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Leaf Pathogen Detection using CNN

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ABSTRACT: Leaf pathogen detection is the process of identifying and classifying diseases affecting plant leaves by analyzing visual features. This project introduces an AI-powered Leaf Pathogen Detection System using Convolutional Neural Networks (CNN) to automatically detect and classify pathogens from leaf images. The system processes images to identify infected regions by analyzing patterns such as color, texture, and shape. It uses morphological operations and feature extraction techniques to isolate diseased areas, filtering out healthy regions. The system is deployed using Stream-lit, allowing users to upload leaf images and receive real-time classification results. This solution offers a fast and automated approach to detecting leaf diseases, aiding farmers and researchers in early diagnosis and effective crop management.

KEYWORDS: Leaf pathogen detection, CNN, Image classification, Morphological operations, Stream-lit deployment.

I. INTRODUCTION

Leaf pathogen detection is a vital process in agriculture, enabling the identification and classification of plant diseases by analyzing visual features. It focuses on detecting infected regions by examining variations in color, texture, and shape, helping in early diagnosis and effective disease management. In real-world agricultural scenarios, farmers often face challenges in identifying diseases through manual inspection, which can be time-consuming and error-prone. Therefore, an automated detection system using Convolutional Neural Networks (CNN) offers a more accurate and efficient solution. This project introduces a CNN-based leaf pathogen detection system capable of identifying and classifying leaf diseases. The system processes leaf images, extracts relevant features, and detects infected areas. It applies morphological operations and feature extraction techniques to isolate diseased regions, filtering out healthy areas. The model is trained on a dataset of healthy and diseased leaf images, enabling it to accurately classify the type of pathogen.

The system is deployed using Stream-lit, providing a web interface for easy accessibility. Users can upload leaf images and receive real-time pathogen classification results, enhancing usability for farmers and researchers. This solution offers a fast, reliable, and automated approach to disease detection, reducing the need for manual inspection. There are numerous applications of automated leaf pathogen detection in agriculture, including crop monitoring, yield optimization, and disease control. It helps in timely intervention, reducing crop losses and boosting productivity.
The paper is organized as follows: Section II covers image pre-processing using morphological operations. Section III explains the classification process. Section IV presents experimental results, and Section V concludes with key findings and future improvements.

II. RELATED WORK

The concept of leaf pathogen detection using image analysis has evolved significantly with the advancement of deep learning techniques. Early methods relied on traditional image processing techniques, which were less accurate in detecting complex patterns. The use of Convolutional Neural Networks (CNN) revolutionized the field by enabling automated and accurate classification of plant diseases.

Initial approaches focused on image segmentation and feature extraction to identify diseased regions. These methods applied techniques such as morphological operations to detect patterns related to infection. For example, Bertamio et al.

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introduced an image inpainting method based on image smoothness interpolation, propagating along gradient directions. Similarly, Criminisi et al. proposed an exemplar-based method using patch propagation to reconstruct missing image regions, which achieved better accuracy in restoring complex structures. In pathogen detection, morphological techniques are widely used to isolate diseased areas by applying operations like dilation, erosion, and thresholding. Recent works have combined CNNs with morphological filtering to enhance detection accuracy. These models extract detailed features from leaf images, identifying pathogens by analyzing shape, color, and texture variations.

The system presented in this project consists of two key stages: 1) Pathogen Detection and 2) Classification. In the first stage, morphological operations are applied to detect infected regions by extracting edges and filtering out healthy areas. The second stage uses a CNN-based classification model to categorize the pathogen type. Finally, the results are displayed through a Streamlit web interface, providing real-time pathogen detection and classification.

III. DATASET DESCIPTION

The Plant Village dataset is a publicly available benchmark dataset widely utilized for leaf disease and pathogen detection in plants. It contains labeled images of healthy and diseased leaves from multiple plant species, making it suitable for training and evaluating deep learning models in agricultural disease diagnosis.

