2112: Leaf Condition Analysis Using Image Processing Technique

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Abstract

Plants have always been playing a core role in human's life. However, just like any living organisms, plants will be infected by diseases and affect human's lifestyle. To solve this issue, this project develops a prototype that can assist users in identifying plant disease through a leaf image accurately and an evaluation on the models will be carried out to find out the most efficient model. In this project, a hybrid model between CNN and ViT will be experimented in this project. Before that, pre-processing stages on the PlantVillage dataset will be carried out and the effectiveness will be evaluated as well. From the findings of this project, it is shown that the PlantVillage dataset that is widely used by many researchers can indeed be improved further by applying pre-processing methods. The hybrid model used in this project has reached an accuracy of 97% to 98% and 24 seconds fast on a dataset that comprises over 2000 leaf images. The proposed hybrid model has also proven to be higher than some of the state-of-the-art models like ResNet. Although the proposed model may not reach the optimization as expected and can be improved further in the future, this project still provides many useful values like the evaluation on the pre-processing methods and also the suitability of an application's deployment.

Problem Statement & Objectives

Problem Statement:

- Unprocessed or wrongly processed dataset on the internet.
- Existing models' architectures are too complicated and unoptimized.
- Existing models' compatibility on real world is under-evaluated.

Objectives:

- To construct a clean image dataset and evaluate the effectiveness of image processing techniques on the existing leaf image dataset
- To develop a light-weighted image classification model that is able to determine the condition of a plant accurately.
- To analyze and evaluate the overall performance efficiency of the proposed classification model with other models and identify the models' usage of compatibility in the plantation fields.

Literature Review

Image Pre-processing:

- (Alruwaili et al., 2019) performed pre-processing stages such as noise accuracy, image enhancement, resizing and image quantization.

Image Augmentation:

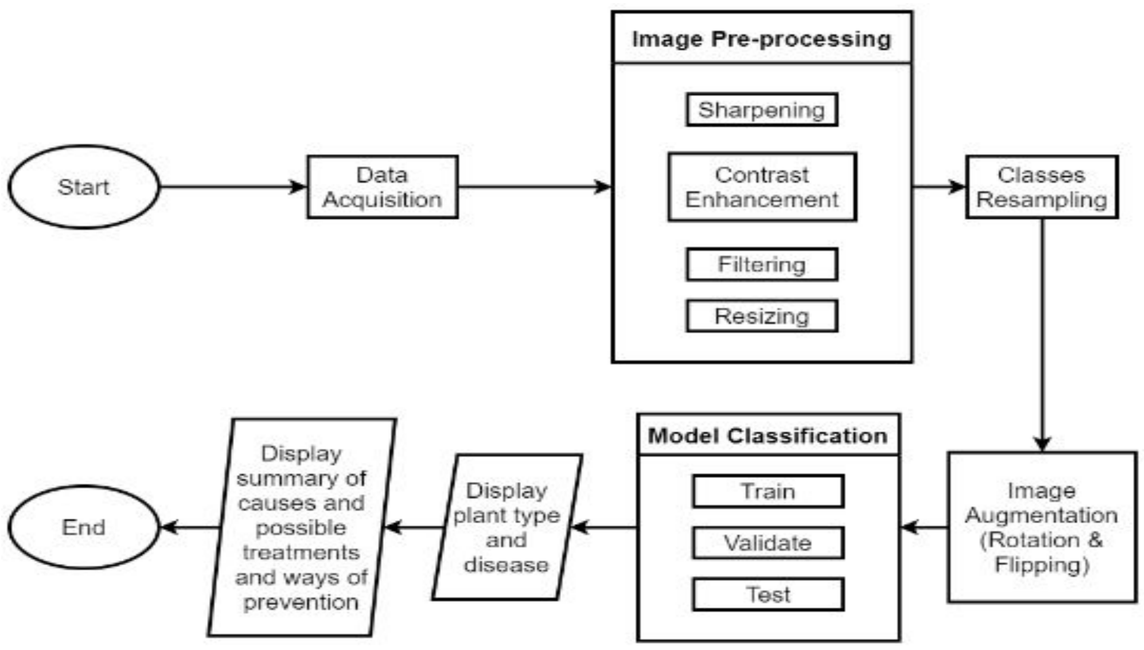
- (Nafi et al., 2020) proposed a GAN-based approach with a ResNet classifier to overcome class imbalance.

Classification Models:

- (Li et al., 2022) proposed a hybrid model between Vision Transformer (ViT) and Convolutional Neural Network (CNN) , they called it the ConvVit with 98.78% accuracy.

