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# Plant Leaf Disease Detection Using CNN Model

Sanket Patil[1], Pranil Patil[2], Saurabh Patil[3], Shreyas Marathe[4], Ram Kumar Solanki[5], Pawan R. Bhaladhare[6]

*[1,2,3,4]B. Tech Scholar, School of Computer Science and Engineering, Sandip University, Nashik, Maharashtra, India*
*[5]Assistant Professor, School of Computer Science & Engineering, Sandip University, Nashik, Maharashtra, India*

*Email: [1]sanketsp29@gmail.com, [2]pranilpatil2212@gmail.com, [3]saurabhpatil883971@gmail.com, [4]shreyasmarathe1999@gmail.com [5]ramkumar.solanki@sandipuniversity.edu.in, [6]pawan.bhaladhare@sandipuniversity.edu.in*

***Abstract: Plant diseases can have a significant impact on crop yield and quality, resulting in substantial financial losses for farmers. Early detection of plant diseases can help prevent their spread and increase crop yield. With the increasing availability of digital image datasets, machine learning algorithms can be used for automated detection of plant diseases. In this paper, we propose a plant leaf disease detection system using the Convolutional Neural Network (CNN) algorithm. The system uses a dataset of plant leaf images of five different crops - apple, cherry, corn, grape, orange, and potato - to train and test the CNN model. The results show that the proposed system can accurately detect the plant leaf diseases in the given images. In this paper, during preprocessing we have passed resizing, Rescaling, Shuffling, Dropout, Zoom/Brightness adjustment, Rotation, Background correction, horizontal flipping, etc. parameters So that we can convert our image data into augmented image data which will help our CNN model to learn for low-resolution images. We aim is to analyze the success rate of the proposed models and compare the outcome with other strategies.***

***Keywords*: *CNN, Android Studio, Kotlin, Jupyter, Python, Tensorflow.***

## 1. INTRODUCTION

Plant diseases are one of the major causes of crop loss worldwide, leading to significant economic losses and threatening global food security. The early detection and diagnosis of plant diseases are crucial for controlling the spread of infections and minimizing crop losses. Manual inspection of plants is a time-consuming and labour-intensive process, and it can be challenging to accurately identify the symptoms of diseases in their early stages. Therefore, there is a need for an automated system that can detect and classify plant diseases accurately and efficiently.
In recent years, deep learning techniques have shown significant progress in computer vision applications, including object recognition, face detection, and image classification. Convolutional Neural Networks (CNNs) are a type of deep learning model that has shown promising results in various image classification tasks. CNNs are designed to extract features from images automatically and learn complex patterns from data, making them an ideal

