IOT BASED SMART CROP DISEASE DETECTION SYSTEM

[1]Patil Harshvardhan Dattatraya, [2]Salunke Tanmay Satish, [3]Tagare Mauli Krushnat, [4]Dr. S. M. Lambe

[123]B.Tech Student, [4]Head Of Department
[1234]Department of Electronics and Telecommunication Engineering,
[1234]Karmayogi Institute of Technology, Shelve, Pandharpur, India.

Abstract : This study presents an "IoT-Based Smart Crop Disease Detection System Using ESP32-CAM" designed to assist farmers in early identification of plant diseases and real-time monitoring of environmental conditions. The system integrates image processing, artificial intelligence, and IoT technology to provide an automated crop-health analysis platform. An ESP32-CAM module captures live images of crop leaves, which are processed by a web server using the Google AI API to identify diseases and recommend remedies. Additionally, the system incorporates DHT11 and capacitive soil moisture sensors to continuously monitor micro-climatic conditions, transmitting data to the Blynk IoT cloud platform for real-time visualization. This dual approach aims to enhance productivity and support smart farming practices.

***IndexTerms* - IoT, ESP32-CAM, Artificial Intelligence, Smart Agriculture, Image Processing, Blynk.**

INTRODUCTION

Agriculture is one of the most important sectors of the Indian economy, yet it faces significant challenges due to crop diseases that reduce yield and quality. Traditionally, identifying plant diseases requires expert observation, which is a time-consuming process and often inaccessible to farmers in remote areas.

To address these challenges, this paper proposes an "IoT-Based Smart Crop Disease Detection System" that combines the Internet of Things (IoT) and Artificial Intelligence (AI). The system utilizes an ESP32-CAM module to capture real-time images of crop leaves, which are analyzed by the Google AI API to detect symptoms such as leaf spot, rust, or blight. In parallel, environmental parameters including temperature, humidity, and soil moisture are monitored via the Blynk IoT platform. This integration provides farmers with an intelligent tool for early disease detection and better decision-making with minimal human intervention.

NEED OF THE STUDY.

The primary need is to detect crop diseases at an early stage using AI-based image processing to help farmers take preventive actions. There is also a necessity for a smart monitoring system that tracks environmental parameters like temperature and soil moisture to ensure better crop management. Furthermore, developing a cost-effective agricultural solution using readily available components like ESP32-CAM and DHT11 ensures the system is accessible. Finally, the system enables remote accessibility, allowing farmers to monitor field data through the Blynk IoT platform.

THEORETICAL FRAMEWORK.

Recent advancements in IoT and AI have transformed agricultural management. Mohanty et al. (2016) demonstrated the use of deep learning for image-based plant disease detection using the Plant Village dataset, proving that Convolutional Neural Networks (CNNs) outperform traditional methods. Similarly, Ferentinos (2018) showed that deep learning models like ResNet50 could achieve high accuracy in disease detection.

Dhingra et al. (2021) proposed an intelligent IoT-based system integrating sensors with machine learning, which serves as a foundational architecture for this study. This project implements a similar setup by using cloud-based AI for image analysis and IoT dashboards for sensor monitoring, validating the hybrid approach of combining visual diagnosis with environmental sensing.

SYSTEM DESIGN.

The system acts as a closed-loop smart monitoring solution. It is comprised of two main functional blocks: the Image Processing Unit and the Environmental Sensing Unit.

