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AI Based Crop Disease Detection and Pesticide Recommendation

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ABSTRACT
Agriculture plays a vital role in the economy of many countries, especially India. Crop diseases significantly affect agricultural productivity and lead to economic losses for farmers. Early detection of crop diseases and providing appropriate pesticide recommendations can minimize damage and improve crop yield. This project proposes an Artificial Intelligence-based system that detects crop diseases from leaf images using **Convolutional Neural Networks (CNN)** and recommends suitable pesticides along with preventive suggestions. The system uses image processing and deep learning techniques to classify healthy and diseased crops accurately. The proposed solution is cost-effective, user-friendly, and can assist farmers in making informed decisions.

Keywords: Crop Disease Detection, Convolutional Neural Network, Image Processing, Pesticide Recommendation, Artificial Intelligence.

1. INTRODUCTION

Agriculture is the backbone of many developing countries. Crop diseases are one of the major challenges faced by farmers, resulting in reduced crop quality and yield. Traditional disease detection methods require expert knowledge and manual inspection, which is time-consuming and error-prone.

Recent advancements in Artificial Intelligence (AI) and Machine Learning (ML) have enabled automated disease detection using image-based analysis. Deep learning models, especially Convolutional Neural Networks (CNN), have shown high accuracy in image classification tasks.

This project aims to develop an AI-based system that detects crop diseases from leaf images and provides pesticide recommendations and preventive measures to farmers. The system uses a structured CSV-based pesticide database to map detected diseases to appropriate treatment options.

By integrating deep learning with agricultural knowledge, the proposed system offers a reliable, automated, and user-friendly platform that can assist farmers in making timely and informed decisions, ultimately improving crop yield and reducing economic losses.

1.1 Background and Motivation

In many agricultural regions, farmers rely on manual inspection to identify crop diseases, which depends on expert knowledge and visual observation of leaf color changes, spots, and texture variations. This process is time-consuming, labor-intensive, and often inaccurate, especially when diseases have similar visual symptoms.

The motivation behind this project is to develop an automated and intelligent system that can detect crop diseases accurately from leaf images without requiring expert intervention. The system aims to reduce manual effort, improve detection accuracy, and provide timely pesticide recommendations.

By leveraging deep learning and image processing, the system enables early disease identification and better crop management, benefiting farmers and improving overall agricultural productivity.

1.2 Need for the Study

There is an increasing demand for automated systems that can assist farmers in detecting crop diseases accurately and recommending appropriate treatments. Existing manual methods are unreliable and lead to improper pesticide usage, which increases production costs and causes environmental damage.

An AI-based crop disease detection system provides a better alternative by offering automated, real-time, and accurate disease identification from leaf images. It also improves accessibility for farmers in rural areas who lack access to agricultural experts.

Such a system is essential for improving crop yield, reducing chemical misuse, and ensuring sustainable farming practices.

1.3 Objectives of the Study

The main objective of this project is to develop an AI-based system that automatically detects crop diseases and provides pesticide recommendations.

Additional objectives include:

- To develop an automated crop disease detection system using CNN
- To perform efficient image preprocessing for better model accuracy
- To classify healthy and diseased crops accurately
- To recommend correct pesticide and dosage based on detected disease
- To provide a cost-effective, user-friendly solution accessible to farmers
- To support sustainable and eco-friendly farming practices

1.4 Problem Statement

Traditional crop disease detection relies on manual inspection by farmers or agricultural experts, which is time-consuming, error-prone, and dependent on expert knowledge. Due to incorrect or delayed diagnosis, farmers may apply the wrong pesticide or use excessive chemicals, increasing production costs and causing environmental pollution.

Existing systems lack real-time detection capability and are not easily accessible to farmers in rural areas. Traditional ML models require manual feature extraction and show limited accuracy on large and complex image datasets.

Hence, an automated AI-based system using deep learning is required to provide accurate disease detection, timely recommendations, and support better decision-making for farmers.

1.5 Research Gap

Most existing systems focus only on disease detection without integrating accurate pesticide recommendation and dosage guidance. Models are mainly trained on controlled datasets and show reduced accuracy in real-world field conditions.

Many systems have limited scalability to support multiple crops and new diseases. High computational requirements make deployment on low-cost or mobile devices difficult, reducing accessibility for farmers in remote areas.

The proposed system addresses these limitations by combining CNN-based disease detection with a structured pesticide recommendation module, providing a complete, scalable, and user-friendly solution suitable for real-world agricultural applications.

