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IOT-BASED SMART PLANT MONITORING AND WATERING SYSTEM

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ABSTRACT

This paper elaborates on the creation and progression of a cutting-edge Smart Nursery Plant Watering and Monitoring System, which harnesses the power of the ESP32 microcontroller alongside the DHT11 sensor and a soil moisture sensor. In a seamless blend of innovation and practicality, the system is designed to continually track and analyze crucial environmental factors such as temperature, humidity, and soil moisture levels. Through the utilization of Firebase for data storage and the development of a user-friendly Android application using Android Studio, users are granted the capability of indulging in real-time monitoring and control. Furthermore, the system showcases a sophisticated automated plant watering mechanism that springs into action based on the plant's specific moisture requirements, enhancing plant care practices while minimizing the need for human intervention and maximizing water efficiency. Detailed within the paper are insights into the system's intricate architecture, comprehensive implementation specifics, integral hardware and software components, potential avenues for improvement, and a glimpse into the myriad of real-world applications that could benefit from this technology in future developments.

Keywords: IoT, Smart Plant Monitoring, Automated Irrigation, ESP32, DHT11 Sensor, Soil Moisture Sensor, Firebase, Android Application, Real-Time Monitoring, Water Efficiency, Smart Agriculture, Precision Farming.

1. INTRODUCTION

The agricultural sector is currently grappling with major issues stemming from climate change, water shortages, and outdated irrigation techniques. Conventional approaches to plant monitoring and irrigation necessitate ongoing human involvement, which results in higher labor expenses and suboptimal resource management. The emergence of the Internet of Things (IoT) has introduced groundbreaking solutions that automate farming practices and boost productivity. Smart agriculture powered by IoT seeks to combine sensors, cloud computing, and mobile applications to enhance resource efficiency and overall effectiveness.

This initiative presents an IoT-enabled Smart Plant Monitoring and Watering System designed to automate plant care by continuously tracking environmental factors such as temperature, humidity, and soil moisture. The system utilizes the ESP32 microcontroller, which features integrated Wi-Fi, along with sensors like the DHT11 for measuring temperature and humidity, and a soil moisture sensor to assess water levels in the soil. The data gathered is stored in Firebase, a cloud-based real-time database, enabling users to access information from anywhere. A specialized Android application, created using Android Studio, retrieves and displays sensor data, facilitating real-time monitoring and management of the irrigation system. The automated irrigation solution guarantees that plants receive the right amount of water precisely when necessary, minimizing water waste and avoiding both overwatering and underwatering. By harnessing IoT and cloud technology, this system offers an effective and scalable approach for home gardening, greenhouse oversight, and extensive agricultural operations. with increasing urbanization and busy lifestyles, plant care has become a challenge for individuals and nurseries. The integration of IoT in agriculture allows remote monitoring and control of plant health, ensuring proper growth conditions. Traditional plant maintenance methods require constant human supervision, which is often impractical. The use of automated systems with IoT enables better efficiency, reducing water wastage and enhancing plant health monitoring.

The objective of this project is to develop an intelligent system that automates plant watering and provides real-time data to users via a mobile application. The system aims to improve agricultural efficiency and reduce water consumption while ensuring plants receive optimal care.

2. METHODOLOGY

The methodology involves hardware and software integration for real-time monitoring and automated irrigation.

2.1 Hardware Components

- The ESP32 microcontroller is a high-performance, energy-efficient device that features integrated Wi-Fi and Bluetooth functionality. It serves as the central processing unit of the system, handling sensor data and transmitting it to Firebase. Additionally, the ESP32 manages the relay module to operate the water pump as needed.

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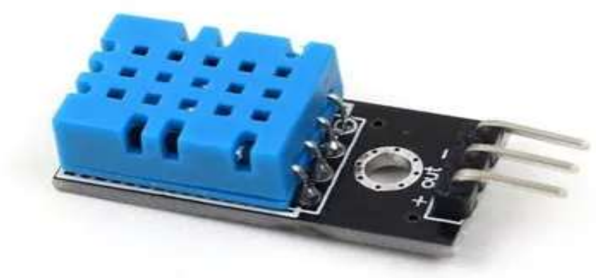
- The DHT11 is a digital sensor designed to measure temperature and humidity, offering precise readings while consuming minimal power. This sensor enables the system to track environmental conditions and assess their effects on plant health. It delivers temperature and humidity data in a digital format, which is then processed by the ESP32.