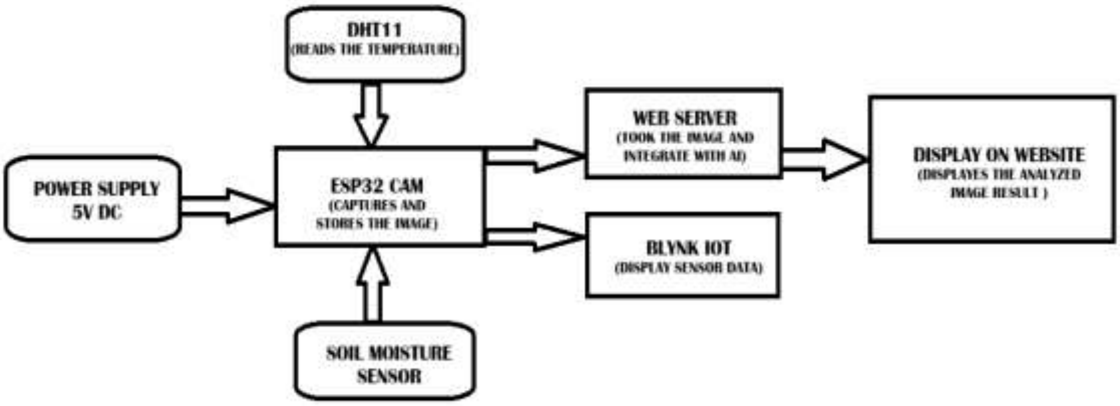

Figure 1: Block Diagram of IoT Based Smart Crop Disease Predictor

4.1 Hardware Design.

The core controller is the ESP32-CAM, a low-cost module with an OV2640 camera and Wi-Fi/Bluetooth capabilities. It captures real-time crop leaf images and collects data from connected sensors.

- **DHT11 Sensor:** Measures atmospheric temperature (0-50°C) and humidity (20-80%)[31].
- **Capacitive Soil Moisture Sensor:** Measures soil water content using capacitance changes, providing durability against corrosion compared to resistive sensors.
- **FTDI Programmer:** Used to upload firmware to the ESP32-CAM as the board lacks an onboard USB interface.

4.2 Circuit Diagram and Working.

The circuit involves interfacing the DHT11 and Soil Moisture sensors with the ESP32-CAM. The sensors send digital and analog signals respectively to the controller.

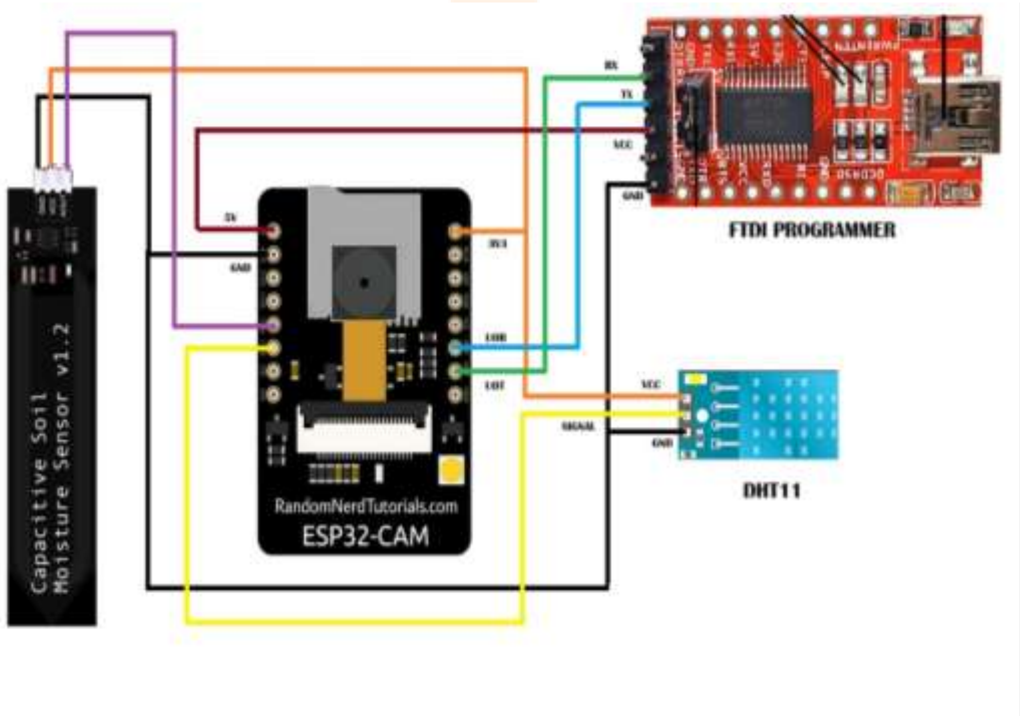

Figure 2: Circuit Diagram of the System

RESULTS AND DISCUSSION.

