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Plant Monitoring System

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ABSTRACT—

The monitoring of plant health is crucial for sustainable agriculture and efficient plant care. This paper presents a Plant Monitoring System utilizing ESP32, soil moisture sensor, DHT11 sensor, PIR motion sensor, BH1750 sensor, relay, and water pump. The system is designed to collect real-time data on environmental factors such as soil moisture, temperature, humidity, light intensity, and motion detection. The collected data is transmitted to an Android application and a website via an XAMPP server for remote monitoring. The implementation leverages Arduino IDE for microcontroller programming. The results indicate that the system provides accurate environmental readings and enables effective plant health monitoring.

Keywords—*Plant Monitoring, IoT, Sensors, ESP32, Remote Monitoring, Smart Agriculture.*

INTRODUCTION

Awareness for effective plant care and farm management has created the door for technological innovations toward smart monitoring systems. The traditional plant monitoring process operated through manual observation, which is inefficient and time-consuming. Use of the Internet of Things (IoT) in agriculture has enabled a more organized way of monitoring environmental factors while enhancing plant growth.

The Plant Monitoring System developed in this paper automates and maximizes plant care. Using various sensors and an ESP32 microcontroller, the system continuously monitors primary parameters of interest like soil moisture, temperature, humidity, light intensity, and motion detection of the plants. Integration of an Android app and website also allows users to remotely monitor and control plant conditions live-time, thus providing a user-friendly and efficient solution.

In recent years, smart agriculture had become the talk in the profession because it has the full potential of maximizing resource use whilst promising quality plant health. The system presented here does not only help in maintaining optimum growth conditions, but also minimizes human interference by automating the irrigation process using a set of sensor data.

LITERATURE REVIEW

In paper [1] there is an automated irrigation system that utilizes Arduino-based microcontrollers and soil moisture sensors to optimize water usage in agriculture. The study highlights how integrating real-time soil moisture data with an automated water supply mechanism improves efficiency and reduces water wastage. The authors emphasize the cost-effectiveness and ease of implementation of the system, making it accessible to small-scale farmers. However, challenges such as sensor calibration and environmental variability affecting sensor accuracy are discussed as limitations.

In this paper [2] it has a greenhouse management system leveraging IoT technologies for real-time monitoring and control of environmental conditions such as temperature, humidity, and soil moisture. The system employs cloud-based data analytics to predict plant health and optimize resource allocation. The study demonstrates improvements in crop yield and reduced manual intervention through automation. However, reliance on internet connectivity and the initial setup costs pose barriers to widespread adoption, especially in rural areas with limited technological infrastructure.

In paper [3] it is an IoT-driven plant monitoring system integrated with a mobile interface, allowing users to remotely track plant health parameters. The system uses wireless sensors to collect data on soil moisture, temperature, and humidity, which is then processed and displayed via a mobile application. The study highlights the convenience and real-time accessibility provided by IoT and mobile integration, enhancing user engagement in plant care. However, the authors identify security concerns and data transmission reliability as potential issues requiring further research.

SYSTEM DESIGN AND IMPLEMENTATION

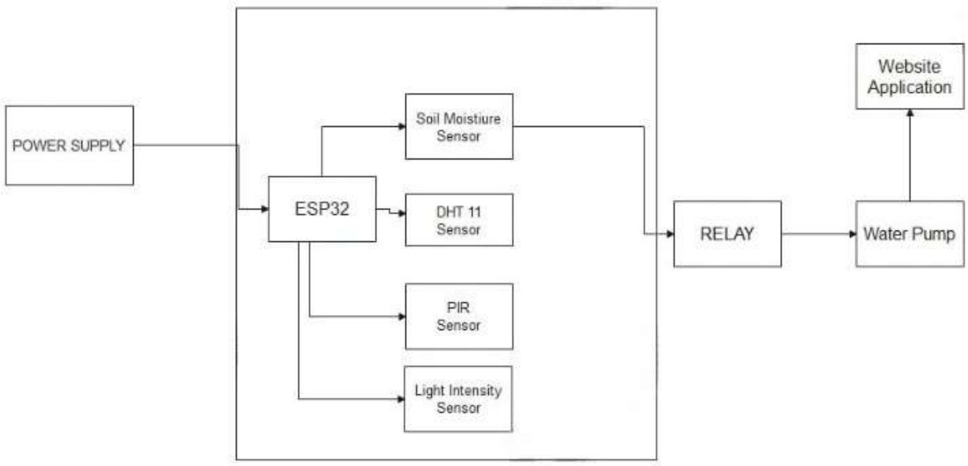
Hardware Components: *The system consists of the following hardware components:*