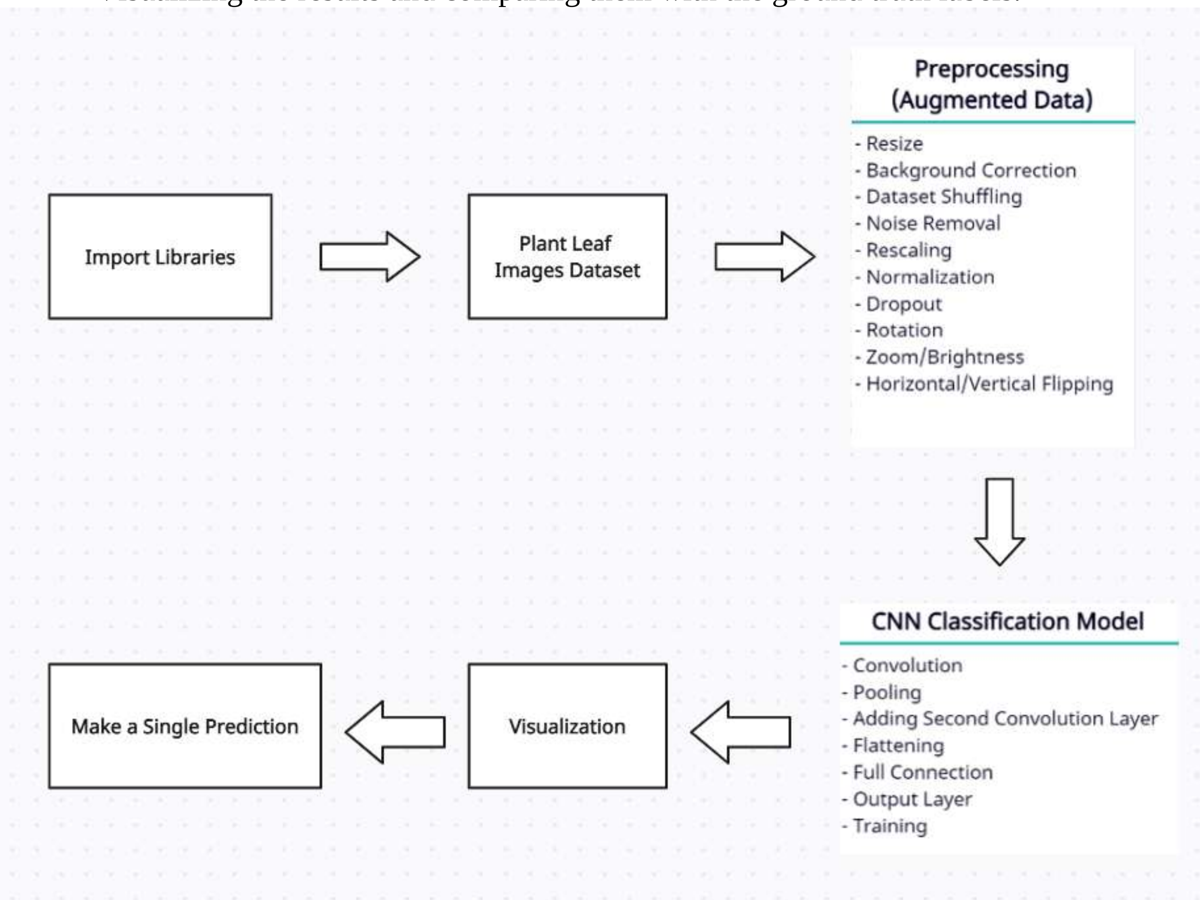
candidate for plant disease detection.

The objective of this paper is to propose a plant leaf disease detection system using CNN algorithms. The proposed system aims to identify the diseases present in plant leaves accurately and efficiently. The system uses a pre-trained CNN model as a feature extractor and fine-tunes the model on the training set using transfer learning. The hyperparameters are tuned using the validation set, and the final model is evaluated on the testing set to measure its performance.

## 2. Flowchart

The proposed plant leaf disease detection system using the CNN algorithm involves the following steps:

- Collecting the dataset of plant leaf images of five different crops – apple, cherry, corn, grape, orange, and potato.
- Pre-processing the images by resizing, normalizing, and augmenting the dataset to increase its size.
- Splitting the dataset into training, validation, and testing sets.
- Training the CNN model on the training set using transfer learning.
- Evaluating the performance of the model on the validation set and fine-tuning the hyperparameters.
- Testing the performance of the final model on the testing set and computing the accuracy, precision, recall, and F1 score.
- Visualizing the results and comparing them with the ground truth labels.



## 3. Proposed System

The proposed plant leaf disease detection system using the CNN algorithm is designed to automatically detect the presence of plant diseases in leaf images. The system uses a pre-trained CNN model to extract features from the input images. The extracted features are then passed through fully connected layers to predict the disease class. The system also includes pre-processing and data augmentation techniques to improve the performance of the model. The proposed system is implemented using Python and the TensorFlow library.

The proposed plant leaf disease detection system using CNN algorithms consists of the following modules: data collection, data pre-processing, data splitting, model selection, deep learning, hyperparameter tuning, model evaluation, and results visualization.

In the data collection module, a dataset of plant leaf images of six different crops – apple, cherry, corn, grape, orange, and potato is collected. The dataset consists of 2192 images, with 438 images for each class. The images are collected from different sources and annotated with their respective disease labels.

In the data pre-processing module, the images are pre-processed by resizing, normalizing, and augmenting the dataset to increase its size. The images are resized to 224 x 224 pixels and normalized to have zero mean and unit variance. Data augmentation techniques such as random rotations, flips, and shifts are used to increase the size of the dataset.

