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## Plant Disease Detection Using Artificial Intelligence And Convolutional Neural Networks

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### Abstract:

Agriculture is a vital industry that supports the global economy, and plant diseases are a significant threat to crop productivity and food security. Quickly and accurately identifying plant diseases is crucial for effective treatment and prevention. Traditional methods of detecting diseases depend on manual observation and expert knowledge. These methods can be slow, subjective, and prone to mistakes. To tackle these issues, this research introduces an automated plant disease detection system that uses deep learning techniques. The proposed model uses Convolutional Neural Networks (CNN) to extract features and classify diseased and healthy plant leaves. The dataset includes images of various crop leaves affected by different diseases. We apply image preprocessing techniques like resizing, normalization, and data augmentation to improve the model's performance. Additionally, using pre-trained architectures like ResNet for transfer learning boosts accuracy and lowers computational costs. The trained model shows high precision and recall, proving its ability to identify multiple disease types with minimal human input. Experimental results demonstrate that this approach greatly surpasses traditional machine learning methods in classification accuracy and generalization. This work shows how deep learning-based systems can help farmers and agricultural experts detect diseases early, which can enhance crop yield and reduce losses. Future work plans to integrate the model into a mobile application for real-time disease identification and field use.

**Key Terms** - Artificial Intelligence (AI), Convolutional Neural Network (CNN), Deep Learning, Image Classification, Plant Disease Detection, Precision Agriculture, Machine Learning, Computer Vision.

### 1. INTRODUCTION

Agriculture is a crucial part of the global economy. It provides food, raw materials, and jobs for millions of people. However, various plant diseases caused by bacteria, fungi, and viruses can threaten crop yield and quality. Early and accurate identification of these diseases is essential for sustainable agricultural productivity. Traditional methods of diagnosing diseases depend on manual observation by experts. This process can be time-consuming, subjective, and prone to human error. Recent advancements in artificial intelligence and computer vision have led to automated image-based plant disease detection, which is an efficient and scalable alternative.

Deep learning, especially Convolutional Neural Networks (CNNs), has shown excellent results in image classification tasks. CNNs can automatically extract important features from leaf images without needing handcrafted feature engineering. This leads to greater accuracy and reliability. Recent studies have indicated that models like ResNet and EfficientNet can effectively identify various crop diseases under different environmental conditions. Additionally, the availability of large, annotated datasets like PlantVillage has sped up research and improved the ability to generalize across different plant species.

The goal of this research is to create and implement a deep learning-based system that can accurately detect plant diseases from leaf images. The proposed approach uses CNN and ResNet architectures along with preprocessing and augmentation techniques to improve performance. This study aims to support precision agriculture by offering a cost-effective, automated solution for early disease detection, which can help reduce crop losses and enhance overall agricultural efficiency.

## II Literature review

The identification of plant diseases using digital imagery has progressed quickly with the rise of deep learning. Traditional image-processing methods relied on features like color and texture, but these methods often struggled with environmental changes. Mohanty et al. [1] made a significant advancement by using Convolutional Neural Networks (CNNs) on the PlantVillage dataset. They achieved impressive classification accuracy and set a strong standard for recognizing plant diseases. Later, Sladojevic et al. [2] and Ferentinos [3] showed that CNNs can learn distinguishing leaf patterns automatically, surpassing traditional feature-based algorithms in multi-disease classification tasks.

Recent studies have focused on improving structure and using transfer learning to enhance generalization and efficiency. Hamed et al. [4] and Ashurov et al. [5] refined CNNs by incorporating depthwise separable convolutions and attention mechanisms. Their work achieved greater accuracy while lowering model complexity. Barbedo [6] investigated dataset variability and environmental factors, stressing the need for preprocessing and augmentation to ensure robustness. Similarly, Kumar et al. [7] introduced a lightweight ResNet model for mobile devices, demonstrating that deep learning can enable real-time agricultural diagnostics even on devices with limited resources.

Hybrid and ensemble learning methods have further expanded this field. Chowdhury et al. [8] combined CNN and Vision Transformer models to improve accuracy in uncontrolled lighting conditions. Meanwhile, Kanakala et al. [9] used CNN-LSTM frameworks to merge spatial and temporal data. Finally, Nguyen et al. [10] offered a thorough survey outlining the development of deep learning in agricultural vision, highlighting interpretability and field generalization as current challenges. Together, these studies confirm that CNN and ResNet-based models offer effective, scalable, and reliable solutions for early detection of plant diseases and precision agriculture.