- **ESP32 Microcontroller**: Acts as the central processing unit, handling sensor data and communication.
- **Soil Moisture Sensor**: Measures the moisture content in the soil to determine irrigation needs.
- **DHT11 Sensor**: Monitors temperature and humidity levels for optimal plant growth.
- **PIR Motion Sensor**: Detects motion near the plants for security monitoring.
- **BH1750 Light Sensor**: Measures light intensity to ensure plants receive adequate sunlight.
- **Relay Module**: Controls the water pump based on soil moisture readings.
- **Water Pump**: Provides irrigation when necessary.

Software Components: The following software tools and platforms are used:

- **Arduino IDE**: Used for programming the ESP32 microcontroller.
- **Android Application**: Allows users to remotely monitor and control plant conditions.
- **Website**: Provides a web-based dashboard for real-time data visualization.
- **XAMPP Server**: Hosts the database and web application for data management.

Block Diagram:



Calculations: In order to ensure accurate monitoring and automated control, various mathematical formulations are used to process the sensor data effectively. The calculations involve determining soil moisture content, temperature-humidity relationships, and light intensity, which play a crucial role in optimizing plant health conditions. By applying these equations, the system can make data-driven decisions, such as activating the water pump when necessary or alerting users when environmental conditions deviate from optimal ranges. The following subsections detail the essential calculations performed by the system to interpret sensor data accurately.

Soil Moisture Calculation: Soil moisture sensors provide an analog or digital value, which can be converted to Volumetric Water Content (VWC) using the following equation:

VWC=a×ADCvalue+b

where:

- VWC = Volumetric Water Content (%)
- ADCvalue = Sensor's analog-to-digital conversion output
- a,b = Calibration constants based on the sensor type

Temperature and Humidity Relation: The heat index (HI) provides a measure of how temperature and humidity affect perceived warmth. It is calculated using the empirical equation:

$$HI = c_1 + c_{2T} + c_{3RH} + c_{4TRH} + c_{5T}^2 + c_{6RH}^2$$

where:

- HI = Heat Index (°C)

- T = Temperature (°C)
- RH = Relative Humidity (%)
- $c1, c2, c3, c4, c5, c6$ = Empirical constants

Light Intensity Calculation : The illuminance (Lux) detected by the BH1750 sensor is determined using:

$$Lux \ = \backslash frac\{Sensor_{\{value\}\times} Scale_{\{factor\}}\}\{Sensitivity\}$$

where:

- Lux = Measured light intensity (lx)
- Sensorvalue= Digital output from the sensor
- Scalefactor = Calibration constant
- Sensitivity = Sensor-specific parameter

RESULTS & DISCUSSION

The proposed Plant Monitoring System has undergone extensive testing in different environmental conditions so that its accuracy and efficiency are evaluated. Results show that the system can provide real-time monitoring of soil moisture, temperature, humidity, light intensity, and motion. Users can then effectively make decisions regarding the care of their plants with the information transmitted to the Android app and website from the sensors.

To start the irrigation through the relay-triggered water pump, the moisture sensor senses dryness. The DHT11 sensors measure temperature and humidity more accurately for plant growth. The BH1750 sensor ensures the delivery of sufficient light, while the PIR motion sensor detects motion around the plants, creating an additional security layer.

The Android app and web interface equip users with a friendly and accessible platform for the remote monitoring of plants' health. Moreover, Watershed is an environmentally friendly solution for rationalized soil moisture-triggered automated irrigation control to cut down on water wastage.

The Plant Monitoring System provides live information about plant management, irrigation automation, and resource conservation capabilities. Experimental findings prove the reliability of the system in sustaining proper plant growth conditions.

CONCLUSION

This paper describes a Plant Monitoring System that incorporates several sensors, an ESP32 microcontroller, an Android application, and a website for effective plant care. Environmental parameters are monitored and irrigation is automated to reduce manual interference and increase plant health. IoT-based technology offers real-time monitoring and control of plants, making it more convenient and resource-efficient.

The system is very scalable and provides a cost-effective solution for plant monitoring: from small home gardens to larger agricultural applications.

Future enhancements to the system might include adding more sensors for nutrient monitoring, machine learning algorithms for predictive analysis, and further compatibility with more plant species. The Plant Monitoring System discussed in this paper shows the promise of IoT technologies to positively disrupt plant care and smart agricultural practices.

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