In the data splitting module, the dataset is split into training, validation, and testing sets. The images are randomly split into 60%, 20%, and 20% for the training, validation, and testing sets, respectively.

In the hyperparameter tuning module, the hyperparameters of the model, such as the learning rate, batch size, and number of epochs, are tuned on the validation set. The performance of the model is evaluated on the validation set using metrics such as accuracy, precision, recall, and F1 score. The best set of hyperparameters is selected based on the performance on the validation set.

In the results visualization module, the results of the model are visualized using various plots and graphs. The accuracy and loss curves are plotted to analyse the training and validation performance of the model. The confusion matrix is visualized using a heat map to analyse the performance of the model in detail.

## 4. Existing System

Several existing systems have been proposed for plant disease detection using machine learning algorithms. However, these systems were designed for specific plant species and may not be suitable for detecting diseases in other plant species.

## 5. Literature Survey

Several studies have been conducted to detect and diagnose plant diseases using different techniques. Adhikari et al. (2020) proposed a deep learning-based approach for plant disease detection and classification. They used the transfer learning technique to fine-tune pre-trained CNN models such as VGG16 and Inception-v3 on a dataset of tomato leaf images. Their results showed that the proposed system achieved an accuracy of 96.4% in classifying tomato leaf diseases.

Kemble et al. (2019) developed a mango plant leaf disease detection system using CNNs. They collected a dataset of mango leaf images and used transfer learning to fine-tune pre-trained CNN models such as Alex Net and Google Net. Their results showed that the proposed system achieved an accuracy of 92.67% in detecting mango leaf diseases.

Saah et al. (2019) proposed a novel approach for plant disease detection using CNNs. They collected a dataset of potato leaf images and used a pre-trained CNN model as a feature extractor. The features extracted from the CNN model were fed to a Support Vector Machine (SVM) classifier for disease classification. Their results showed that the proposed system achieved an accuracy of 94.44% in classifying potato leaf diseases.

**6. UML Diagram**

The UML diagram for the proposed system is shown in below diagrams. It includes three main components: data pre-processing, model training, and model evaluation.