The system was tested under real-world conditions, yielding results in both image detection and environmental monitoring.

5.1 Hardware Implementation.

The complete hardware setup, including the sensor interface and power supply, was assembled and tested successfully.

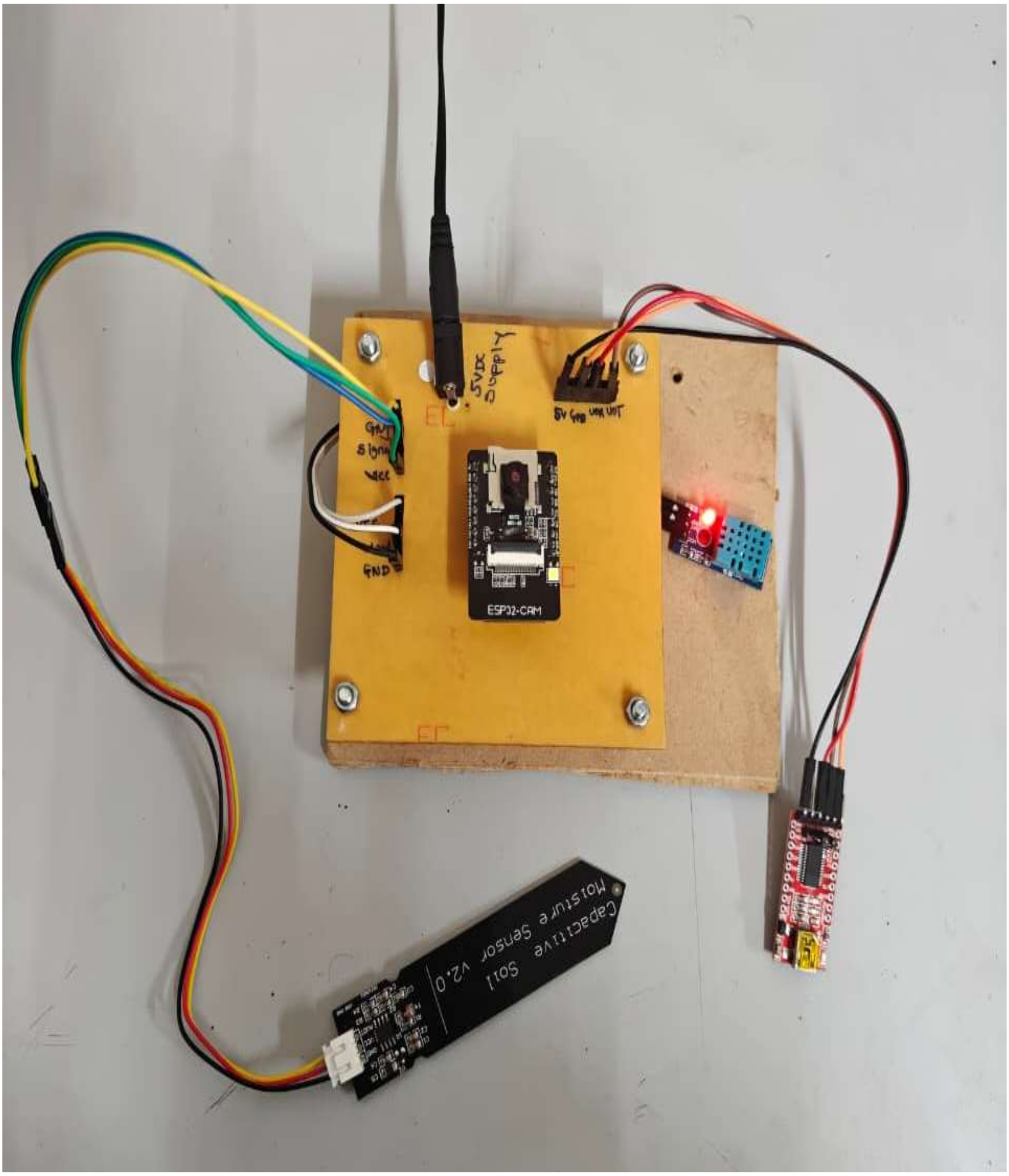

Figure 3: Hardware Project Prototype

5.2 Image Capture and AI Analysis.

The ESP32-CAM successfully captured clear JPEG images of crop leaves under natural