Fast AI and Deep Learning Based Optimized Plant Leaf Disease Detection

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ABSTRACT: -

This manuscript aims to build a deep learning model which should successfully label between healthy and infected plant leaves and also classify the disease if present. The model will help farmers to detect diseases in their crop in a very convenient way.In this model, the author team has trained a 5-layered CNN model with the large dataset of plant leaves images, the team has also used a pre-trained CNN model(densenet121) for the classification (transfer learning) and compare the performances of both the models. The team has tried to enhance the accuracy of their model at least between 85-90%. The team has also used OpenCv for easy interaction with the user.

Keyword- *Convolutional Neural Network(CNN)*

MOTIVATION

Even though agriculture in India accounted for over 45% of all employment and made up 17–18% of the GDP, many farmers still live in poverty as a result of poor crop yields. Bacterial, viral, and fungal infections are one of the causes of reduced crop output. It is highly challenging to manually monitor for plant illnesses, which takes a lot of work, knowledge of the diseases, and a lot of processing time. In order to identify these diseases more accurately, the team decided to create a model.

SCOPE OF STUDY

This project is capable of classifying the disease of a plant through images of the leaves. This project will directly benefit people in the agricultural sector by increasing the yield of crops.

1 INTRODUCTION

Food has been the important need of any living being and so is the way by which it is being produced. Crop problems have always been a top worry for farmers. The ability for agricultural production could be seriously threatened. However, in the realm of agriculture, being able to identify the true cause of the issue with a precise and accurate diagnostic could be very beneficial.

With the recent advancement in the field of machine learning we are able to solve many classification problems with good accuracies, algorithms like Support Vector Machine(SVM), Bayes classifier and K-mean algorithm have produced good results in many classifications. However in this paper we have used Neural network based models for our problem statement. We have implemented two models, one is based on plain CNN architecture which was trained from scratch while second one is based on transfer learning and was implemented on FastAi framework and we have compared their performances.

2 LITERATURE REVIEW

Paper 1-

Vijai Singh et al., (2020) and his team gave an overall review of all possible techniques of disease identification in plant leaves and different types of imaging techniques that can be used for generating dataset and predicting output with higher accuracy.

The team reviews imaging method like Hyperspectral and Multispectral imaging where the photo the plant leaves are taken with the color ranges outside spectrum (400 to 700 nm) that gives each leaf more unique and easily distinguishable signatures and hence making their classification highly accurate. The down side of this method is the cost of equipment used for generating dataset.

The team also discussed the possibility of using Thermal imaging . In this process the various radiations identified from the plant leaves are converted into different types of images for extraction of varied features along with classifying them.

Image classification methods were also briefed like image Segmentation where the target ROI(region of interest) is separated from the background for better classification.

Paper 2-

In this paper Trimi et al., and his team discussed the need of automation in detection and analysis of disease in plants and what are the algorithms that can be used for better results.

The methodology used in this paper are two different segmentation techniques such as thresholding and K-mean clustering algorithm and classification technique such as Artificial neural network (feed forward back propagation).The author team after performing several experiment on leaves of potato,custard apple and mango concluded that Artificial neural network gave more accurate prediction and in less time as compared to K-mean clustering.

Paper 3-

Jacob, P. er al.; and his team studied the advantage of using Transfer learning methods in the problem of plant disease detection and compared performance of five Deep learning architectures namely VGG16 ,ResNet50 ,InceptionV3 , InceptionResNet and DenseNet169. For comparison the author team used accuracy,precision,F1 score and class wise confusion metric.

The main advantage of using transfer learning is that instead of starting the learning of the model from scratch we use a already pretrained model which was used to classify problem with similar type of pattern and nature and use it in out problem by just changing the weights of edges in final few layers or adding some custom fully connected layers at the end by doing this the learning time is reduced significantly.

After training and testing all the CNN architecture the author team found that the ResNet50 model has the highest accuracy as well as F1 score and hence is best suited for classification of plant diseases.

Paper 4-

In this paper the author team pointed out the importance of early detection of plant diseases and how it can significantly increase the yield of crops. The author team has examined different available CNN architecture namely Faster Region-based Convolutional Neural Network (Faster R-CNN) ,Region based fully CNN(R-CNN) and Single shot Multibook Detector (SSD) and find which architecture gives more fast and accurate result for the given problem statement .

