Plant Disease Image Classifier – CNN

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Abstract:

Plants are essential to global food security, yet plant diseases can cause significant crop losses. Manual monitoring for disease detection is labour-intensive and cause errors, which can hinder timely intervention. This project aims to develop an automated system using computer vision and AI to detect plant diseases early, improving crop health and yield. We propose a context aware 3D Convolutional Neural Network (CNN) based on the approach for classifying plant diseases based on leaf images, leveraging the widely used PlantVillage dataset. The classifier aims to assist in early disease detection, potentially improving crop yield and aiding precision agriculture.

Introduction:

Agriculture, a cornerstone of economies worldwide, relies on healthy crop yields. However, factors such as microbial infections and pests can severely impact crops, leading to yield losses and economic strain. Some of the low GDP countries where most of their population is fully dependent on agriculture for their livelihoods, disease prevention is crucial. AI and Deep Learning techniques provide a promising approach for automated plant disease identification, offering farmers faster, more accurate diagnoses without manual intervention. This research aims to focus on a CNN-based framework for plant disease detection and survival estimation, aimed at enhancing yield quality and productivity by early and accurate disease detection.

Related Work:

The CNN-based approach has shown success across various studies in plant disease classification. For instance, Tugrul et al. [1] (2022) developed a GA-CNN hybrid model for tomato disease recognition that achieved promising results on a dataset of 500 images, effectively capturing the visual characteristics of four disease types. Similarly, Yu et al. [2] (2022) used LeNet, a lightweight CNN model, to classify diseases in soybean leaves, achieving an accuracy of 98.44% on 13,842 images from the PlantVillage benchmark dataset. This outcome underscores CNN's effectiveness in plant disease classification, even when using a relatively simple architecture.

Other studies further validate CNN's utility in identifying various plant diseases. Sladojevic et al. [3] (2016) utilized the Caffe framework to identify 13 plant illnesses from leaf images, achieving an accuracy range between 91% and 98%. Additionally, He et al. [4] (2020) proposed a two-stage detection approach for diseases in plants like olives and sugar beets, achieving high accuracy by combining regional CNN-based models (e.g., R-CNN and SSD) with VGG-16 and Inception-V3 architectures. This two-stage approach offered superior accuracy and time efficiency when compared to traditional methods.

In addition to CNN-based methods, researchers have also explored transfer learning and colour segmentation for plant disease detection. For instance, Alshammari et al. [5] (2022) improved CNN accuracy on an olive disease dataset by utilizing data augmentation, enhancing the model's performance from 88% to 95%. Colour-based segmentation methods, such as those proposed by Siddiqua et al. [6] (2022), segment images by analysing red, green, and blue colour components, which aids in identifying infected areas, especially in crops where colour differences are diagnostic.

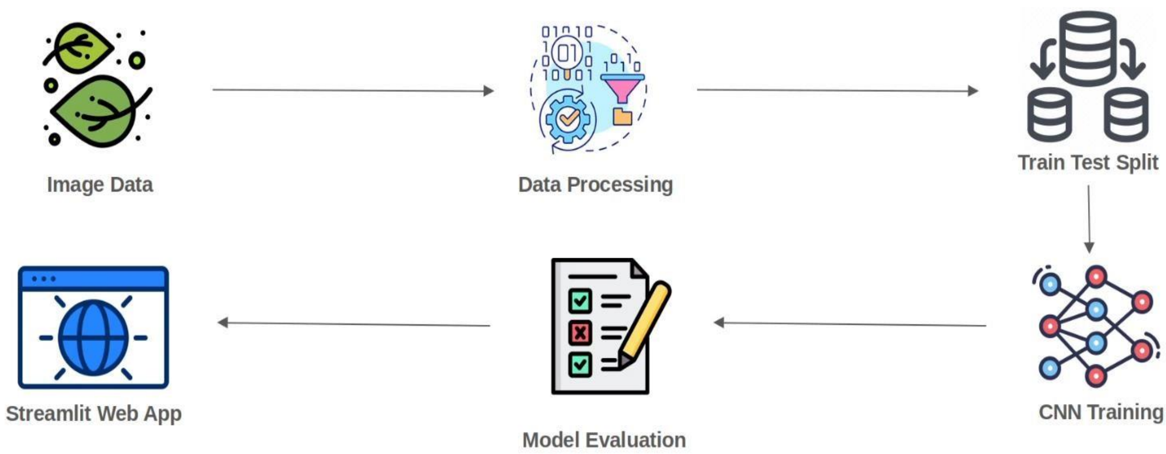
Plant Disease Image Classifier project, several studies have applied CNN-based models to the PlantVillage dataset, offering potential benchmarks for comparison. Multiple CNN Architectures like AlexNet that achieved the accuracy of about 97.5% followed by VGG16 with accuracy of 97.3% have been used.

DenseNet-121 and ResNet-50 also stand out, often reaching accuracies of over 98% for various leaf diseases, making them strong models for plant disease detection.

The proposed project will thus draw upon these techniques to develop a framework that uses CNN for visual feature extraction and providing a robust and accurate classification model.

Proposed Work:

The Workflow for the project is-
Step 1: Setup and Preprocessing of Dataset
Step 2: Proposed Model
Step 3: CNN Training
Step 4: Model Evaluation
Step 5: Streamlit Web Application (Uploading an image and the app will provide the prediction on the web application)



Dataset:

The proposed project will use the **PlantVillage** Dataset, a well-established, publicly available dataset widely used for plant disease identification research. The dataset contains thousands of labelled images of plant leaves, representing both healthy and diseased states for various crops.

