An Intelligent Approach to Detect Diseases of Tomato Plants from Its Leaf using Deep Learning Algorithms

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Abstract

Agriculture plays a major role in the growth and development of the country. But in the last few Years there is a drastic change in the production due to several kinds of plant diseases infecting on the crop. The main reasons for decreasing the crop production are due to lack of knowledge in identification of diseases. To add support to the farmers and overcoming the problem, we are going to develop an Automated model for identifying the plant diseases using the images of the plant leaves. Many of the Existing Models worked on the Manual Segmentation and some of them are using existing Deep Learning models. Manual Segmentation of images is a time taking process and there is a chance of errors to overcome this manual segmentation we are going to propose an automatic leaf disease identification Using the Deep Learning Models, we are going to construct a new Plant Leaf Detection Model based on the accuracy of the existing models when they trained on the tomato leaf images by changing the desired image size of the prescribed Model. Due tothis automated plant leaf disease detection, we can detect the disease at early stage so that we can take necessary measures to prevent. It will help Farmers and Agriculture Sector a lot in increasing their crop production. In order to solve this problem, we try to use some deep learning models like ResNet50, ResNet101, ResNet152V2 and inceptionV3 with the help of Transfer Learning. We conducted experiments on these models by using dataset that comprises of different kinds of diseased tomato leaf images for identifying which model is going to perform better in identification of disease. After conducting experiments ResNet50, ResNet101, ResNet152V2 and InceptionV3 has got 48.35%, 90.02%, 95.08%, 84.33%. we found that ResNet152V2 gives better accuracy when compared to other models.

Keywords: *Tomato Leaf Disease Detection, Farmers, Deep Learning Models, Disease Detection, Automated Model*

1. Introduction

The main and most important thing of a Living and Non-Living Organisms is plants, without plants every organism has to struggle for its food and growth because everything in the society that is always going to be interrelated with plants. Plants not only helps in the growth of the ecosystem but also plays a major role in the economy and livelihood of any creature. When comes to production last few years there is huge loss in the production and livelihood of the plants due to several kinds of diseases are impacting on plants[1]. But when comes to identification of the disease there is no such methodology or procedure that is going to identify the disease at the early stage of the plant life. Due to this lack of facility for identification of disease at early stage many of the plants are infecting with diseases this leads to huge loss for the farmers. To support farmers many of the researchers and corporate companies have done a lot of research for identification of the plant disease at early stages so that it will give us better yield and great support to the farmers [2].

But over the last few years there had been drastic decrease in the growth of the plants due to several unknown diseases are impacted on different parts of leaves like leaves, stem, roots [3] etc. Farmers are really struggling to identify disease at early stages due to this reason there is decrease in the growth of the production. Formers had less support in identifying the disease that impacted on the leaves since they are going to visit specialists once in a while due to this, they are suffering from less crop production. For this reasons agriculture has become a major area/field for research since there are lot of problems in the agriculture sector and these problems needs to answered for these reasons many researchers and engineering graduates are performing lot of project works and researches are going around. Among those this research is also going to help the farmers in identification of the tomato leaf disease [4].

After careful observation and studying of various research methods proposed [5] and work done by different researchers helped in making a clear view of tasks and problems that need to be solved. The work done by different researchers also helps in understanding what are the gaps that are needed to be filled by doing this project [6] and what are the changes that we have to make so that this proposed system is going to identify tomato plant disease better than the existing models. Taking all the aspects and views into consideration a new architecture and methodology is going to be proposed for better identification of disease in tomato leaves.

Tomato is one of the finest vegetables which has huge demand in the market due to this high demand whenever a sudden damage occurs in the plant production the prices of this tomato plant is going to be raised. Tomato plants has been infecting with several kinds of diseases. Each and every disease has some specific characteristics which can’t be visible to our naked eyes. Most of the diseases are going to be implanted on the leaves. Here are some of the research papers that I have chosen to support my work [7] have done work on citrus leaves here they collected the images of citrus leaves for identification of the disease here the author has developed a methodology by using images of the citrus leaves.[8] had also done work on detection of plant disease through Support Vector Machine using image Processing. By studying all these papers, we found that image processing [9] is one of the best ways to implement. Also found that there is less research work done by using deep learning methodology.

The main aim and objectives of this research is to identify the tomato leaf disease by using deep learning models by considering the resolution of the images also. Apart from the identification our main aim is to get best accuracy in identification of the disease. After careful implementation one of the best transfer learning models which has highest accuracy is going to be selected. By making changes in the image size of high accurate transfer learning model. from the accuracies obtained the model with high accuracy is going to identify whether the tomato plant leaf is infected or not.

2. Related Works

Literature review was conducted to identify the existing methods with tomato leaf diseases. Brief summary of those works was presented below.

Guan Wang *et al*. (2017) [10] proposed an automatic image-based plant disease severity estimation to improve the identification of severity level in plants. The plant diseases will be detected here by using the Deep Convolutional Neural Network. The author proposed an automatic image-based plant disease severity estimation and overcomes all the issues by Deep Convolutional Neural Network and the methods like VGG16, VGG19, ResNet50. The resultant of this methodology is an accurate automatic image-based plant disease severity estimation which helps to improve the severity level in the plants. And VGG16 has got the best accuracy of 90.4%. This system performs better than the various existing system.

Brahimi *et al*. (2018) [11] proposed a plant disease detection and saliency map visualisation to improve the better sight about the symptoms of plant diseases. The model proposed here overcome all the issues by using Convolutional Neural Network and the methods like Alex Net, DenseNet169, Inception_V3, ResNet34, Squeezenet1_1, VGG13. The resultant of this methodology was an accurate proposed a plant disease: detection and saliency map visualisation which helps to improve detection of the diseases in the plants. And Inception_V3 has got the best accuracy of 99.76%.

