control

The Android application provided farmers with real-time access to plant conditions. Manual pump control via the app functioned as intended, giving users flexibility in emergency situations. Data visualization in Firebase improved user decision-making, making the system suitable for urban and rooftop gardening.

D. Limitations

1. *Connectivity Issues*: Occasional Wi-Fi disruptions resulted in *short delays in data transmission.*
2. *Sensor* Calibration: Variations in soil type affected soil moisture readings, requiring periodic recalibration.
3. *Power Dependency*: Continuous operation required stable power supply; solar-powered integration is suggested for future development.

Fig. 7. User interface

4. Conclusion

The IoT-based Plant Monitoring and Automated Irrigation System using ESP8266, soil moisture, DHT11, LDR, buzzer, relay module, and water pump was successfully designed and implemented. Based on the observations, the following conclusions can be drawn:

- The system efficiently monitored soil moisture, temperature, humidity, and light intensity in real time.
- Automated irrigation reduced manual intervention while maintaining healthy soil moisture levels.
- The buzzer alert provided an effective local warning mechanism when soil moisture dropped below the threshold.
- Integration with Firebase and an Android application enabled remote monitoring and manual control, making the system user-friendly.
- The solution demonstrated potential for small-scale applications such as rooftop gardens, indoor plants, and greenhouses.
- Limitations such as Wi-Fi connectivity, sensor calibration, and power dependency suggest that future work may include AI-based predictive irrigation, solar-powered operation, and more advanced sensor calibration techniques.

References

[1] V. Nehra, P. Kumar, and S. Sharma, "IoT based smart plant monitoring system," in *Proc. IEEE Conf. Smart Technologies*, 2023

[2] "Smart sensors and NodeMCU ESP8266-based automated irrigation system," *Int. J. Recent Advances Sci. Eng. Technol.*, vol. 12, no. 9, pp. 45-52, Sep. 2024.

[3] S. Gupta, R. Kumar, and M. Patel, "Smart agriculture using IoT for automated irrigation, water management and resource optimization," *ScienceDirect*, 2025.

[4] K. Obaideen, B. A. Yousef, and M. N. AlMallahi, "An overview of smart irrigation systems using IoT," *Energy Nexus*, vol. 7, pp. 100-118, 2022.

[5] W. T. Sung, S. J. Hsiao, and S. Y. Tsai, "An IoT-based aquaculture monitoring system using Firebase," *Procedia Computer Science*, vol. 192, pp. 1672-1681, 2023.

[6] S. Mansoor, G. Zahoor, and S. A. Shah, "Integration of smart sensors and IOT in precision agriculture: trends, challenges and future prospectives," *Front. Plant Sci.*, vol. 16, no. 1587869, May 2025.

[7] F. R. Saputri, D. Hartono, and A. Wibowo, "Design and development of an irrigation monitoring and control system using IoT technology," *PMC*, 2025.

[8] E. Navarro, N. Costa, and A. Pereira, "A systematic review of IoT solutions for smart farming," *Sensors*, vol. 20, no. 15, pp. 4231-4248, Jul. 2020.

[9] "Automated irrigation system using temperature sensor and ESP8266," *Int. J. Recent Advances Sci. Eng. Technol.*, vol. 11, no. 6, pp. 78-85, Jun. 2024.

[10] V. Lohchab, A. Devi, and D. Singh, "A review of IoT based smart farm monitoring systems," in *Proc. IEEE Int. Conf. Computing Communication*, 2018, pp. 1-6.

[11] H. M. Jawad, R. Nordin, S. K. Gharghan, A. M. Jawad, and M. Ismail, "Energy-efficient wireless sensor networks for precision agriculture: A review," *Sensors*, vol. 17, no. 8, pp. 1781-1805, Aug. 2017.

[12] A. Fuentes, S. Yoon, J. Lee, and D. S. Park, "Comprehensive plant health monitoring: expert-level spatiotemporal plant health assessment using sequential RGB images," *Front. Plant Sci.*, vol. 16, no. 1511651, May 2025.

[13] R. Sujatha, J. M. Chatterjee, N. Z. Jhanjhi, and S. N. Brohi, "Advancing plant leaf disease detection integrating machine learning with IoT for sustainable agriculture," *Sci. Rep.*, vol. 14, no. 21467, Apr. 2025.

[14] I. Ivanochko, D. Shakhovska, and N. Shakhovska, "Smart farming system based on cloud computing technologies," *Procedia Computer Science*, vol. 231, pp. 640-645, 2024.

[15] K. Phasinam, T. Kassanuk, and P. Shabaz, "Application of IoT and cloud computing in automation of agriculture irrigation," *Wireless Communications and Mobile Computing*, vol. 2022, pp. 1-8, 2022.

[16] M. S. Mekala and P. Viswanathan, "A survey: Smart agriculture IoT with cloud computing," in *Proc. IEEE Int. Conf. Microelectronic Devices, Circuits and Systems*, 2017, pp. 1-7.

[17] "An intelligent framework for crop health surveillance and early disease detection using deep learning and IoT," *PMC*, May 2025.

[18] V. Choudhary, H. S. Hota, and A. K. Sahu, "An overview of smart agriculture using internet of things and artificial intelligence," *Smart Agricultural Technology*, vol. 6, pp. 100-118, 2025.

[19] K. N. Rahman, M. H. Bhuiyan, and A. Das, "A real time monitoring system for accurate plant leaves disease detection using deep learning approach," *Smart Agricultural Technology*, vol. 8, pp. 234-245, 2025.

[20] M. R. M. Kassim, I. Mat, and A. N. Harun, "Wireless sensor network in precision agriculture application," in *Proc. IEEE Int. Conf. Computer, Information and Telecommunication Systems*, 2014, pp. 1-5.