1.6 Proposed System

The proposed system is an AI-Based Crop Disease Detection and Pesticide Recommendation platform that uses Convolutional Neural Networks (CNNs) to automatically identify crop diseases from leaf images.

The system takes a leaf image as input, processes it using deep learning techniques, and classifies the crop as healthy or diseased. Based on the detected disease, the system recommends suitable pesticides using a structured CSV-based pesticide database.

The solution is cost-effective, efficient, and user-friendly, making it accessible to farmers. It eliminates the need for manual inspection and expert dependency, enabling timely and accurate disease management.

2. Materials and Methods

The AI-Based Crop Disease Detection System is developed as a web application that integrates deep learning with a pesticide recommendation module. It follows a structured pipeline where leaf images are uploaded, preprocessed, classified, and matched against a pesticide database.

The system uses Python 3.8 as the core programming language, with Convolutional Neural Networks (CNN) and OpenCV for image processing and disease classification. Streamlit is used for the front-end interface and Python Flask Framework for the backend.

The design focuses on providing an accurate, fast, and user-friendly interface that allows farmers to upload leaf images and receive disease diagnosis and pesticide recommendations in real time.

2.1 System Overview

The system operates through a sequential processing pipeline that includes image acquisition, preprocessing, feature learning using CNN, disease classification, and pesticide recommendation.

When a farmer uploads a leaf image, the system preprocesses it for quality enhancement and noise reduction. The processed image is then fed into the trained CNN model, which classifies the crop as healthy or identifies the specific disease.

Based on the classification output, the system queries the pesticide database and displays appropriate recommendations to the user, including pesticide name and dosage guidance.

2.2 Use Case Diagram

The use case diagram illustrates the interactions between the three main actors — Admin, AI Model, and Farmer — and the core functionalities of the Crop Disease Detection System.

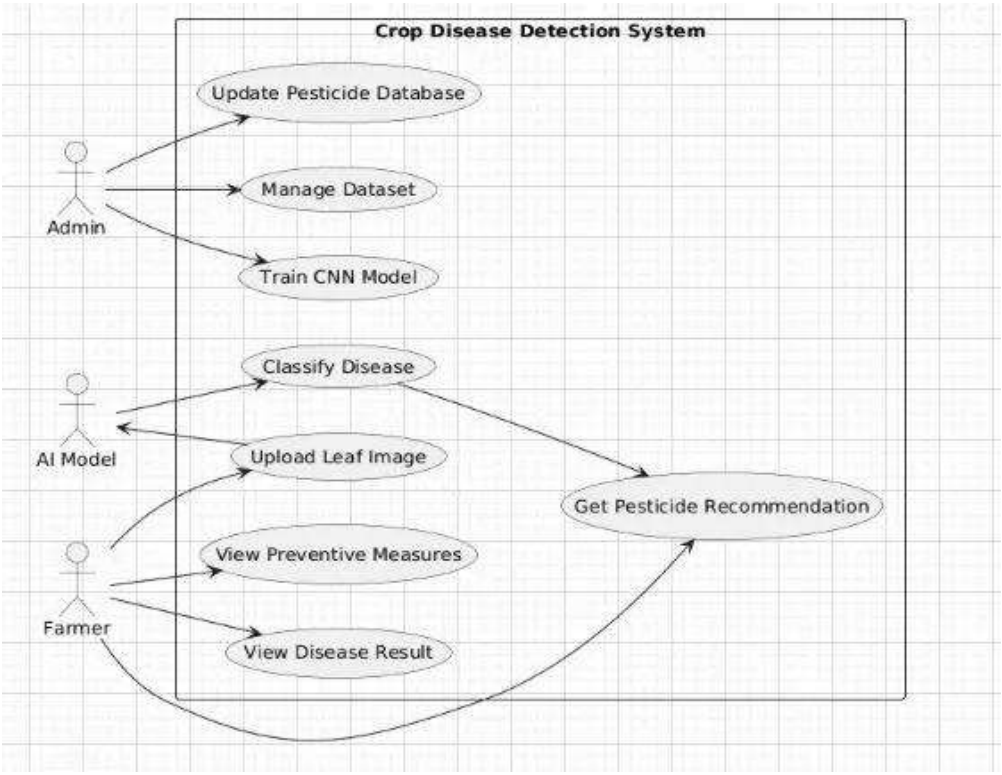


Figure 1: Use Case Diagram of Crop Disease Detection System

The Admin manages the pesticide database, dataset, and CNN model training. The AI Model handles disease classification and leaf image processing. The Farmer interacts with the system to upload leaf images, view disease results, preventive measures, and obtain pesticide recommendations.