Research Methodology

General Flowchart:

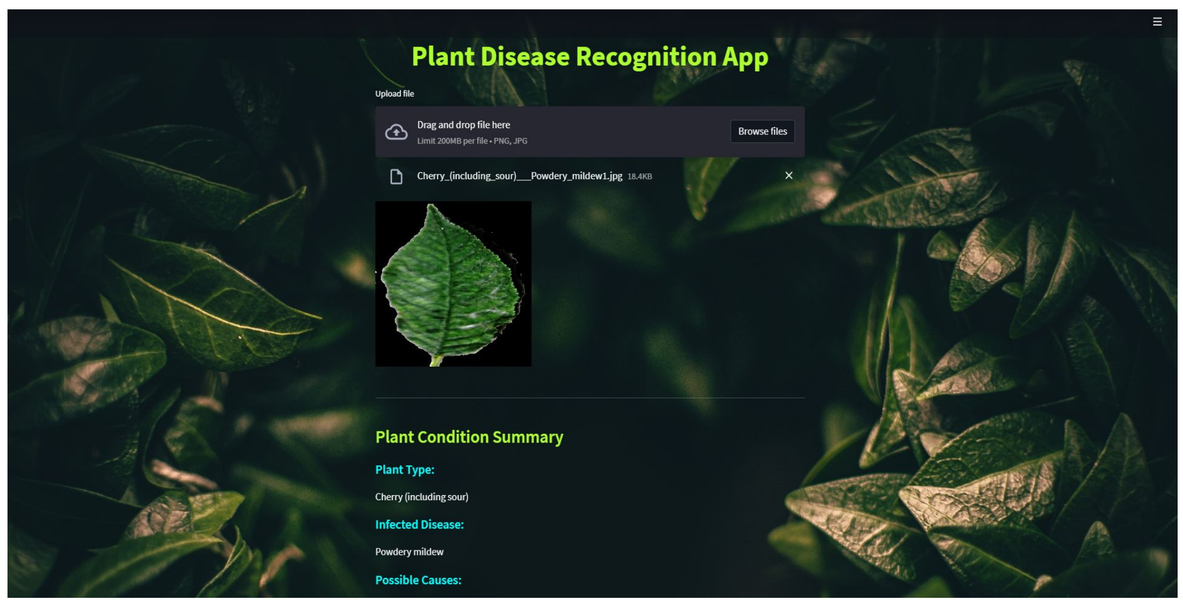


Model Classification (Hybrid):

1. CNN (Backbone): Convolutional layers for feature map extraction, pooling for spatial downsizing, batch normalization and ReLU activation function.
2. ViT (2nd layer processing + classifier): Patch + position embedding, transformer encoding, attention modules and MLP classifier.

Implementation & Evaluation

Real Time Web-Application Prototype:



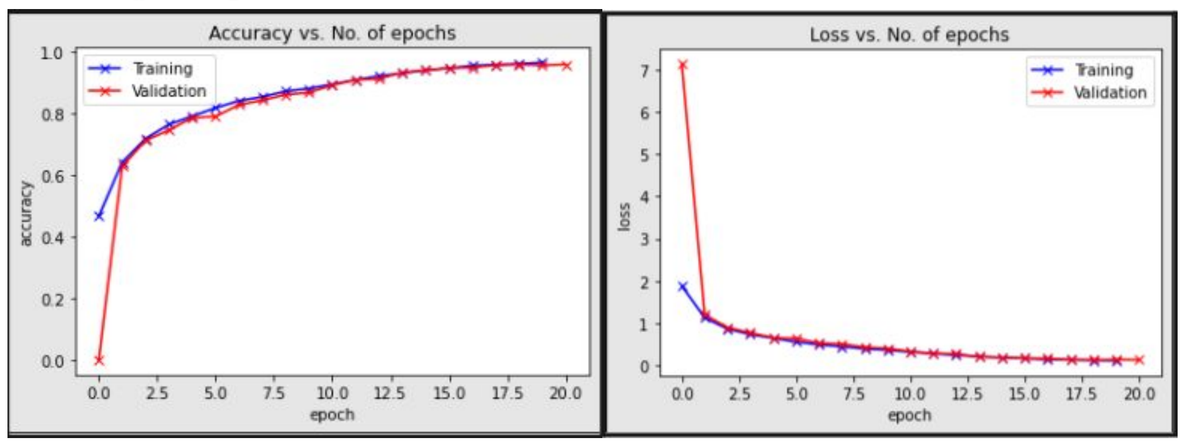
Preprocessing Method's Effectiveness Evaluation:

Dataset	Raw Original	Pre-processed	Augmented
Accuracy	89%±1%	92%±0.5%	93%±0.5%

State-of-the-Art Models Evaluation & Ablation Study:

Models (image size)	Accuracy (%)	Speed (Secs)	RAM Usage (12.7GB)
Hybrid CNN+ViT (550|50)	93.80 | 97.19	7 | 24	5 | 5.1
CNN (550|50)	93.44 | 97.24	5 | 23	3.3 | 4.7
ViT (550|50)	75.92 | 90.45	6 | 24	4.8 | 4.6
ResNet (550|50)	89.23 | NA	9 | NA	12.1 | 12.7

Training Graphs:



Conclusion

In summary, objective 1 is accomplished by implementing pre-processing methods on the PlantVillage dataset with effectiveness being evaluated. Next, objective 2 is also achieved by constructing a light-weight and accurate hybrid classification model that can reach 97.19% accuracy under 25 seconds on over 2000 testing images. Lastly, objective 3 is also fulfilled by performing comparative analysis with state-of-the-art model like ResNet and ablation study with the CNN and ViT standalone models. Hence, this project successfully provides some useful and informative insights on leaf disease recognition via image processing.

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