- Soil Moisture Sensor This device gauges the moisture level in the soil by assessing its electrical resistance. When the moisture content falls below a specified threshold, the system activates the irrigation process. This sensor plays a vital role in identifying when plants need watering.
- A relay module functions as a switch that regulates the power supply to the water pump. The ESP32 transmits a signal to the relay, which subsequently activates or deactivates the pump according to the readings from the soil moisture sensor. This mechanism promotes effective water distribution.
- The water pump is tasked with delivering water to the plant as needed. It operates solely when the relay module is engaged, thereby avoiding excessive water consumption and facilitating efficient irrigation.
- Power Supply To maintain uninterrupted operation, the system needs a reliable power source. The ESP32 and sensors generally function on a 5V DC power supply, whereas the water pump might necessitate a distinct power source based on its specific voltage and current needs. For backup during power outages, a rechargeable battery or solar panel can be utilized.
- Wi-Fi Module (Integrated into ESP32)The ESP32 features an integrated Wi-Fi module that facilitates effortless internet connectivity. This capability allows the microcontroller to send real-time sensor information to Firebase, enabling remote monitoring and control via an Android application. The Wi-Fi module is essential for maintaining ongoing communication between the IoT system and the cloud, removing the necessity for physical interaction with the hardware. It operates in both station (STA) mode, where the ESP32 connects to a local Wi-Fi network, and access point (AP) mode, which permits direct communication with mobile devices. This versatility improves the system's reliability and efficiency, allowing users to access plant health data from any location.

2.2 Software Components

Arduino IDE: Used for programming the ESP32 microcontroller.

- Firebase: Stores sensor data in a real-time database for accessibility from multiple devices.
- Android Studio: Used to develop the mobile application with a user-friendly interface.
- Google Firebase Realtime Database: Ensures seamless synchronization between the IoT system and the mobile application.

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3. MODELING AND ANALYSIS

3.1 Fowchart :

1. **Start** – The system initializes and begins operation.
2. **Read Temperature, Humidity, and Soil Moisture** – Sensors (DHT11 for temperature & humidity, soil moisture sensor) collect data from the environment.
3. **Check Soil Moisture Level** – The system evaluates if the soil moisture is below the required threshold.
   - **If No** – The system continues monitoring without watering.
   - **If Yes** – The system proceeds to water the plant.
4. **Activate Water Pump** – The system turns on the water pump to irrigate the plant until the moisture level reaches the required value.
5. **Update Data to Firebase** – The latest environmental readings and system actions are sent to Firebase for real-time monitoring.
6. **Display Values in App** – The data is displayed in an Android app, allowing the user to monitor plant conditions remotely.
7. **Manual Control** – Users can manually control the system via the app, overriding automation if necessary.

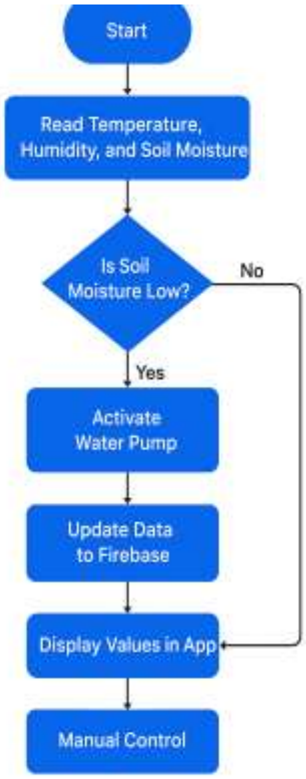

Figure 1: Fowchart

This system ensures efficient watering, reduces human effort, and optimizes plant care using IoT and automation.

3.1 Block Diagram

This IoT-based Smart Nursery Plant Watering and Monitoring System utilizes the ESP32 microcontroller along with DHTII (temperature & humidity sensor) and a soil moisture sensor to track environmental conditions essential for plant growth. The system continuously reads temperature, humidity, and soil moisture levels and sends the data to Firebase, a cloud database, for real-time monitoring.

