Plant Leaf Disease Detection using Convolutional Neural Network

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Problem Statement

Aims to find the best solution to the problem of Tomato, potato and bell pepper leaf disease detection using a deep learning approach. Several types of Tomato, potato and bell pepper diseases affect the crop at an alarming rate. We have to develop a Convolution Neural Network (CNN) based models deployed for Tomato, potato and bell pepper leaf disease classification.

Introduction

Tomatoes,potatoes and bell peppers are a versatile crop, widely used in the food industry, and highly nutritious. However, like any other crop, these are vulnerable to various diseases, which can cause significant losses in both quality and quantity. Early disease diagnosis and treatment are essential to mitigate these losses and protect farmers' livelihoods.

Objective

This study focuses on vegetable leaf disease classification using CNN (Convolutional Neural Network). The main objectives of this paper are:

- To identify the optimal set of features from the available dataset of vegetable leaf images for disease classification.
- To develop a CNN model using the identified optimal features to accurately classify tomato, potato and bell pepper leaf diseases.
- By facilitating early disease detection, the system aims to reduce the use of chemical treatments, promote sustainable agricultural practices, and minimize crop losses.

By addressing these objectives, the study aims to improve the accuracy and efficiency of leaf disease classification.

Literature Review

Authors and Year	Method	Advantages	Limitations
Afonso et al. (2019)	Deep learning methods for detecting blackleg diseased potato plants	- Use of deep convolutional neural networks (ResNet18) - Achieved high precision (95%) and recall (91%) for disease class	- Limited to blackleg disease detection - Potential challenges in generalizing to other potato diseases
Sharma et al. (2022)	CNN model for classifying rice and potato leaf diseases	- High accuracy in disease classification (99.58% for rice, 97.66% for potato) - Superior performance compared to other machine learning classifiers	- Dataset limited to specific diseases and crops - Potential challenges in generalizing to other plant diseases
Hari et al. (2019)	Plant Disease Detection Neural Network (PDDNN) for analyzing leaf images of different crops	- Utilization of a novel CNN model (PDDNN) - Improved performance and higher accuracy compared to Mobilenet 50 network	- Limited information provided on specific advantages and limitations
Archana et al. (2021)	Detection and classification of tomato leaf diseases using CNN	- High accuracy (99.66%) and low loss value with SGD optimizer - Effective utilization of the Kaggle-based tomato leaf dataset	- Limited comparison or discussion of other optimization algorithms - Limited discussion on generalization to other tomato varieties or diseases
Jiachun Liu et al. (2018)	Ten-layer CNN for classifying plant leaves	- Impressive overall accuracy (87.92%) - Automatic feature extraction capability of the CNN	- Limited discussion on specific advantages and limitations of the methodology

Research Gap

1. Limited dataset availability: One research gap in leaf disease detection is the scarcity of diverse and comprehensive datasets for training and evaluating disease detection models.
2. Variability in disease symptoms: The variability in disease symptoms across different plants, disease types, and environmental conditions presents a challenge in accurately identifying and classifying diseases based on visual cues.
3. Lack of real-time detection: Many existing methods focus on offline analysis, while real-time detection systems that can identify diseases as they develop are needed for timely intervention.

Methodology

- **Dataset:**

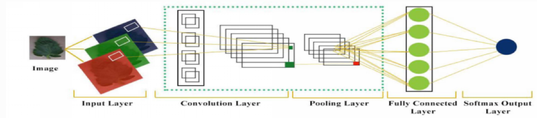
The research utilized the PlantVillage dataset, consisting of 54,000 labeled images of various crops. Among them, 20,639 images were of tomato, potato and bell pepper leaves, categorized into 15 classes representing diseased and healthy leaves. The dataset was divided into a validation set 15%, a test set 15%, and a training set 70%.

