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Smart Irrigation and Environmental Monitoring System using IoT

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Abstract: ***The Smart Irrigation and Environmental Monitoring System using IoT is designed to improve water management and plant monitoring in agriculture. The system uses ESP32, soil moisture, temperature-humidity, and water level sensors to collect real-time environmental data. Based on soil moisture levels, the irrigation process is automatically controlled using a relay and water pump. Users can also manually start irrigation through a web application, while the system automatically stops watering at the desired threshold level. Sensor data is continuously displayed and stored on a customized website for monitoring and analysis. Additionally, the ESP32-CAM module enables plant image monitoring and supports AI-assisted plant disease detection. The proposed system provides a low-cost, efficient, and scalable solution for smart farming applications.***

Keywords: IoT, Smart Irrigation, ESP32, Environmental Monitoring, Soil Moisture Sensor, ESP32-CAM, Plant Disease Detection, Automation, Real-Time Monitoring, Smart Agriculture.

I. INTRODUCTION

Agriculture plays a vital role in human survival and economic development. However, traditional irrigation methods often lead to excessive water wastage, inefficient resource management, and increased dependency on manual labor. Farmers also face difficulties in continuously monitoring environmental conditions such as soil moisture, temperature, humidity, and water availability, which directly affect crop growth and productivity. With the advancement of Internet of Things (IoT) technology, smart agriculture systems are becoming increasingly important for improving farming efficiency and promoting sustainable agricultural practices. This project presents a Smart Irrigation and Environmental Monitoring System using ESP32, ESP32-CAM, and multiple environmental sensors. The system continuously monitors soil moisture, temperature, humidity, and water level conditions in real time and automatically controls irrigation based on predefined threshold values. The collected sensor data is displayed on a web-based dashboard and stored for future analysis. Additionally, the ESP32-CAM module supports remote plant monitoring and AI-assisted plant health analysis. The proposed system aims to improve water utilization, reduce manual effort, and support smart and efficient farming practices.

II. LITERATURE REVIEW

Sr. No	Author& Year	Title	Technology Used	Key Features	Limitations
1	Pereira et al., 2023	*IoT-Enabled Smart Drip Irrigation System Using ESP32*	ESP32, IoT Sensors, Wi-Fi	Automatic irrigation and real-time monitoring	Limited AI integration
2	Kumar et al., 2023	*IoT Based Smart Irrigation System Using Sensors*	IoT, Soil Moisture Sensor, Cloud	Smart irrigation and environmental monitoring	No plant disease detection
3	Mehta et al., 2023	*Smart Irrigation System Using ESP WROOM 32*	ESP32, Web Monitoring	Real-time sensor monitoring and automation	Limited image monitoring
4	Zheng et al., 2024	*Fuzzy Automatic Control for Smart Farming*	IoT, Fuzzy Logic Control	Intelligent irrigation decision-making	Complex implementation
5	Kunt, 2025	*Smart Autonomous Irrigation System Using IoT and AI*	AI, IoT, Automation	AI-based irrigation optimization	High computational requirements