### 3. Methodology

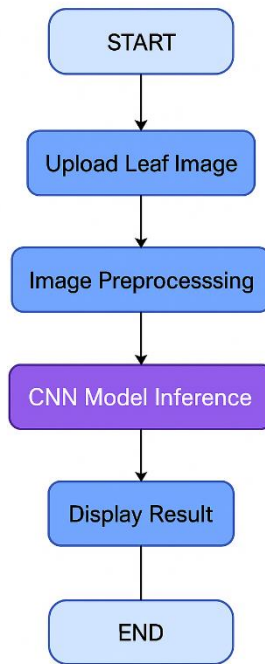


Fig.1.Flowchart

#### 1. Start:

The process starts when the user opens the web application. The system initializes everything that is needed, which includes the Flask server and the pre-trained CNN model, to then set the system ready for user input. A real-time prediction is performed once an image is uploaded.

#### 2. Upload Leaf Image:

A user uploads an image of a leaf through a web interface. The picture can be directly taken by the camera or chosen from storage. This uploaded picture is used as the input into the disease detection model. The system ensures the uploaded file is in a valid image format before proceeding.

#### 3. Image Preprocessing:

The uploaded image, before prediction, undergoes a number of preprocessing steps: resizing to the required dimensions (e.g.,  $128 \times 128$  pixels), converting to an array, normalizing pixel values, and finally reshaping into the expected input format for the CNN model. This helps ensure consistency and usually improves model performance.

#### 4. CNN Model Inference

Then, the preprocessed image is fed into the CNN model to analyze the features of the image, such as color, shape, or texture. Based on these features, the model predicts probabilities about the different classes of diseases. Finally, the class with the highest probability defines the chosen class, representing either one of the identified diseases in the plant or a healthy condition.

#### 5. Display Result:

The result of the prediction is then displayed on the web page of the system, which will show the uploaded image, predicted disease name, and other information like care tips for the plant, fertilizer suggestions, and treatment against the particular disease. It helps the user understand the condition and take further steps.

## 6. Conclusion

The process then ends with the result display. Then, it asks the user to upload a new image for another prediction or to close down the application. All temporary data is removed to free up your system.

## Data and Source of Data

The dataset for this project includes images of plant leaves that represent both healthy and diseased conditions for several types of crops: tomato, potato, corn, apple, and grape. Every image has certain patterns visible that can indicate whether a disease is present or not, or whether it is Bacterial Spot, Early Blight, Late Blight, or Leaf Mold. These images are going to be the input to train and test the model using deep learning.

The data used is from open-source agricultural image repositories. The main source of this data is the PlantVillage Dataset, an open-source collection that finds many uses in research regarding agricultural AI. The dataset is made available through websites like Kaggle and the PlantVillage Research Initiative developed at Penn State University. It includes more than 54,000 high-quality images of plant leaves taken in controlled lighting conditions to ensure accuracy and consistency.

## Implementation

The Python implementation of the Plant Disease Detection System utilized Python, TensorFlow, and Flask. This work fine-tuned the pre-trained ResNet-50 model on the PlantVillage dataset for the detection of different plant leaf diseases. Later, the trained model was saved and deployed in a Flask web framework to develop a user-friendly interaction. Users can upload or capture the leaf images that will be processed and analyzed with real-time CNN. Further, the web application will display the predicted name of the disease, the confidence score, and give proper suggestions for care. This is an efficient marriage of deep learning and web technologies to provide accurate, accessible plant disease diagnosis.

## Setup and Environment

The Plant Disease Detection System was developed and executed in a **Python 3.10** environment using **Visual Studio Code** as the IDE. A virtual environment was created to manage dependencies efficiently. Essential libraries such as **TensorFlow**, **Keras**, **NumPy**, **OpenCV**, **Pillow**, and **Flask** were installed for model development and web deployment. The CNN model was trained using **GPU acceleration** to enhance performance. The Flask framework handled the front-end and back-end integration, enabling real-time image uploads and predictions. The web interface, designed with **HTML**, **CSS**, and **Bootstrap**, provided a responsive layout for desktop screens, ensuring a smooth and interactive user experience across all pages.