2.3 Data Input

The system accepts leaf images uploaded by the user as input. Images are collected through the web interface and validated for quality and format before processing.

The PlantVillage dataset is used for training the CNN model, which contains a large collection of labeled leaf images covering multiple crop diseases. This ensures the model is trained on diverse and representative data.

2.4 Image Preprocessing

Before feeding images into the CNN model, the system performs preprocessing steps to enhance image quality and ensure consistency. These steps include resizing, normalization, noise reduction, and image augmentation techniques such as rotation, flipping, and zooming.

2.5 Feature Learning Using CNN

The system uses a Convolutional Neural Network (CNN) for automated feature extraction from preprocessed leaf images. The CNN model learns discriminative features such as texture, color patterns, and lesion characteristics that distinguish healthy crops from diseased ones.

2.6 Disease Classification

After feature extraction, the system classifies the crop image into predefined categories: healthy or a specific disease class. The model outputs the predicted class label along with a confidence score, providing reliable disease identification.

2.7 Pesticide Recommendation Module

Based on the detected disease, the system queries a structured CSV-based pesticide database to retrieve appropriate treatment recommendations including pesticide name and dosage guidelines.

2.8 System Requirements

Software Requirements:

- Operating System: Windows 10
- Language Used: Python 3.8
- IDE: Visual Studio

Hardware Requirements:

- Processor: Intel Core i5 (8th Gen)
- RAM: Minimum 8 GB

Technologies Used:

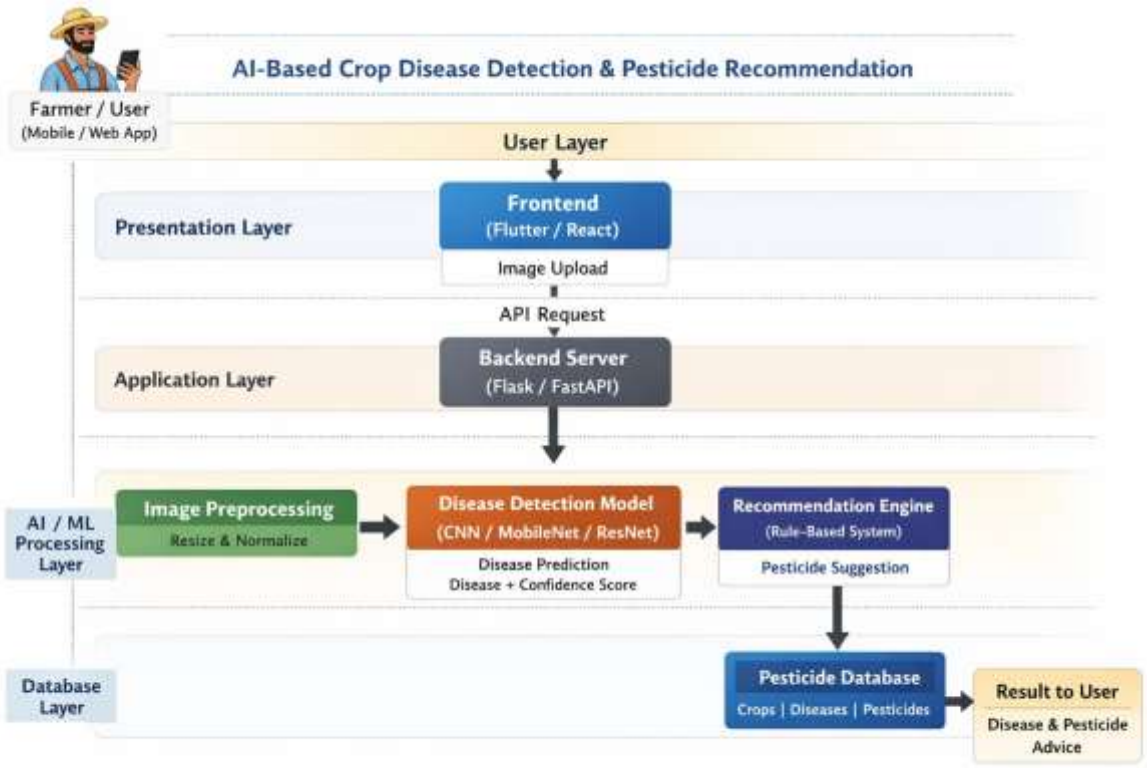
- Algorithms/Frameworks: Convolutional Neural Networks, OpenCV
- Front End: Streamlit
- Back End: Python Flask Framework

2.9 System Workflow

The workflow begins when the user uploads a leaf image through the web interface. The system preprocesses the image, extracts features using the CNN model, classifies the disease, retrieves pesticide recommendations from the database, and displays all results to the user in real time.