PlantVillage Dataset
https://www.kaggle.com/datasets/abdallahalidev/plantvillage-dataset

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Evaluation:

In Comparative Analysis we have measured the accuracy and loss values for each crop type and Accuracy comes between 90% to 92%.

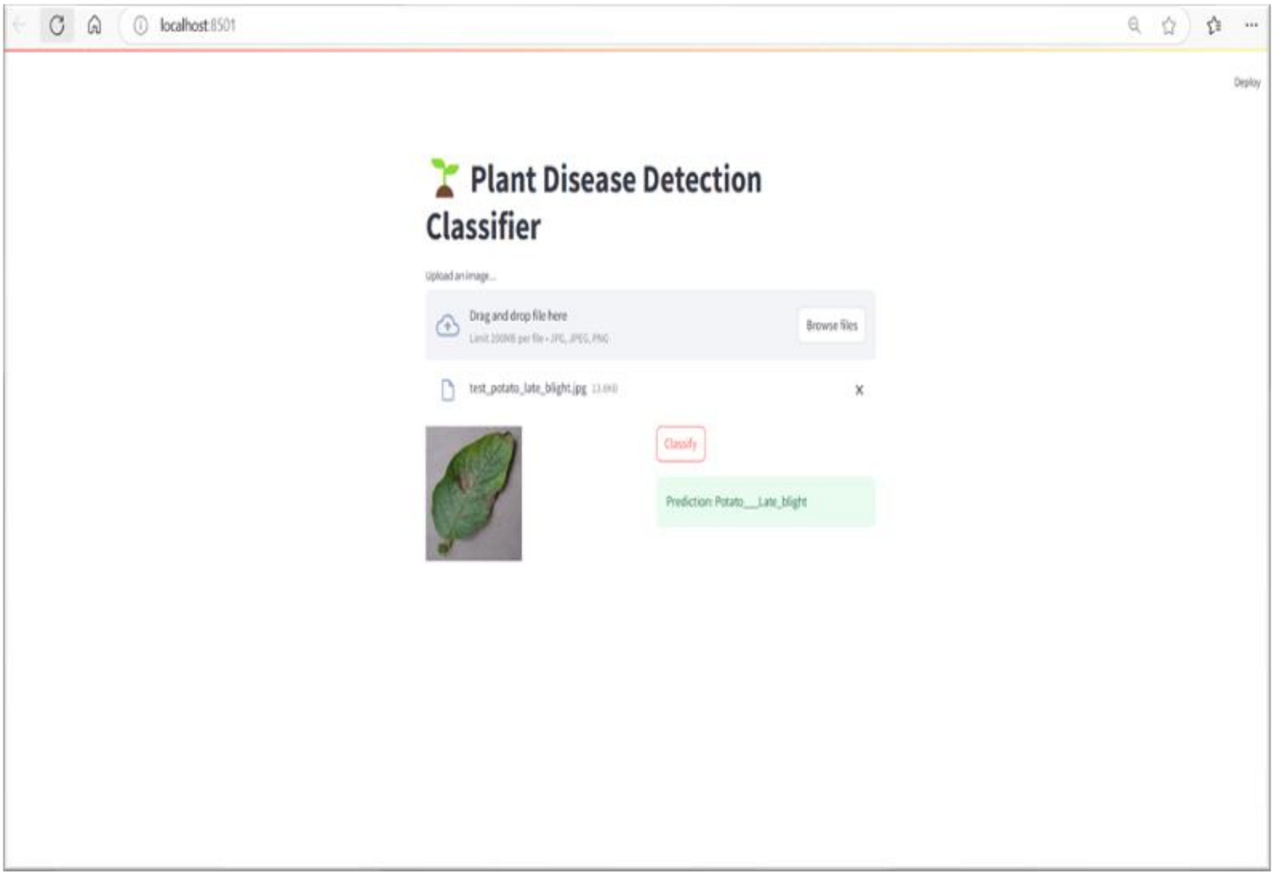
```
[ ] # Model Evaluation
    print("Evaluating model...")
    val_loss, val_accuracy = model.evaluate(validation_generator, steps=validation_generator.samples // batch_size)
    print(f"Validation Accuracy: {val_accuracy * 100:.2f}%")

    Evaluating model...
    339/339 ━━━━━━━━━━━━━━━━━━━━ 21s 63ms/step - accuracy: 0.9020 - loss: 0.5385
    Validation Accuracy: 90.32%
```

Plant Disease Detection Classifier App:

Plant Disease Detection App is created using Streamlit library in PyCharm. This will enable us to view the prediction in a more convenient manner.

Functionality- From the image it's clear that first we need to click on Browse Files and choose the test image for checking the prediction. As the image is visible, we need to click on the Classify button to check the prediction.



Conclusion:

This project aims to develop a comprehensive plant disease diagnostic framework using deep learning and plant leaf imagery. Key objectives include segmenting disease lesions on plant leaves, classifying the specific disease types, and predicting the plant's potential survival outcomes. By integrating this technology, farmers can receive timely health updates on their crops, reducing yield loss risks and supporting food security and will offer an efficient and scalable method for plant disease detection and survival prediction, with applications in precision agriculture.

GitHub Repository:

https://github.com/aashreyjain/DL_Project_Plant_Disease_Detection

References:

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