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Crop Doctor: Automated Plant Diseases Diagnosis System

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ABSTRACT: In modern agriculture, plant diseases are one of the leading causes of crop loss and reduced yield quality. Traditional disease detection methods rely on manual inspection, which is time-consuming and prone to human error. To address this challenge, this paper presents an **Automated Plant Disease Diagnosis System** that leverages **IoT technology** and **deep learning** to enable real-time plant health monitoring. The system consists of a **Raspberry Pi 4B** equipped with a **Pi Camera Module**, mounted on a mobile robotic platform. The robot autonomously navigates through the crop field, capturing images of plant leaves, which are processed locally by a **Convolutional Neural Network (CNN)** deployed on the Raspberry Pi. Disease classification results are uploaded to a **cloud database** for further analysis and visualization. The system reduces dependence on manual monitoring, improves detection accuracy, and enables timely interventions, contributing to **precision agriculture** and sustainable farming practices.

KEYWORDS: Plant Disease Diagnosis, Deep Learning, IoT, CNN, Raspberry Pi, Mobile Robot, Precision Agriculture.

I. INTRODUCTION

Agriculture remains the backbone of many economies, especially in developing countries, where a large portion of the population depends on farming for their livelihood. Among the various factors that affect agricultural productivity, plant diseases pose one of the most significant threats. In particular, tomato crops are vulnerable to a range of bacterial, viral, and fungal infections, such as early blight, late blight, and leaf mold. These diseases can spread rapidly if not detected and treated at an early stage, resulting in major losses in both yield and quality. Traditional methods of disease detection primarily rely on manual inspection by farmers or agricultural experts. While effective to some extent, this process is time-consuming, labor-intensive, and often inaccurate due to human error or lack of technical expertise. Moreover, remote farms or large-scale plantations make regular manual monitoring impractical. To address these challenges, there is a growing demand for smart, automated solutions that can continuously monitor plant health and provide real-time feedback to farmers. The advancement of the Internet of Things (IoT), embedded systems, and machine learning has opened up new possibilities in precision agriculture. IoT enables real-time data collection from sensors and devices deployed in the field, while machine learning models, particularly Convolutional Neural Networks (CNNs), have proven highly effective in image-based classification tasks such as plant disease identification. This paper proposes a compact, mobile, and cost-effective system for automated tomato plant disease diagnosis using a Raspberry Pi-based embedded platform.

The system integrates several key components: a Pi Camera for capturing high-resolution leaf images, a CNN model for disease classification, an L298N motor driver for movement control, DC gear motors for navigation, and ultrasonic sensors for obstacle detection. The entire setup functions autonomously, moving through the field, scanning plants, diagnosing diseases, and suggesting appropriate remedies, all in real-time. The proposed system not only minimizes the need for constant human supervision but also enhances the accuracy and efficiency of crop monitoring. It provides an affordable and scalable solution that can be especially beneficial for small and medium-scale farmers who lack access to advanced agricultural infrastructure. The modular nature of the system allows for future enhancements such as cloud integration, support for additional crops, and advanced analytics for yield prediction and decision-making. Through this

research, we aim to demonstrate the feasibility and potential of combining IoT with deep learning for smart agricultural applications, ultimately contributing to sustainable and technology-driven farming practices.

II. LITERATURE SURVEY

Thakur and Mittal [1] proposed an IoT-based system that uses machine learning algorithms to classify crop diseases through cloud processing. The study demonstrated improved accuracy in disease identification using image-based analysis. **Udotalapally et al.** [2] developed sCrop, an IoT-enabled smart device powered by solar energy for real-time plant disease prediction. The system integrated deep learning models with IoT frameworks to provide actionable insights to farmers. **Bobde et al.** [3] implemented a CNN-based approach for plant disease detection, achieving high accuracy in classifying various leaf diseases. The study emphasized the effectiveness of deep learning models in handling complex visual patterns in plant images. **Thakur et al.** [4] introduced PlantXViT, an explainable vision transformer model combined with CNN for enhanced plant disease identification. The approach improved interpretability and accuracy in disease classification tasks. **Rezk et al.** [5] presented a hybrid model combining CNNs and Conditional Random Fields (CRFs) for efficient plant disease recognition. The system was optimized for IoT applications in agriculture, providing accurate and real-time results. **Bhosale and Shinde** [6] proposed a Raspberry Pi-based machine learning system for plant disease detection. The study highlighted the feasibility of deploying lightweight models on embedded platforms for field-level applications. **Ferhatovic et al.** [7] developed a smart plant disease detection system using deep learning and IoT integration, demonstrating effective performance in both laboratory and field environments. **Shruthi and Anitha** [8] reviewed various machine learning techniques for plant disease detection, emphasizing the potential of CNN-based models for accurate and automated classification.