2.10 System Modules

The proposed system is divided into the following modules: Image Acquisition Module, Preprocessing Module, CNN-Based Feature Learning Module, Disease Classification Module, Pesticide Recommendation Module, and Result Display Module. Each module performs a specific function, and together they ensure accurate and efficient crop disease detection and recommendation.



3. Results and Discussion

The proposed AI-Based Crop Disease Detection System successfully performs key operations including image preprocessing, CNN-based disease classification, and pesticide recommendation. After processing the input leaf image, the system displays the disease classification result and recommended pesticide to the user in real time.

The system was tested using various leaf images covering multiple crop disease categories. The CNN model demonstrated high classification accuracy, correctly identifying diseases in the majority of test cases. The system provides clear and structured outputs including disease name, AI confidence score, risk level, possible causes, treatment steps, recommended fertilizers, prevention tips, and an action plan.

The following screenshots demonstrate the working outputs of the system across different pages of the application.

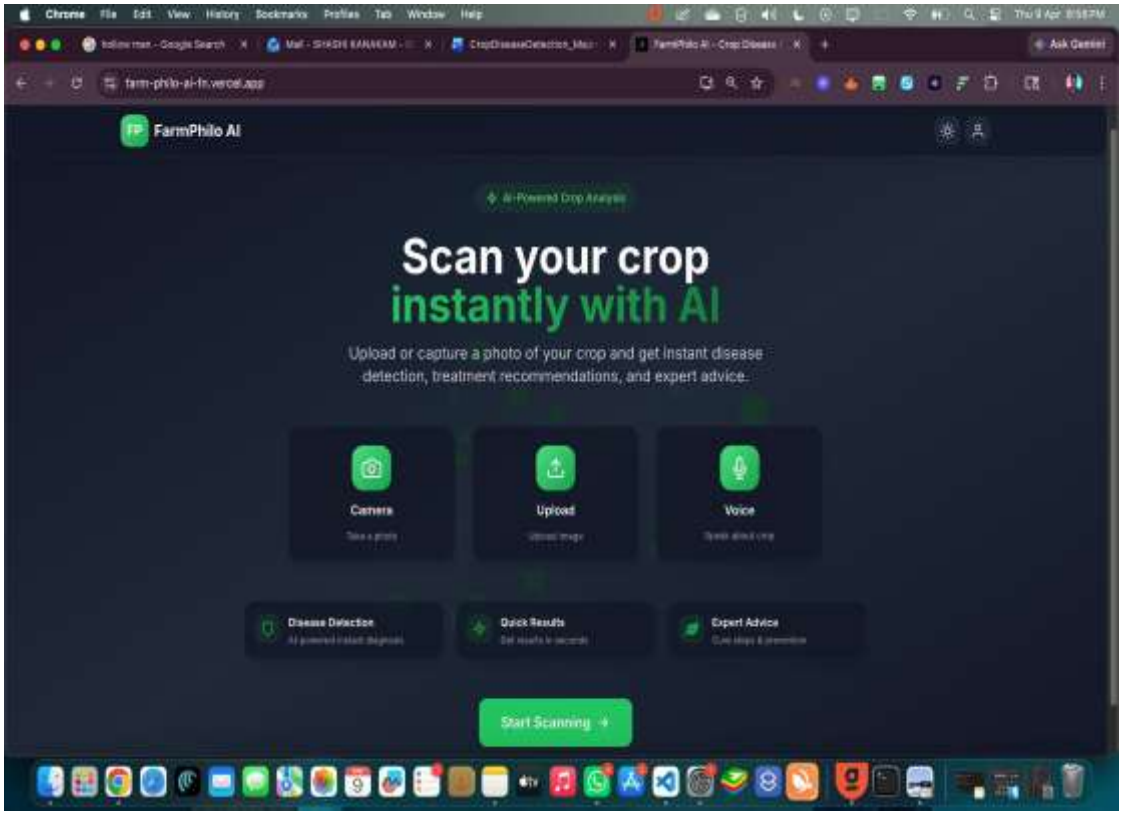