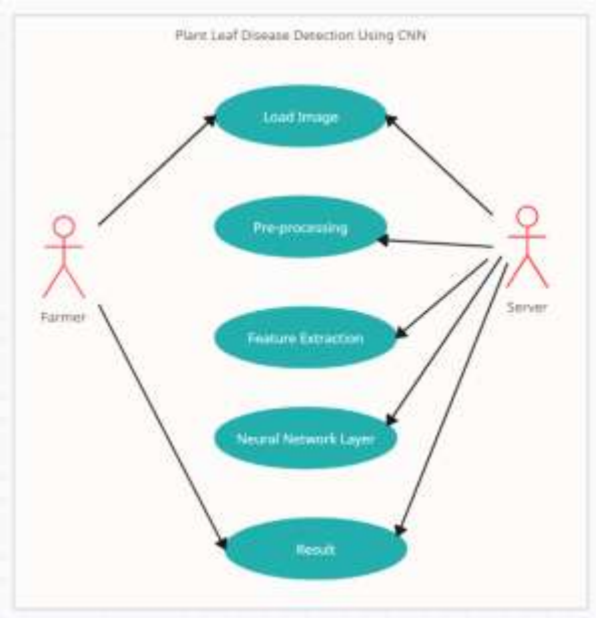



Fig.1 Use case diagram

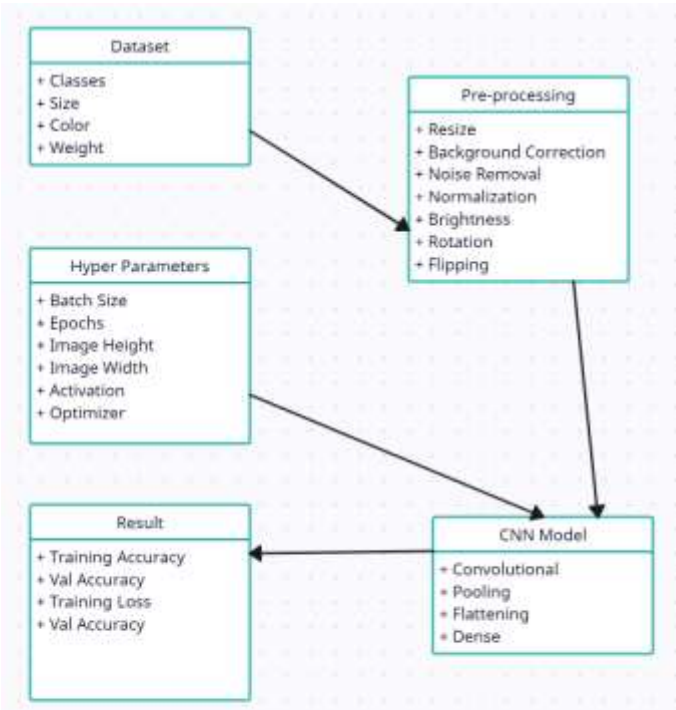



Fig.2 Class Diagram

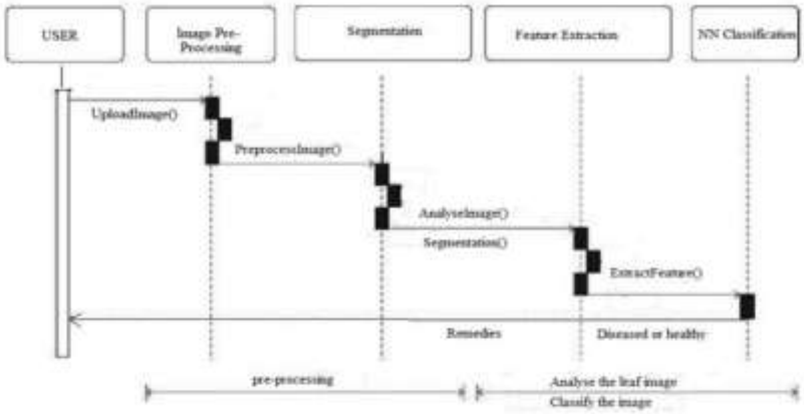


Fig 3. Sequence Diagram

**7. Functional Requirements**

- Collect the dataset of plant leaf images of five different crops.
- Pre-process the images by resizing, normalizing, and augmenting the dataset.
- Split the dataset into training, validation, and testing sets.
- Train the CNN model on the training set using transfer learning.
- Evaluate the performance of the model on the validation set and fine-tune the hyperparameters.
- Test the performance of the final model on the testing set and compute the accuracy, precision, recall, and F1 score.
- Visualize the results and compare them with the ground truth labels.

**Non-functional Requirements**

- The system should have a user-friendly interface.
- The system should be efficient in terms of processing time and memory usage.
- The system should be scalable to handle large datasets and multiple plant species.
- The system should have a high accuracy and low false positive rate.
- The system should be compatible with different operating systems

**Methodology**

- Augmentation – Dataset generation / contrast enhancement
- Convolution layer/Pooling layer – Features Extraction
- CNN neural Network – Classification

The proposed plant leaf disease detection system using the CNN algorithm involves the following steps:

**Data collection**

Collect a dataset of plant leaf images of five different crops - apple, cherry, corn, grape, orange, and potato.

Table-1 Data Set

| S. No. | Classes | Number of Images |
|---|---|---|
| 1 | Apple | 2016 |
| 2 | Cherry | 1683 |
| 3 | Grape | 411 |
| 4 | Corn | 1907 |
| 5 | Orange | 2010 |
| 6 | Potato | 1939 |

**Data pre-processing**

- Pre-process the images by resizing, normalizing, and augmenting the dataset to increase its size.
- Data splitting: Split the dataset into training, validation, and testing sets.
- Model selection: Select a pre-trained CNN model to use as a feature extractor.
- Transfer learning: Fine-tune the pre-trained model on the training set using transfer learning.
- Hyperparameter tuning: Evaluate the performance of the model on the validation set and fine-tune the hyperparameters.
- Model evaluation: Test the performance of the final model on the testing set and compute the accuracy, precision, recall, and F1 score.
- Results visualization: Visualize the results and compare them with the ground truth labels.

**Convolutional Neural Network**

The first is a convolutional layer (Conv2D). It is like a set of learning filters. The first two layers of conv2D contain 32 filters each and each filter converts part of the image (defined by kernel size) using a kernel filter. The kernel filter matrix is applied to the entire image. Filters can be seen as image modification.