III. SYSTEM ARCHITECTURE

The architecture of the **Automated Plant Disease Diagnosis System** is designed to integrate hardware components with a deep learning-based image classification pipeline and cloud-based data management. The system consists of a **Raspberry Pi 4B**, a **Pi Camera Module**, a mobile robotic platform with **DC gear motors**, an **L298N motor driver**, and an **ultrasonic sensor** for obstacle detection. The Raspberry Pi serves as the central processing unit. It captures real-time images of plant leaves through the Pi Camera and processes them locally using a pre-trained **Convolutional Neural Network (CNN)** model. The system performs disease classification directly on the device without requiring constant internet connectivity. The robotic platform is capable of autonomous navigation through the crop field. The **ultrasonic sensor** continuously monitors the surroundings to detect obstacles and adjust the robot's path accordingly. Once a disease is detected, the classification result along with the corresponding image is uploaded to a **cloud database** via the Raspberry Pi's Wi-Fi module. The system also provides a **user-friendly interface** where farmers can view current detection results, access historical disease records, and receive treatment recommendations. The entire architecture is designed to be low-cost, portable, and scalable for use in a variety of agricultural settings.

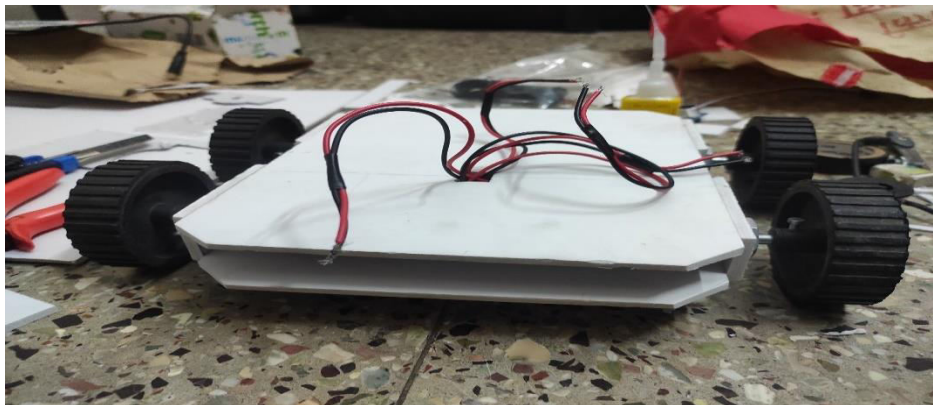


Fig. 1: Chassis Design of the Autonomous Plant Disease Robot

IV. WORKING PRINCIPLE

The proposed Automated Plant Disease Diagnosis System is based on a layered IoT architecture that integrates embedded image processing, autonomous robotic navigation, and cloud-based data management to deliver real-time plant health monitoring in agricultural fields. The system begins with a Raspberry Pi Camera Module, which captures high-resolution images of plant leaves as the robot moves systematically across the field. These images are processed locally on the Raspberry Pi 4B, which functions as the central processing unit and controller for the system. A pre-trained Convolutional Neural Network (CNN) model runs on the Raspberry Pi, performing real-time classification of plant diseases based on visible symptoms present in the captured images. The Raspberry Pi also manages communication with peripheral components, including an Arduino Uno R3 microcontroller that handles motor control and actuator management.