Figure 2: Home Page – FarmPhilo AI Landing Page

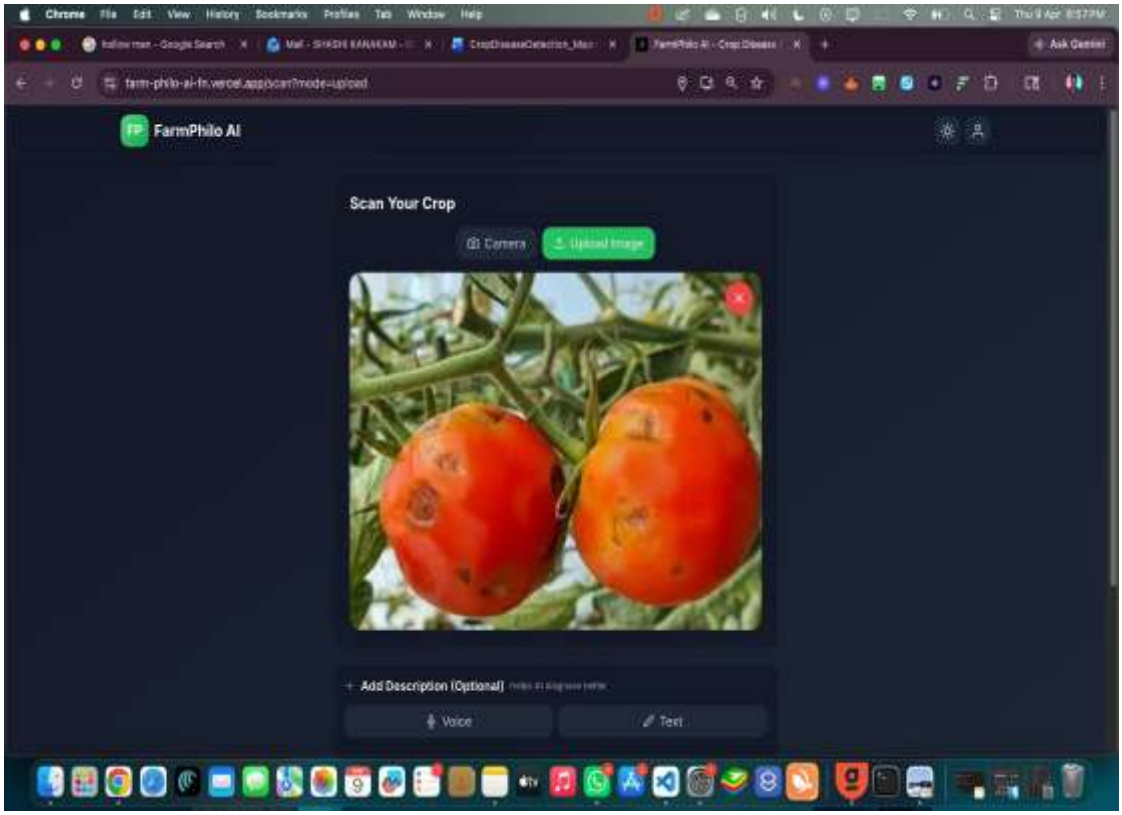


Figure 3: Scan Page – Upload Crop Image for Disease Detection

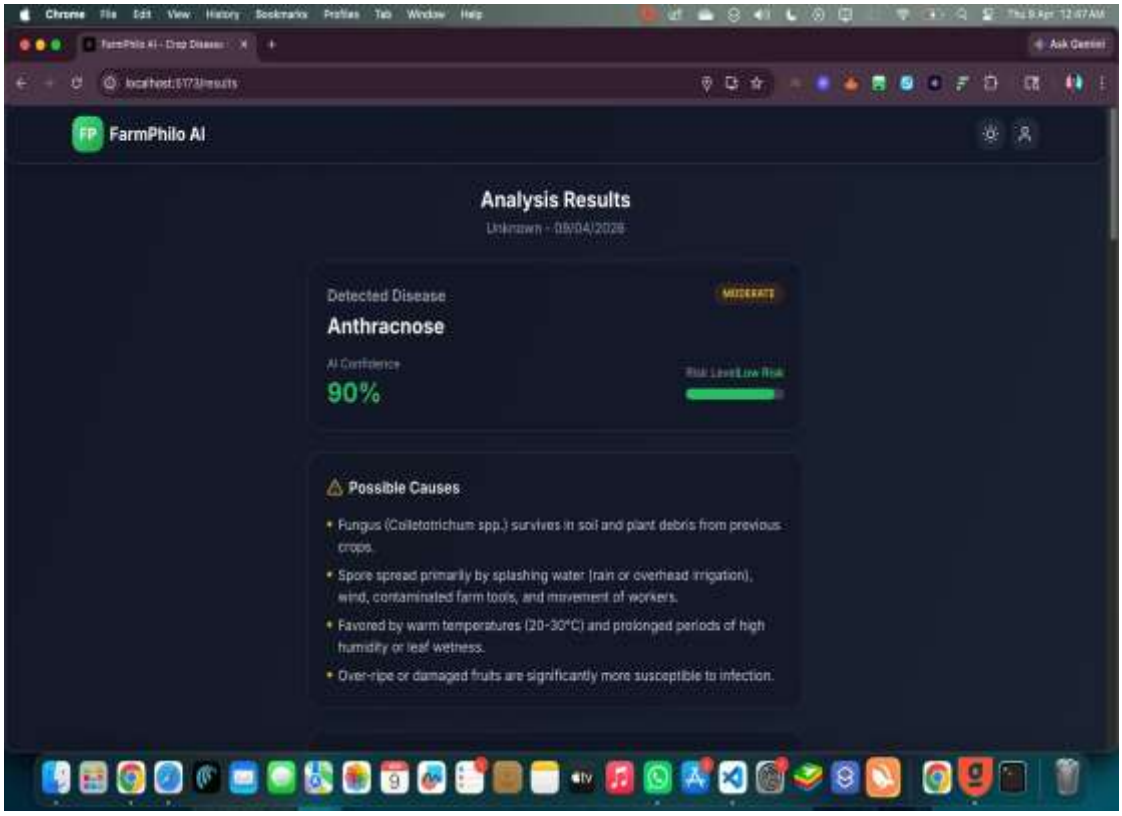


Figure 4: Analysis Results – Detected Disease with AI Confidence Score

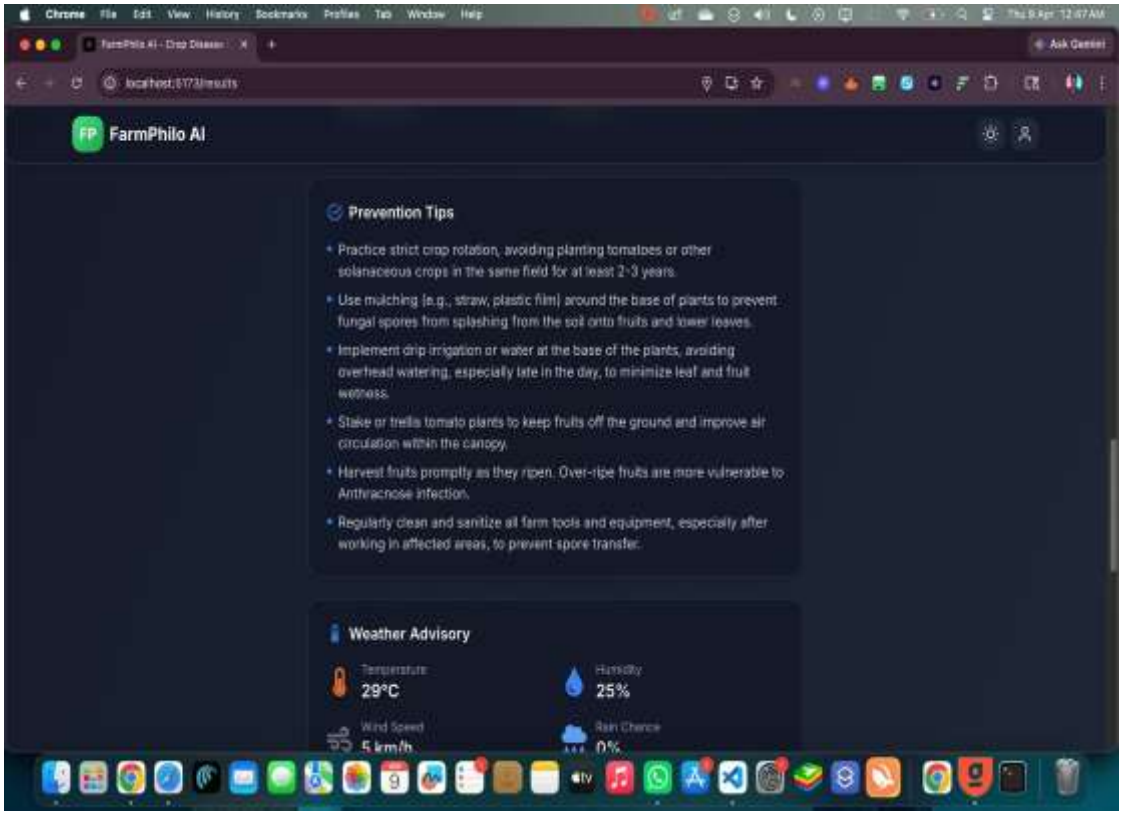


Figure 5: Prevention Tips and Weather Advisory

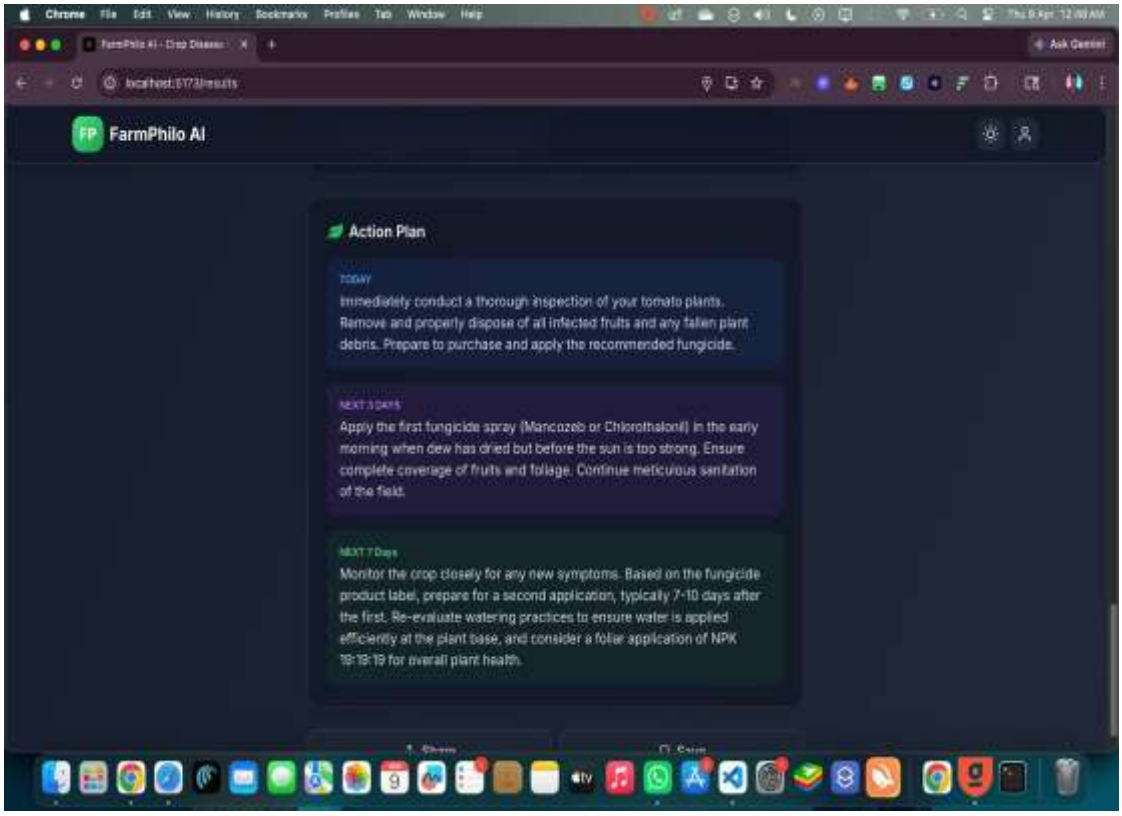


Figure 6: Action Plan – Treatment Timeline

To better understand existing approaches and position the proposed system, a comparative analysis of recent research works is presented in Table 1.

Table 1: Comparative Analysis of Related Work

Year	Title	Authors	Methods	Journal	Key Contribution & Limitations
2025	Plant Disease Identification and Pesticides Recommendations Using CNN Deep Learning	J. Vyshnavi, S. Sowmya, P. Dhanvitha, M. A. Khatoon, L. S. Rekha	Deep Learning, CNN, Image Segmentation, Classification	IJSRST	Automates plant disease detection and provides pesticide recommendations. Limitation: Requires high-quality images only.
2025	AI-Based Crop Disease Detection Using CNN	M. Jain, S. Jain, S. Kumar, A. Pandey	CNN, PlantVillage Dataset, Image Classification	SCITEPRESS	AI framework using CNNs to identify plant diseases efficiently. Limitation: Does not include pesticide recommendation.