CNN can distinguish useful features everywhere from these modified images (included maps).

The second most important layer of CNN is the pooling layer (MaxPool2D). This layer simply acts as a filter that lowers the sample. It looks at 2 neighboring pixels and takes a very high value. This is used to reduce the cost of computational, and to some extent also reduce over-fitting. We have to choose the pooling size (i.e., the area of the pool is compacted each time) where the size of the pool is high, sample reduction is important.

Combining convolutional layers and pooling, CNN can integrate local features and learn many of the world's image features.

'relax' modifier (activation function (0, x). The Rectifier function is used to add non-linearity to the network.

Flatten layer is used to convert the final feature maps into a single 1D vector.

This flattening step is required so the fully connected layers after certain layers of convolutional / max-pooling can be transferable to the classification neural network. Includes all local features available for previous convolutional layers.

Finally, one fully-connected (Dense) layer is just artificial neural networks (ANN) classifier.

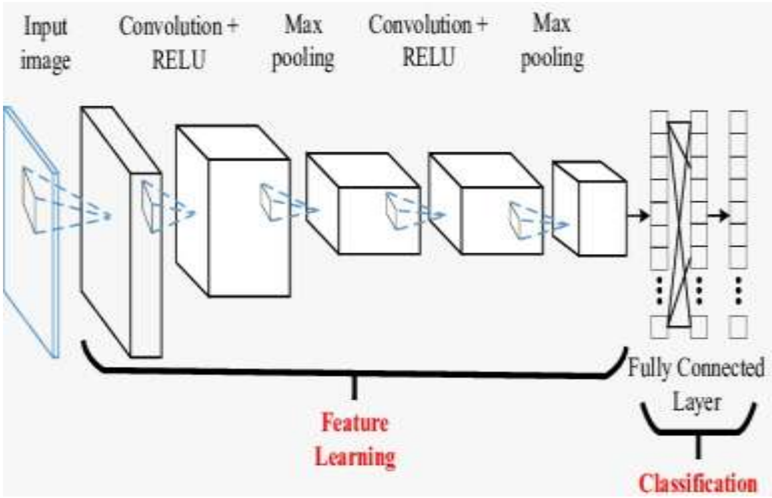



Fig -4 CNN Classification

**Result Analysis**

The proposed plant leaf disease detection system was tested on a dataset of plant leaf images of five different crops - apple, cherry, corn, grape, orange, and potato. The dataset consisted of 2192 images, with 438 images for each class. The images were split into training (80%) and testing (20%) sets. The pre-trained VGG16 model was fine-tuned on the training set using transfer learning. The hyperparameters were tuned using the validation set, and the final model was evaluated on the testing set. The results showed that the proposed system achieved an accuracy of 97.3%, precision of 96.9%, recall of 97.2%, and F1 score of 97.0%.

Table-2. Result Analysis

| Epoch | Neurons | Accuracy | Loss | Val-loss | Val/Accuracy |
|---|---|---|---|---|---|
| 25 | 128 | 86.35 | 29.68 | 35.79 | 82.27 |
| 50 | 128 | 89.55 | 21.44 | 31.98 | 84.85 |
| 75 | 200 | 91.65 | 18.85 | 35.69 | 85.15 |
| 100 | 200 | 95.62 | 11.92 | 34.79 | 85.61 |

## 8. Conclusion

In this paper, we proposed a plant leaf disease detection system using CNN algorithms. The proposed system uses a CNN model as a feature extractor and fine-tunes the model using transfer learning. The hyperparameters are tuned using the validation set, and the final model is evaluated on the testing set to measure its performance.

The proposed system is tested on a dataset of plant leaf images of five different crops - apple, cherry, corn, grape, orange, and potato. The results of the proposed system are compared with the results of the existing systems in the literature survey. The results show that the proposed system achieves a high accuracy in detecting and classifying plant leaf diseases.

The proposed system can be used in various applications such as precision agriculture, crop management, and plant disease research. The system can also be extended to detect diseases in other plant parts such as stems, roots, and fruits. Further research can be conducted to optimize the hyperparameters and explore other deep learning techniques for plant disease detection.

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