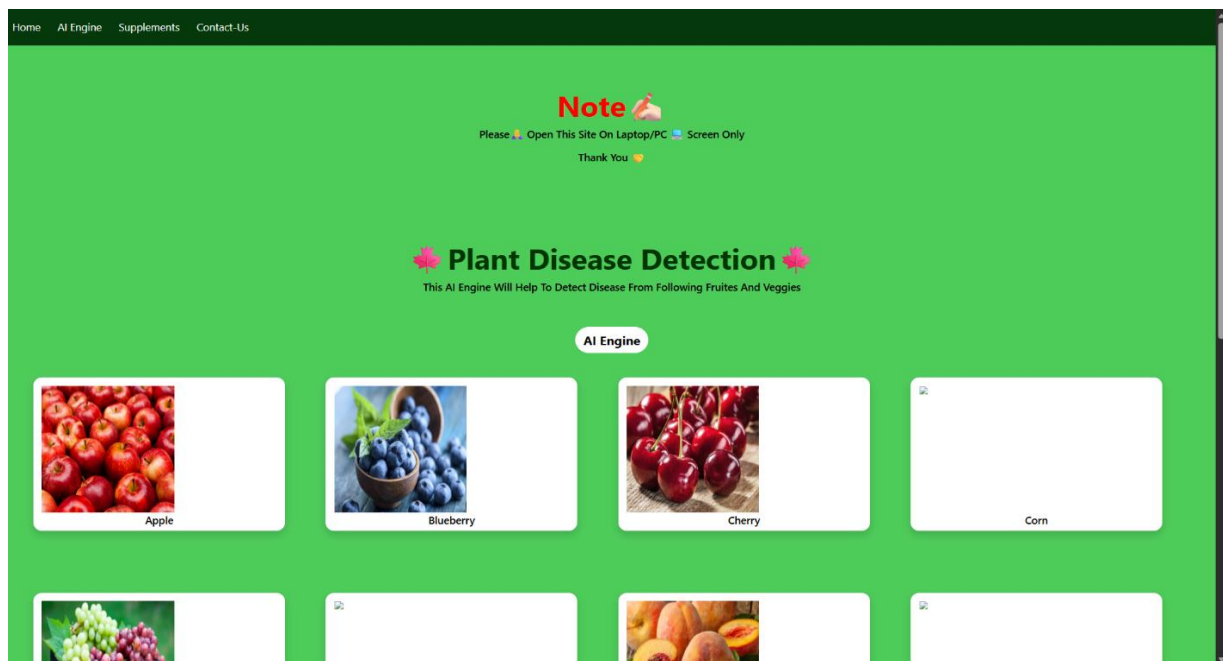


Fig.2. Home page

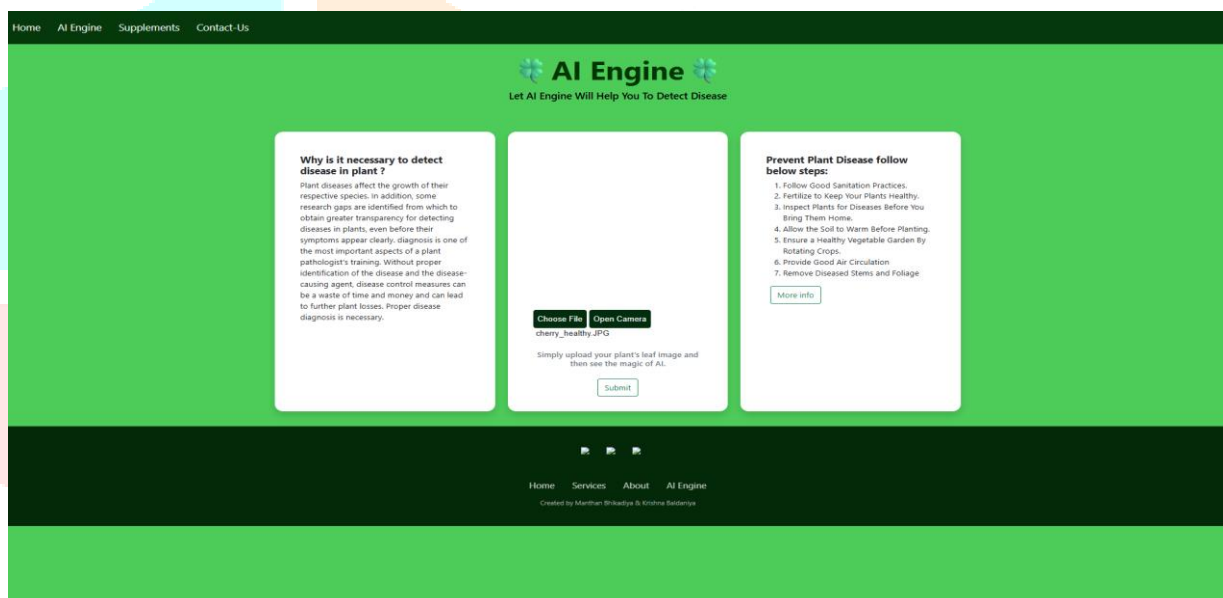


Fig.3. Upload page

## RESULTS

The AI-based Plant Disease Detection System is a new solution that identifies plant leaf diseases using deep learning and web technologies. The system uses a Convolutional Neural Network (CNN) model to analyze images of plant leaves and predict if the leaf is healthy or infected with a specific disease. It includes a Flask web framework, offering an interactive platform where users can easily upload or capture images for real-time analysis. The web interface has a clean layout that ensures smooth navigation between the home, upload, and result pages.