Dataset Composition

- Total Images: 54,305
- Image Format: RGB images in .JPG format
- Image Resolution: Varies (consistent dimensions for deep learning compatibility)
- Classes: 38 categories (including healthy and diseased leaves)
- Plant Species: 14

Categories and Labels

The PlantVillage dataset consists of images from multiple plant species, categorized into healthy and diseased classes. For apple leaves, the dataset includes images of leaves affected by apple scab**,** black rot**,** and cedar apple rust**,** along with a class for healthy leaves. The corn category contains images of leaves with Cercospora leaf spot (Gray leaf spot)**,** common rust**,** and northern leaf blight**,** as well as healthy samples. Similarly, the grape category features diseases such as black rot**,** Esca (Black measles)**,** and leaf blight (Isariopsis Leaf Spot)**,** alongside healthy grape leaves. The potato section includes images of leaves with early blight and late blight, along with a healthy category. Lastly, the strawberry category contains images of leaves affected by leaf scorch**,** along with healthy samples. This diverse set of categories makes the PlantVillage dataset highly suitable for training deep learning models to accurately classify plant diseases.

IV. METHODOLOGY

The leaf pathogen detection system uses a CNN-based classification model combined with morphological operations to detect and classify plant diseases. The process begins by preprocessing the input leaf image, where morphological filters such as dilation, erosion, and thresholding are applied to highlight infected regions. This enhances the contrast between diseased and healthy areas, making it easier to isolate pathogen-affected regions.

The system automatically identifies and masks the infected areas without user interaction. It then applies feature extraction techniques to analyze color, texture, and shape variations. The CNN model (VGG16) processes the image and classifies the pathogen type based on the detected features. The model prioritizes areas with distinct infection patterns, ensuring accurate classification.

The system uses Streamlit for deployment, allowing users to upload images and receive real-time pathogen detection results with confidence scores.

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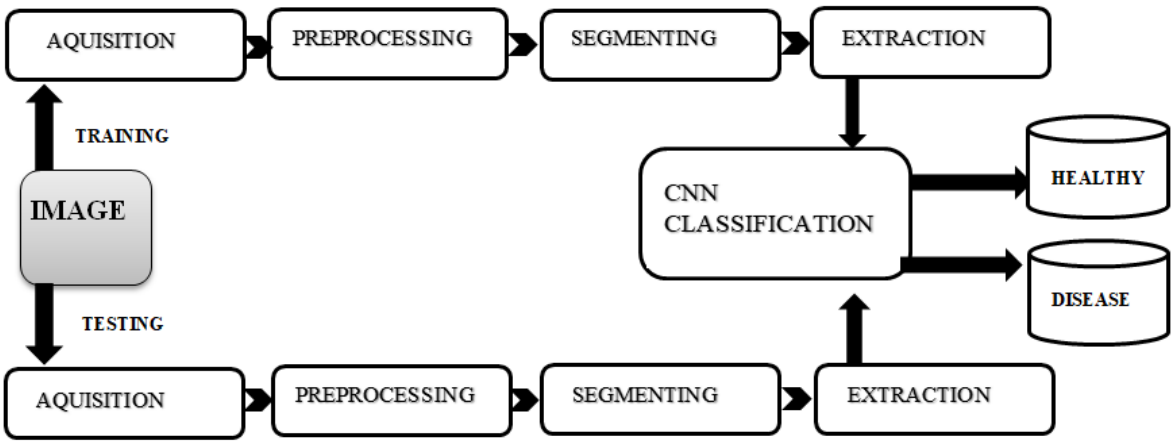
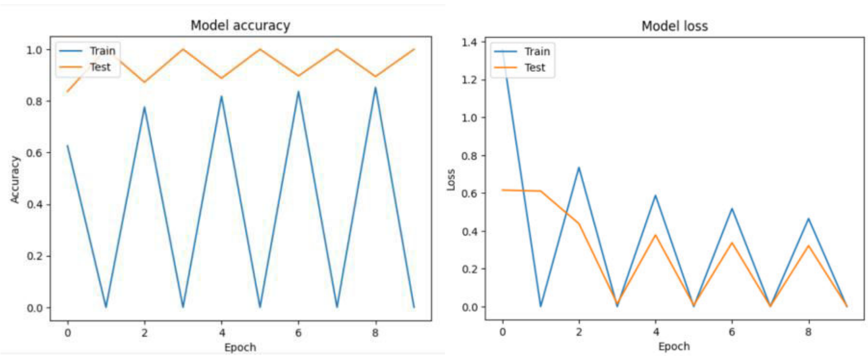
FLOW DIAGRAM:



V. RESULT & DISCUSSION

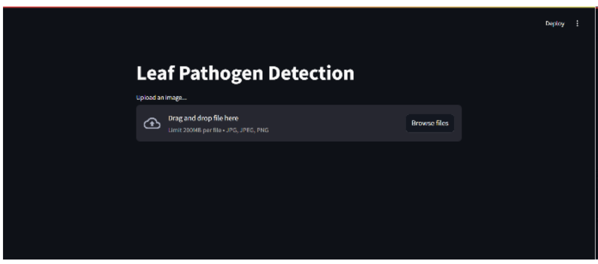
CURVES:



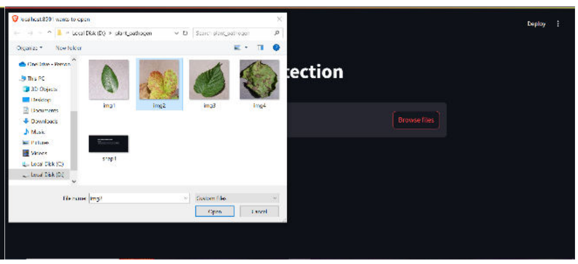
The figures illustrate the results of the leaf pathogen detection system. Figures 1, 2, 3, and 4 demonstrate the different stages of the process.

- **(a)** shows the upload page where the user selects the image file for analysis.
- **(b)** displays the file selection interface, allowing the user to choose the desired leaf image.
- **(c)** shows the uploaded image being displayed in the interface, ready for classification.
- **(d)** presents the final output with the predicted pathogen name displayed after the classification process.

The system accurately detects and classifies leaf pathogens, providing real-time results with a user-friendly interface.



(a) Upload Page



(b) File Selection

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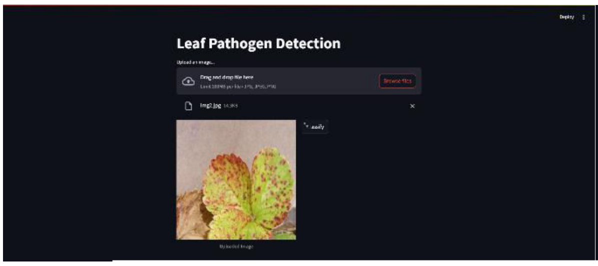
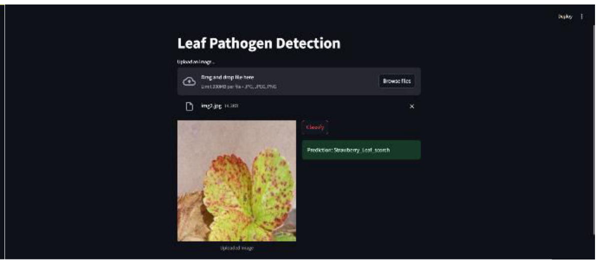


(c) Uploaded image file



(d) Predicted output

VI. CONCLUSION

We have implemented an automated leaf pathogen detection system using CNN and morphological operations**.** The system effectively detects infected regions in leaf images containing mixed healthy and diseased areas. We tested the system on various leaf images and found that it accurately identifies and classifies pathogen-affected regions**.**

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