III. PROBLEM STATEMENT

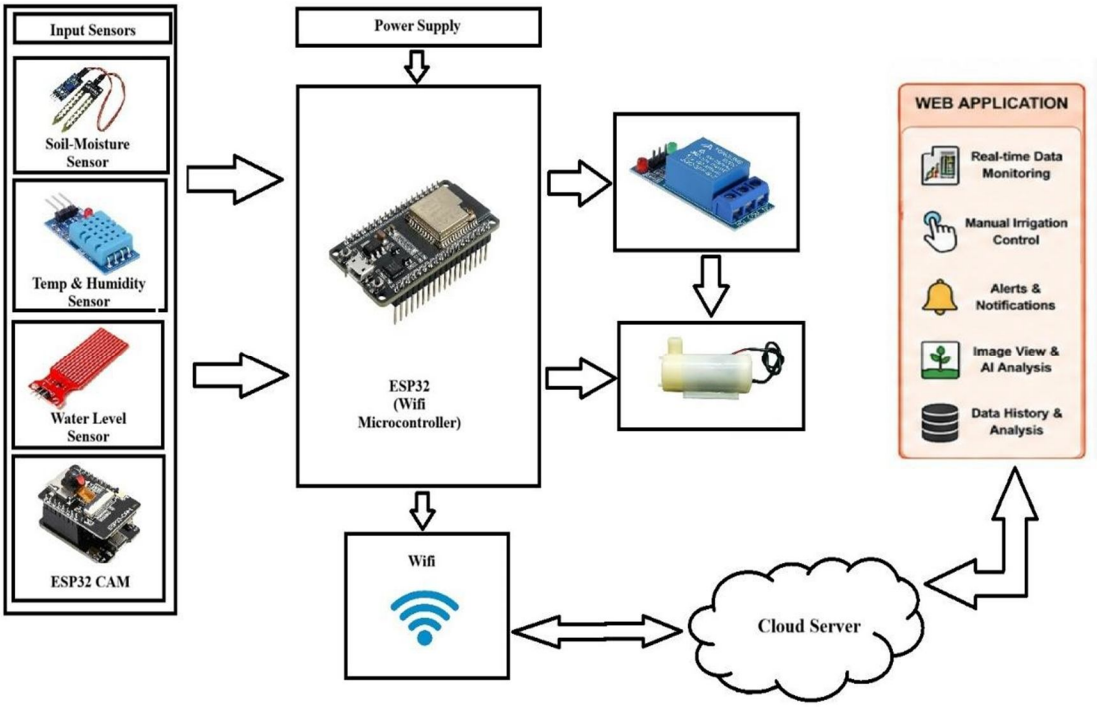
Agriculture largely depends on proper irrigation and continuous environmental monitoring for healthy crop growth and improved productivity. Traditional irrigation methods often result in excessive water wastage due to manual operation and lack of real-time monitoring systems. Farmers frequently face difficulties in checking soil moisture, temperature, humidity, and water availability continuously, especially in large agricultural fields. These limitations increase labor effort, reduce irrigation efficiency, and may negatively affect plant health and crop yield.

In addition to irrigation challenges, the absence of proper plant monitoring systems makes it difficult to identify plant health issues at an early stage. Existing agricultural systems often lack integrated solutions that combine automated irrigation, real-time monitoring, data storage, and plant health analysis in a single platform. Therefore, there is a need for an IoT-based smart irrigation and environmental monitoring system that can automate irrigation, provide real-time environmental data, support remote monitoring, and improve overall agricultural efficiency using modern IoT and AI technologies.

IV. OBJECTIVES

1) To develop an IoT-based smart irrigation and environmental monitoring system using ESP32.
2) To monitor soil moisture, temperature, humidity, and water level in real time using environmental sensors.
3) To automate the irrigation process based on soil moisture threshold values.
4) To provide manual and automatic irrigation control through a web-based platform.
5) To display and store real-time environmental data for monitoring and analysis.
6) To integrate ESP32-CAM for remote plant monitoring and AI-assisted plant health analysis.
7) To reduce water wastage, minimize manual effort, and improve agricultural productivity.

V. SYSTEM DESIGN AND METHODOLOGY



A. Architecture Overview

The system consists of ESP32 and ESP32-CAM modules connected with soil moisture, temperature-humidity, and water level sensors. Sensor data is collected and processed by ESP32, which controls the irrigation motor through a relay module. The data is transmitted to a web application using Wi-Fi for real-time monitoring, data storage, and plant health analysis.

B. Technology Stack

1) Hardware: ESP32, ESP32-CAM, Soil Moisture Sensor, DHT11/DHT22, Water Level Sensor, Relay Module, Motor
2) Frontend: React.js, HTML, CSS
3) Backend: Node.js, Express.js
4) Database: MongoDB
5) AI Module: Python, TensorFlow
6) Communication: Wi-Fi, IoT

C. Workflow

The sensors continuously collect environmental data and send it to the ESP32 module. Based on soil moisture values, the system automatically controls irrigation through the relay and motor. The sensor data is displayed on a real-time web dashboard and stored for analysis. The ESP32-CAM captures plant images, and the AI module analyzes the images to identify possible plant health issues.

VI. FUTURE SCOPE

1) Integration of solar-powered energy systems for improved sustainability.
2) Development of a mobile application for remote monitoring and control.
3) Implementation of advanced AI models for accurate plant disease detection.
4) Integration of weather forecasting APIs for smarter irrigation decisions.
5) Expansion of the system for large-scale smart farming applications.