lighting. When tested on a pumpkin leaf, the Web Server & AI API correctly identified the disease as **"Powdery Mildew"**. The interface provided immediate actions such as "Remove affected leaves" and treatment methods like "Apply fungicides"

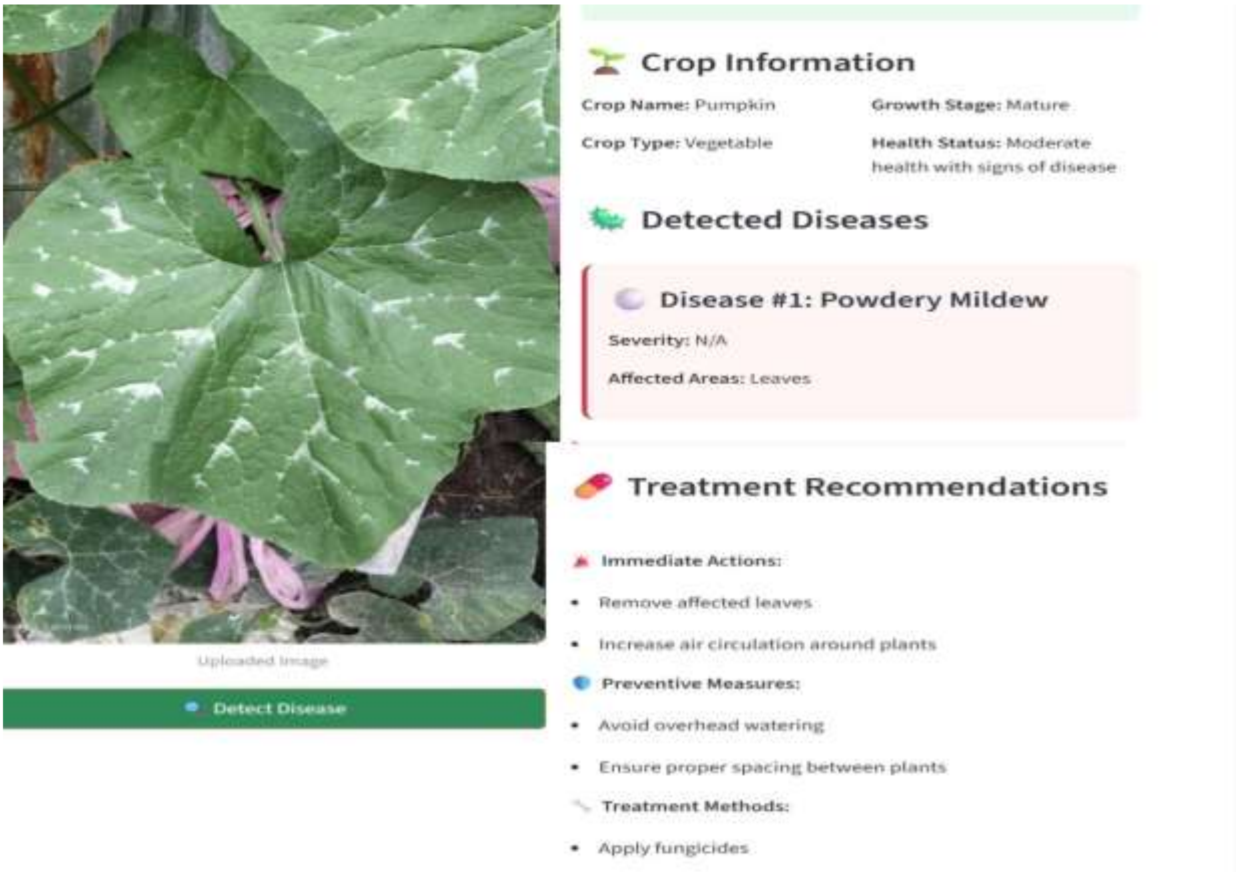

Figure 4: Web Interface Showing Disease Detection Results

5.3 IoT Sensor Monitoring

The Blynk IoT dashboard displayed real-time environmental data. The observed values during testing were:

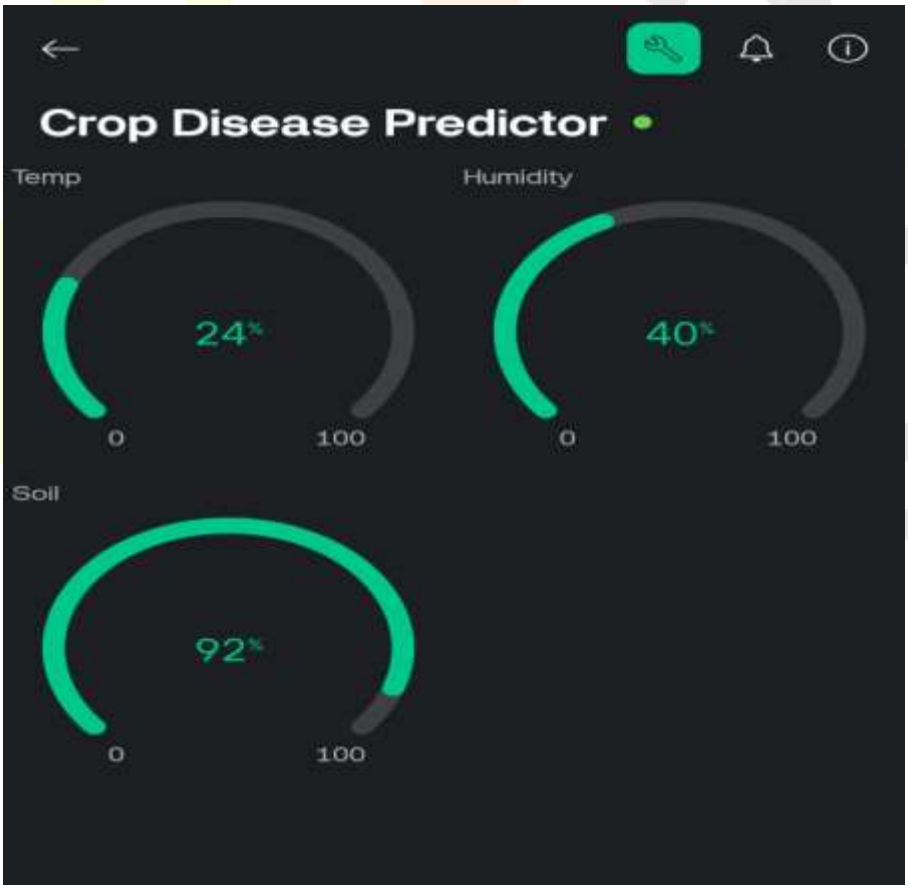

Figure 4: Blynk IoT Dashboard Displaying Real-Time Data

CONCLUSION.

The "IoT-Based Smart Crop Disease Detection System" successfully integrates image processing, cloud-based AI, and real-time environmental monitoring. The project demonstrates that combining ESP32-CAM for image capture with Google AI API for prediction creates a reliable, low-cost solution for smart agriculture. The dual approach of AI diagnosis and IoT monitoring offers a comprehensive method for assessing crop health, reducing dependency on manual inspection and supporting precision farming.

FUTURE SCOPE.

Future improvements include fully automating image uploads directly from the ESP32-CAM to the cloud without PC intervention. Additionally, integrating lightweight AI models (TinyML) directly onto the device would allow for offline disease detection. The system could also be expanded to automate irrigation and pesticide spraying based on sensor thresholds.

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