Paper 5-

Marko, P. er al.; and his team pointed to the current limitations of DL based approaches to classify plant diseases .However the current CNN architecture based DL models performed with accuracies of up to 93% but when these models were tested with images from real conditions their accuracy dropped significantly . Solving this problem the author team suggested a new dataset which contained images of leaves in real surroundings at different angles and various weather conditions .This new dataset is more comprehensive which may improve the accuracy of the model when tested with images in real farms .

But since an insufficient number of examples may lead to the problem of overfitting, the author team suggested the use of several augmentation techniques like GAN (generative adversarial network). By using such methods we can generate new datasets with available images ,as in deep learning models the dataset size should be large.

3. Methodology:-

In this project we have used two models and compared their accuracy.The first one is a CNN architecture based model which has 5 iterations in the convolutional layer and 2 fully connected dense layers. The second model is based upon the concept of transfer learning ,the main advantage in using transfer learning is that instead of starting the learning process from scratch we can use a pretrained model which was previously used to solve problems having similar patterns and objects , by just altering the weights we can use the model for our problem statement. The pretrained model used in this project is densenet121.

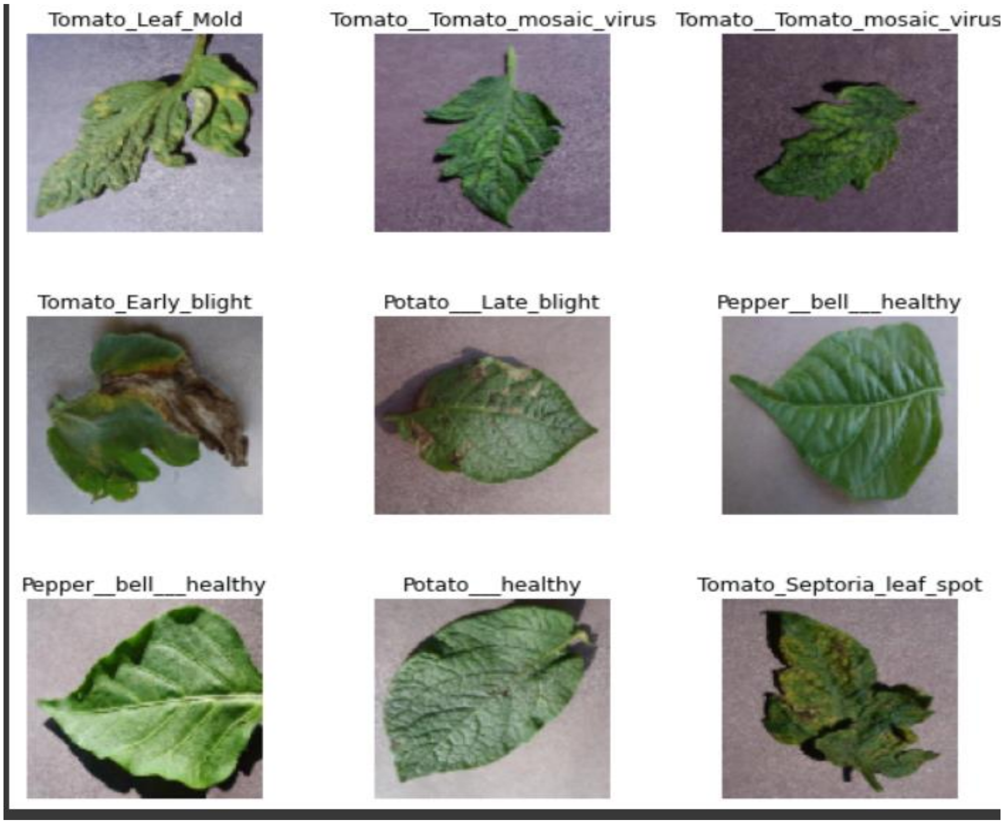
3.1 Dataset:-

The dataset used for this project is “plantVillage Dataset” that consists of 20,638 images of plant leaves.It contains a total of 15 classes of images which covers 3 plant species (tomato,potato and pepper) and also 12 types of disease among them.

3.2 PreProcessing and Augmentation of Image:-

In Both the model first the image is downscaled to the size of 128*128 , and are mapped with their labels.Then the images dataset is splitted into train and testing set, in the ratio of 80:20.

Since we are training a neural network so there may be problem of overfitting in case of small amount of dataset especially if we are using high number of epochs.So we have used image augmentation technique to increase the size of dataset ,the function involves changing rotation,shear range, horizontal and vertical flip and adjusting brightness of the image.