An Android application, developed using Android Studio, enables users to view sensor data remotely and control the watering system. If the soil moisture level drops below a certain threshold, the system automatically activates a water pump to irrigate the plant until optimal moisture is restored. Additionally, users can manually control the pump via the mobile app.

This automated plant care system ensures efficient water management, reduces human effort, and improves plant health by providing optimal watering conditions. Future enhancements could include multiple plant monitoring, AI-based plant health analysis, and integration with voice assistants for more advanced control.

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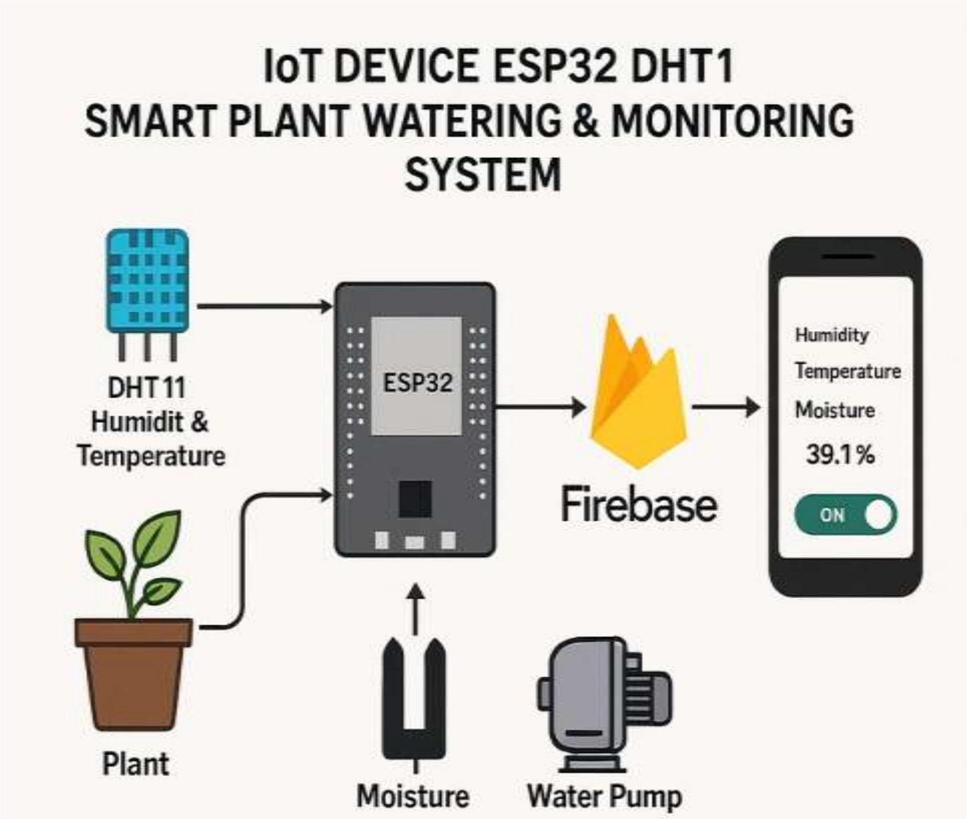

Figure 1: Pycnometer Test Procedure.

4. RESULTS AND DISCUSSION

The system was tested in real-world conditions, demonstrating effective plant monitoring and automated irrigation. Key observations include:

- Optimized water usage by activating the pump only when needed.
- Reduced human intervention, enhancing convenience.
- Accurate real-time monitoring with Firebase synchronization.
- Consistent soil moisture maintenance leading to improved plant health.
- Potential for AI-based predictive irrigation scheduling.

Table 1: System Performance Metrics

Parameter	Observed Performance
Water Consumption Reduction	30-40%
Response Time	< 2 seconds
Remote Access Efficiency	99% uptime
Sensor Accuracy	95-98%

5. CONCLUSION

The IoT-based Smart Plant Monitoring and Watering System efficiently automates irrigation, minimizing manual effort and optimizing water use. By integrating the ESP32, Firebase, and an Android application, the system offers a practical solution for both domestic and commercial agricultural applications. Future enhancements, such as AI-driven predictive analytics, additional environmental sensors, and solar-powered operation, could further improve its efficiency and scalability.

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