2024	Crop Disease Detection and Recommendation of Pesticides and Secondary Crops Using Deep Learning	J. Benita, G. S. Reddy, K. V. Rao, V. B. Kumar, P. Anil Kumar	Deep Learning, CNN, Image Processing	IJSRST	CNN-based model that detects diseases and suggests pesticides and alternative crops. Limitation: No dosage precision.
2023	Crop Disease Detection and Pesticide Recommendation Using CNN	S. R. Holkar, G. S. Gaikwad, M. G. Bhattad, P. Solanki, V. A. Suryawanshi	CNN, Image Preprocessing, Feature Extraction	IJRASET	CNN-based system to detect crop diseases and recommend pesticides. Limitation: No optimization of pesticide dosage.
2022	Smart Crop Disease Detection Using Deep Learning	R. Kumar, P. Kumar	CNN, Image Segmentation, Feature Extraction	SAI Organization	Smart agriculture framework using deep learning for early disease diagnosis. Limitation: Accuracy reduces with noisy images.
2022	Deep Learning Approach for Crop Disease Identification	N. Patel, H. Shah	CNN, Image Enhancement	IJACSA	Emphasizes sustainable agriculture by reducing pesticide misuse. Limitation: Does not handle multiple diseases in a single leaf.
2021	Leaf Disease Detection Using Machine Learning and Deep Learning	A. Singh, S. Jain	CNN, SVM, Image Processing	IEEE	Compares ML and DL techniques; CNN outperforms classical methods. Limitation: Lacks pesticide or treatment recommendation.
2021	Crop Disease Detection and Classification Using CNN	K. Thenmozhi, U. Srinivasulu Reddy	CNN, Image Preprocessing	IEEE	Accurate detection of multiple crop diseases. Limitation: Focuses only on

					classification, not severity estimation.
2020	Plant Disease Detection Using Deep Learning	Y. Lu, S. Yi, N. Zeng, Y. Liu	CNN, Image Augmentation, Transfer Learning	IEEE Access	Demonstrates robustness of CNN for large-scale classification. Limitation: Requires large labeled datasets.
2019	Deep Learning-Based Classification for Crop Disease Detection	P. Ferentinos	CNN, Deep Neural Networks	Elsevier	Achieves accuracy above 99% for several crop-disease categories. Limitation: High computational requirements.
2018	Image-Based Plant Disease Detection Using Machine Learning	S. Sladojevic, M. Arsenovic	CNN, Image Classification	Int. Journal Computer Application	Early work laying foundation for deep learning in plant disease identification. Limitation: Limited to controlled environments.
2016	Using Deep Learning for Image-Based Plant Disease Detection	S. P. Mohanty, D. P. Hughes, M. Salathé	Deep CNN, Transfer Learning, Image Classification	Frontiers in Plant Science	Achieved over 99% accuracy on controlled datasets. Landmark paper. Limitation: No treatment or decision-support system.

The above comparison shows that earlier crop disease detection systems mainly relied on basic CNN architectures and focused solely on disease classification without integrating pesticide recommendation features. These systems provided limited functionality and lacked comprehensive treatment guidance, making them insufficient for practical agricultural use.

Recent approaches have introduced improved deep learning architectures, transfer learning techniques, and dataset augmentation methods to enhance model accuracy and generalization. However, many of these systems still lack proper pesticide recommendation modules, real-time deployment capabilities, and user-friendly interfaces suitable for farmers in rural areas.

The proposed system addresses these limitations by combining CNN-based disease detection with a structured pesticide recommendation module. It offers real-time detection, accurate disease classification, and practical treatment guidance, making it a more comprehensive and user-friendly solution for modern smart agriculture.

4. Conclusion

The AI-Based Crop Disease Detection and Pesticide Recommendation System provides an effective solution to the challenges faced in traditional crop disease management. It simplifies disease identification by automating the detection process using deep learning techniques.

The system improves accuracy, reduces manual workload, and provides timely pesticide recommendations, minimizing chemical misuse and crop losses. It also ensures a cost-effective, user-friendly solution accessible to farmers.

Overall, the system is efficient, accurate, and scalable, making it suitable for modern smart agriculture needs.

5. Future Scope

The system can be further improved by adding advanced features such as mobile application support, integration with IoT sensors, and support for more crop types and disease categories.

Future enhancements may include:

- Deployment as a mobile application for easy farmer access
- Support for more crops and disease types
- Integration with IoT sensors and weather data for better recommendation
- Cloud-based deployment for scalability
- AI-based severity estimation and treatment tracking

These improvements will make the system more powerful, flexible, and suitable for large-scale smart agricultural applications.

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