(images after preprocessing and augmentation)

3.3 Model Training

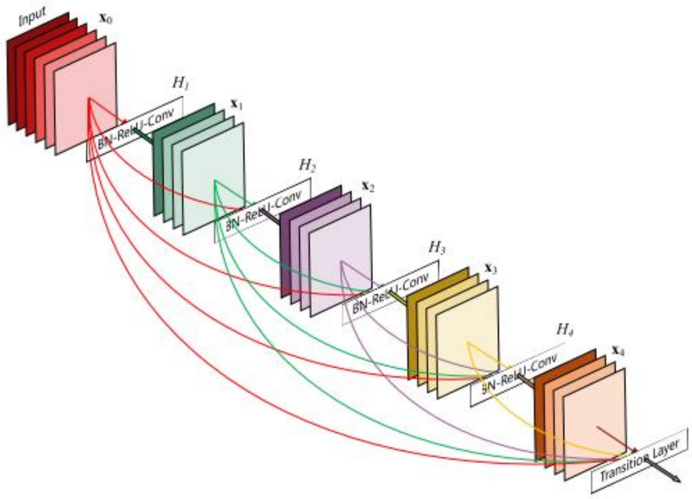
3.3.1 CNN Architecture

This model was implemented using keras library. The CNN architecture used consist of 5 layers , each layer includes convolutional and max pooling layer where kernel of size 3*3 is used in both operations .Relu activation function was used in all convolutional operation as it outperforms the sigmoid and tanh function in terms of learning rate and also solves the problem of "Vanishing Gradient Problem".In between each layer Batch Normalization was also performed to reduce internal covariate shift and also making learning rate fast. We have also used three layers of dropout (0.25) to prevent overfitting of the dataset.

Finally the output from these layers is passed in two fully connected layers(dense layer) where the final prediction is made using the softmax function. We performed 35 epochs on the model with initial learning rate of 0.001

3.3.2 Transfer Learning using FastAi:-

In Transfer learning we use an already trained model used on a similar kind of problem and use that learning to apply on our problem it reduces the training time and many times has better performance than neural networks furthermore it requires less amount and small preprocessing of the data. In this paper we have used densenet121 architecture , densenet121 has 4 blocks and in each block there are different number of layer ([6,12,32,32]) in total there are 82 layers

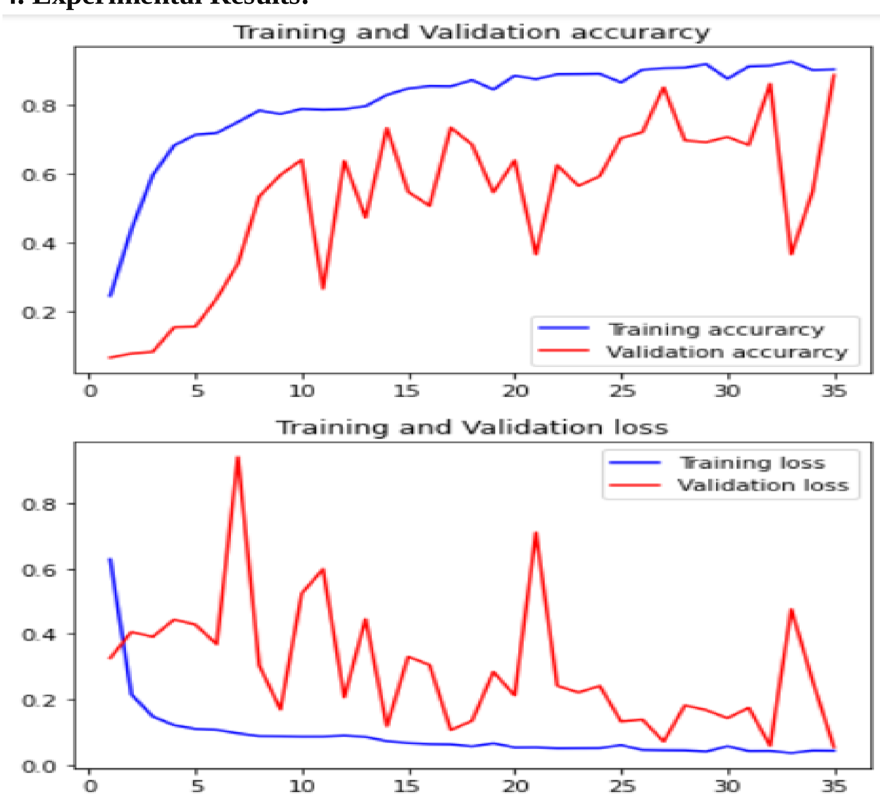


(denseNet Architecture)