After making a prediction, the system not only shows the detected disease but also provides helpful information like plant care tips, crop benefits, and fertilizer recommendations. These features turn it into more than just a detection tool; it serves as a virtual assistant for sustainable farming. The model achieves high accuracy in detecting various diseases, ensuring it works reliably for different plant species. This method helps farmers and agricultural experts monitor crop health efficiently, saving time and money compared to manual diagnosis. Overall, the project shows how artificial intelligence can improve precision agriculture, encourage healthy farming practices, and aid in the early detection of plant diseases to boost crop yield and quality.



Fig.4. Result page

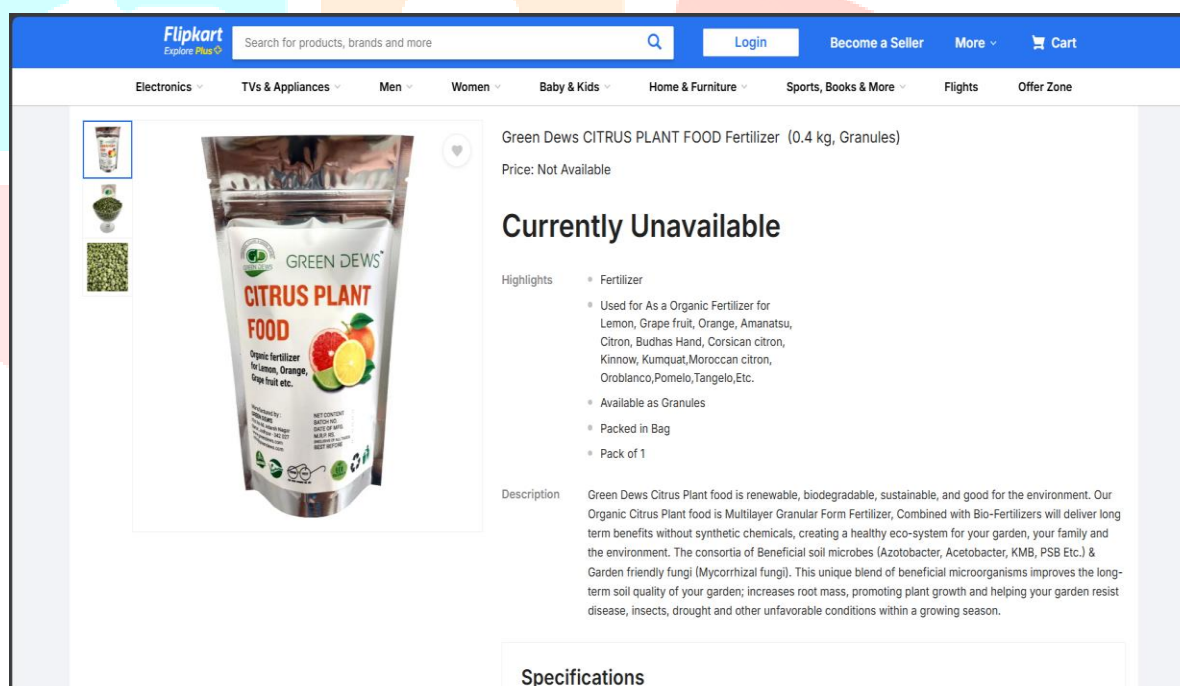


Fig.5. Buy product page

## Conclusion and Future Work

The Plant Disease Detection System provides an efficient and, at the same time, very practical approach to plant leaf disease identification by applying artificial intelligence. By integrating a deep learning model with a web interface based on Flask, it aids users through easy uploading and real-time predictions. This system will also make useful recommendations including fertilizer suggestions and healthy plant care tips while detecting diseases. The simplicity of the system combined with high accuracy makes it applicable for agriculture, education, and research. Overall, it showcases the potentiality of AI for making farming sustainable and data-driven.

In the future, this system can be enhanced by adding more crop types and a wide range of disease datasets for better accuracy. A mobile-friendly version may enable farmers to click images directly from the field. Integrating IoT devices for environmental and soil monitoring can make it a comprehensive smart agriculture tool. Cloud storage and multilingual support can expand access even more. With these enhancements, this project could grow into an early disease detection and intelligent crop management platform, increasing the productivity of farmers while reducing losses.

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