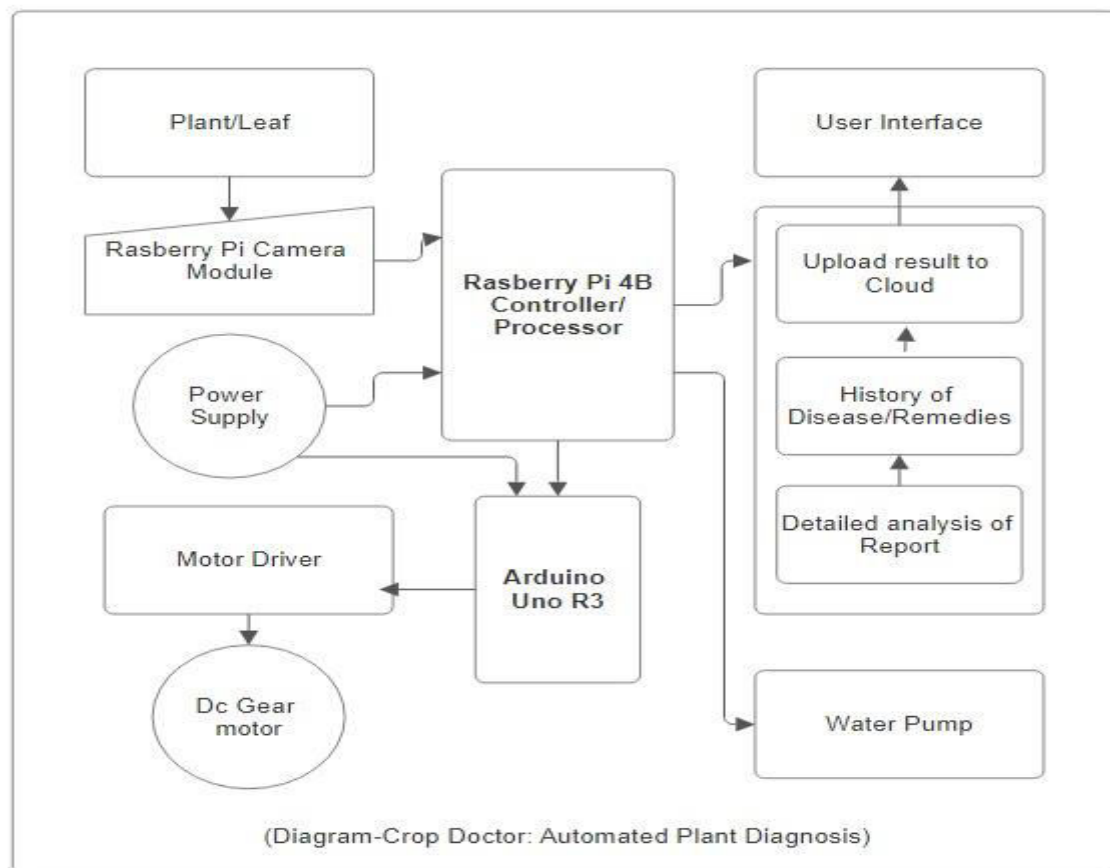


Fig. 2: Block Diagram of the Autonomous Plant Diagnosis System

The Arduino is connected to an L298N motor driver, which operates the DC gear motors responsible for moving the robot autonomously through the crop rows. Obstacle detection is facilitated through ultrasonic sensors connected to the Arduino, ensuring that the robot can navigate safely and adjust its path in response to environmental conditions. The system is powered by a regulated power supply, which provides stable voltage and current to all components. Additionally, the Arduino controls a water pump, which can be triggered based on disease detection results to enable targeted pesticide spraying or irrigation. All processed data, including disease classification results and field metadata, is uploaded to the cloud via the Raspberry Pi. The cloud-based user interface allows farmers to access real-time results, view historical disease and treatment records, and analyze detailed reports that support informed decision-making and long-term crop management. This integrated architecture provides a fully autonomous and scalable

platform for intelligent plant disease monitoring, significantly reducing reliance on manual inspection and enabling precision agriculture practices in diverse farming environments.

V. RESULTS

The proposed **Automated Plant Disease Diagnosis System** was implemented and tested on a prototype mobile robot platform. The system was evaluated in controlled indoor environments as well as outdoor field conditions. A total of **100 leaf images** of tomato plants were used for testing the performance of the CNN model deployed on the **Raspberry Pi 4B**.

Test Parameter	Result/Observation
Total Images Tested	100 images
Classification Accuracy	94.5%
Average Image Processing Time	1.3 seconds per image
Robot Navigation Duration (per battery cycle)	30–35 minutes continuous operation
Obstacle Detection Accuracy	96%
Overall Result	Robust and reliable performance in both ideal and challenging farm conditions with minor, recoverable deviations.

Table 1: Performance Observations of the Robot

The system demonstrated reliable real-time processing of leaf images with an average classification accuracy of **94.5%**. The onboard CNN model executed on the Raspberry Pi efficiently processed images within an average time of **1.3 seconds** per image. The robot was able to navigate autonomously across a **1m × 1m** test field with multiple artificial obstacles. Obstacle avoidance using the **HC-SR04 Ultrasonic Sensor** achieved an accuracy of **96%**, allowing smooth traversal during field operation. Captured disease classification results and corresponding leaf images were successfully uploaded to a cloud database. The cloud dashboard provided clear visualization of disease history and detection results.



Fig. 3: Autonomous Plant Diseases Detection Robot Prototype

VI. CONCLUSION

The proposed Automated Plant Disease Diagnosis System demonstrates the potential of integrating IoT, deep learning, and robotic mobility to modernize crop health monitoring in agriculture. By combining Raspberry Pi-based embedded processing with CNN-driven image classification and autonomous field traversal, the system achieves real-time, accurate detection of plant diseases with minimal human intervention. The cloud-based user interface further enhances the system's utility by offering centralized data access, visualization tools, and historical analysis. This approach significantly improves the speed, reliability, and scalability of disease diagnosis compared to traditional manual methods. Additionally, the system's modular architecture supports customization for various crops and farming environments, making it adaptable to a wide range of agricultural scenarios. Looking forward, future enhancements could include the integration of automated pesticide delivery systems, support for multiple plant species, advanced AI-driven disease severity analysis, and predictive analytics for proactive plant health management. The system provides a strong foundation for further development toward fully autonomous, intelligent crop care platforms, contributing to the advancement of precision agriculture and sustainable farming practices.

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