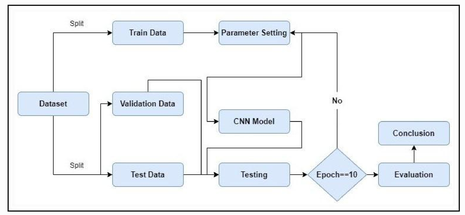
- **Proposed Work:**

The proposed research aims to utilize CNNs for the detection and classification of diseases affecting leaves. The dataset is divided into training and testing sets, with a separate validation subset within the testing set. The model is trained using the training data and its hyperparameters are fine-tuned using the validation data. The model's performance is evaluated using the test data to assess its effectiveness.

- **Experimental Setting:**

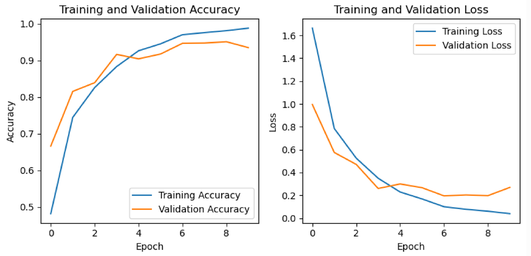
Python programming language and a number of libraries, including as TensorFlow, Keras, and OpenCV, are used to create the proposed CNN model for detecting leaf illnesses in potato plants. An i7-6800 processor running at 3.4 GHz, a 2 GB NVIDIA GeForce GPU, and 16 GB of RAM power the computer system used to run the model. A learning rate of 0.001 and a batch size of 32 are used throughout the course of 10 epochs to train the model using the Adaptive Moment Estimation optimizer. A training set, a validation set, and a testing set, each with relative proportions of 70%, 15%, and 15%, are created from the collection of potato leaf pictures.

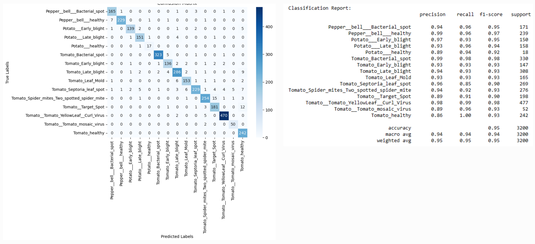




Result

The proposed CNN model for classifying tomato leaf diseases was evaluated using multiple metrics, primarily focusing on classification accuracy. Additional measures such as recall, precision, and F1-score were also used to assess the model's performance. These evaluation metrics collectively provided a comprehensive evaluation of the model's effectiveness in detecting and classifying tomato leaf diseases.





Classification Report:

	precision	recall	f1-score	support
Pepper__bell___Bacterial_spot	0.94	0.96	0.95	171
Pepper__bell___healthy	0.99	0.96	0.97	219
Potato___Early_blight	0.97	0.93	0.95	150
Potato___Late_blight	0.93	0.96	0.94	158
Potato___healthy	0.89	0.94	0.92	18
Tomato_Bacterial_spot	0.99	0.98	0.98	338
Tomato_Early_blight	0.93	0.93	0.93	147
Tomato_Late_blight	0.94	0.93	0.93	306
Tomato_Leaf_Mold	0.96	0.93	0.95	180
Tomato_Septoria_leaf_spot	0.96	0.95	0.96	269
Tomato_Spider_mites_Two_spotted_spider_mite	0.94	0.92	0.93	276
Tomato__Target_Spot	0.89	0.91	0.90	198
Tomato__Tomato_YellowLeaf__Curl_Virus	0.98	0.99	0.98	477
Tomato__Tomato_mosaic_virus	0.89	0.96	0.93	52
Tomato_healthy	0.86	1.00	0.93	242
accuracy			0.95	3200
macro avg	0.94	0.94	0.94	3200
weighted avg	0.95	0.95	0.95	3200

Conclusion

The research highlights the importance of detecting crop diseases in the Indian agricultural sector. The proposed CNN model shows promising results in classifying tomato, potato and bell pepper leaf diseases. Data augmentation techniques contribute to the model's robustness and accuracy. Further experimentation with optimization methods and architectures can enhance the model's performance. Additionally, parameter tuning holds potential for reducing training time. The model's versatility extends beyond tomatoes to other plants like Apples, Potatoes, Cucumber, and Brinjal, providing a comprehensive solution for disease detection in agriculture.