VII. CONCLUSION

The Smart Irrigation and Environmental Monitoring System using IoT provides an efficient and cost-effective solution for modern agriculture. The system automates irrigation based on real-time environmental conditions, reducing water wastage and manual effort. By integrating real-time monitoring, data storage, and ESP32-CAM-based plant observation, the system improves plant health monitoring and agricultural productivity. The proposed solution demonstrates the effective use of IoT and AI technologies in supporting smart and sustainable farming practices.

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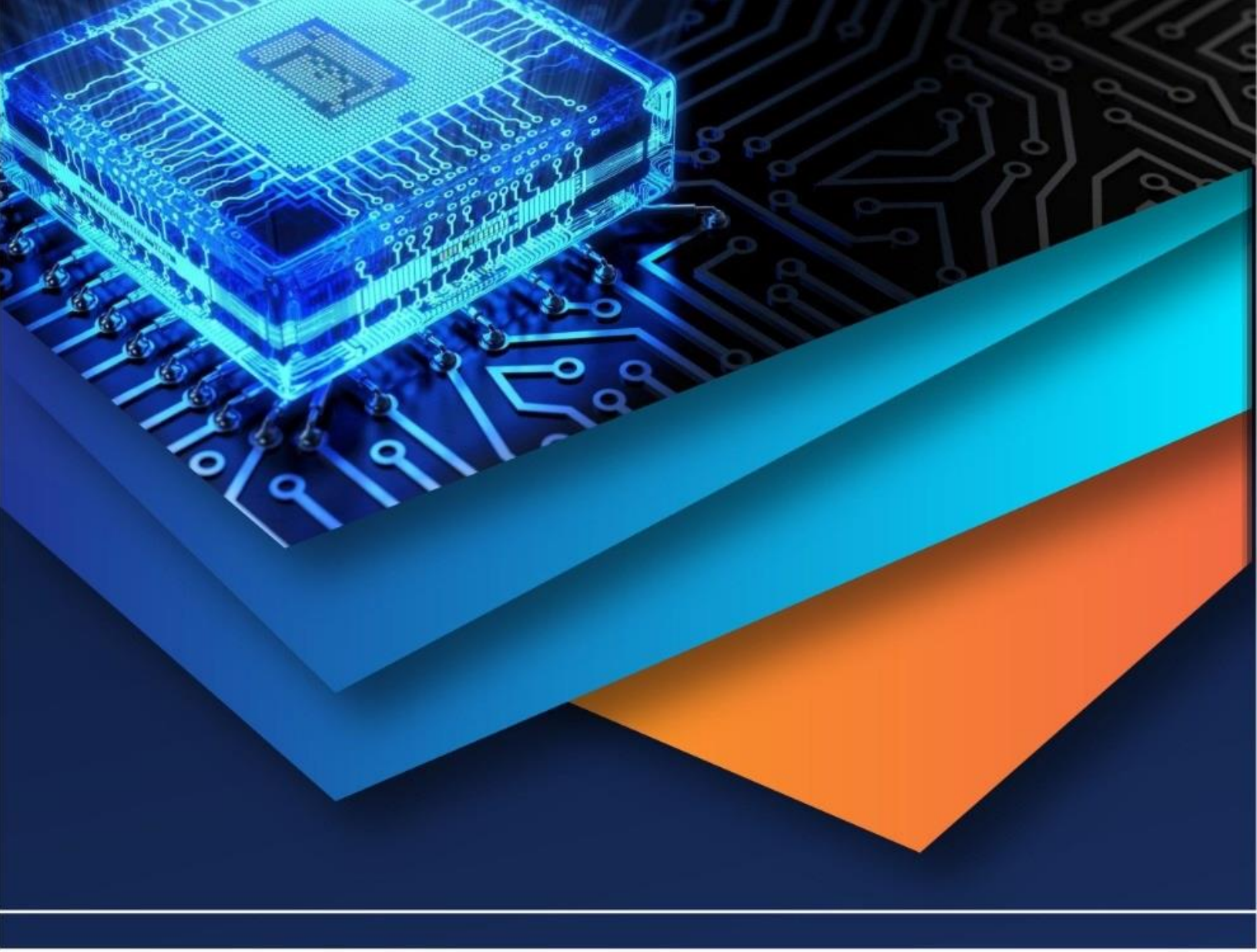

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