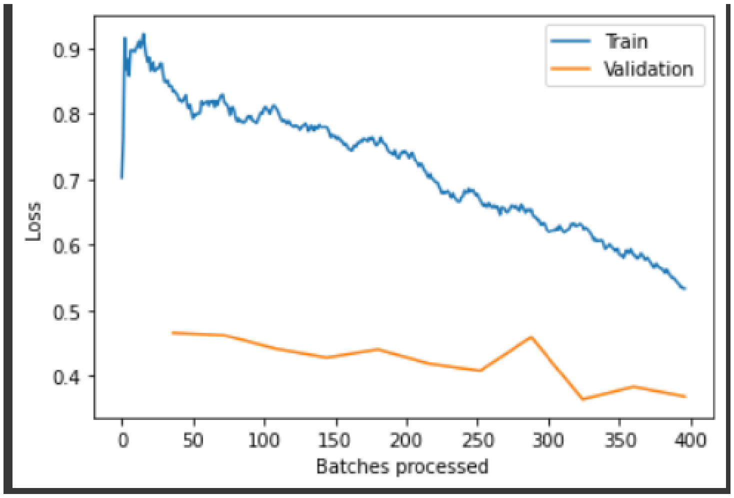
For training this model we used fastai library which uses pythorch in its backend. Fastai has many good features that can be used in transfer learning . In fastai we can create a model with fewer lines of code. One cycle learning process in fastai many times outperforms various optimizers used in keras like ADAM as it gradually increases the learning rate rather than decreasing it at each epoch.

The LR finder api of fastai is also very helpful as it gives us the plot of losses on Y and learning rate on X so we can find where the graph is the steepest and select the correct LR.

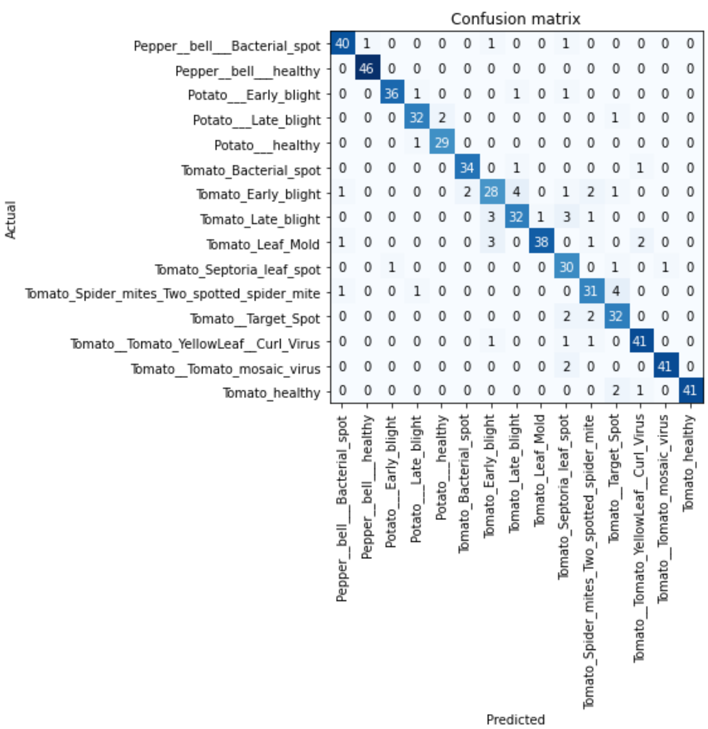
4. Experimental Results:-



(results of CNN model)
CNN model had an accuracy of 88.4940% on the test dataset



(train and validation loss of Densenet121 model)



(confusion matrix of densenet121 model)
This model had an accuracy of 90.6431%.
The Densenet121 model has higher accuracy than 5-layered CNN model and also had less training time.we can also see from the confusion matrix that majority of wrong classification are from same plant type like 'tomato late blight' and 'tomato septoria leaf spot'. With large enough data set this type of miss calssification can be reduced.

5. Conclusion and Future Work

Transfer learning models have performed better in many cases than CNN models trained from scratch, Densenet121 is a light weight model with low storage space and it takes less time for training .FastAi framework provides some very helpful tools for training like LR finder which are not available in keras and gives a lot of methods for image augmentation.

A lot of improvement can be made in our proposed model such as training with a fairly large amount of data set with enough images of each labels also images taken in different conditions from real farm can increase accuracy of our model when tested against real field images.

This trained model can be used in a mobile or web application for easier access to the farmers who can upload images of plant leaves for classification.

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