Apple leaf disease identification using Region-of- interest to improve the identification of the disease in the plant by Hee-Jin Yu *et al*, (2019) [12] developed an. The ROI feature map has included three areas of the plant and they are: Leaf area, Background, Spot area. The plant diseases will be detected here by using the Deep Convolutional Neural Network. ROI-aware DCNN has got the best accuracy of 84.3%.

Mohammad Ihsan Aquil *et al*, (2021) [13] designed an evaluation of scratch and pre-trained convolutional neural networks for the classification of tomato plant disease to improve the identification plant disease in tomato leaves. The plant diseases will be detected here by using the Deep Convolutional Neural Network.

A plant disease identification by using image processing to identify the plant disease proposed by Vagisha Sharma *et al.* [14] (2020). This helps in identifying the different types of diseases that plant is being affected and this helps in identifying the plant disease that plant is going through and shows how to predict the plant diseases. The proposed architecture is going to work with image based on those results. The proposed architecture applied Support Vector Machine Classifier to classify whether the image was infected or not.

Ashwini *et al.* [15] (2020), had devised a methodology using Support Vector Machine. The proposed methodology helped in identifying the plant disease at the early stages which will

helps in increasing the crop production. The author had classified the images based on the colour of the leaf images and the texture of the images by using all the edge detection techniques after the images is converted to grey scale images after the grey scale images are used for adaptive histogram equalization based on the shape, colour and texture the images are going to classify by the Support Vector Machine to identify whether the plant leaves were infected or not.

Pranesh Kulkarni *et al*. [16] 2020 developed a methodology of identification of plant disease in plants like Apple, Corn, Grapes, Potato, Tomato using machine learning and image processing. Here the author had converted into RGB images and these images are going to convert it into grey scale and then used gaussian filter for removing the noise from the images. Otsu thresholding algorithm for converting grey scale images to binary images. Here tomato plant had got an accuracy of 87%.

Rudresh dwivedi et al [17] 2021had designed a new methodology for identifying the grape leaf disease detection network by using faster R-CNN and also added a feature of multitask learning which helps in identifying esca, black-rot, isariopsis diseases. The author had started the process by using stacked Blocks of ResNet-18 for feature extraction. Here the author had obtained high accuracy of 99.1% but he mainly concentrated on three kinds of diseases like Black rot, esca, isariopsis.

Atharva Milgir et al [18] 2021 had proposed a methodology in identification of disease in the crops here the author had used inception v3 which is based on deep learning which helps in better identification of the disease. Apart from many researchers here the author is going to recommend what kind of medicine is required for the crop to overcome from the disease.

It was observed from the literature survey that Kera's models were given better results with plant leaf disease identification methods. Also, it is identified ResNet versions and InceptionV3 models were not used for the implementation of leaf disease detection. None of the papers in the literature used the concept of image resolution during the training and testing the model So, it was decided to conduct experiment with some keras models for tomato leaf disease identification through this paper by including the image resolution of the tomato leaves.

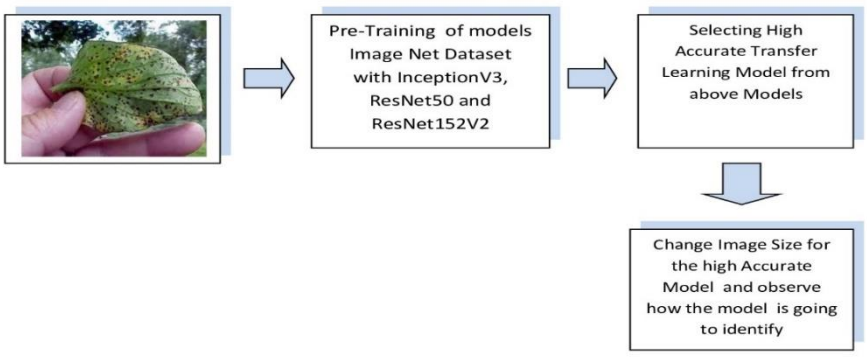


Figure 1. Block diagram of the proposed method

After careful observation of work and methods that are done by different researchers, anew methodology was proposed such that it helps in better for identification of disease in tomato plant leaves. Apart from the architecture diagram to make a short view of the proposed methodology let us have a look of the below figure which helps in better understanding of the work.

Figure 1 explains about the work and the stages for tomato leaf disease detection. At first the user is going to upload the images of the tomato plant leaf and the user going to click predict button. It is going to call the API[19] and the API is going to perform the task of reading the image based on the value that is going to be obtained. The API is going to give value based on the value it is going to predict the type of the disease i.e., whether it is infected or healthy. If it infected then it is going to describe what kind of disease that the plant leaf is suffering from [20].

3.Proposed Work

This part of paper is going to explain about the methodology i.e., what is the procedure and what are the algorithms, dataset used. This part is also going to explain you the implementation of the research work, what are the features that are gathered for implementation of this research work. All these kinds of details are going to be discussed in a clear and efficient manner.

A. ResNet50

CNN is mostly employed in image processing-related works and applications due to its image classification method, which provides more accuracy with less errors. It will take images as input from the user, and based on the input image, the CNN will extract features from the image, and then classify the image based on the features collected. It consists of convolutional layers with the ReLu function and pooling layers to reduce the amount of the convolutional matrix's input features. CNN's most notable feature is that it assists with both extraction and classification jobs.

The main difficulty in CNN designs is reducing error rates while boosting model accuracy and avoiding overfitting by using too small vanishing explosive gradient problems. ResNet, or residual networks designs, was launched by Microsoft in 2015 to address the aforementioned issues. It also has skip connections, which bypass some layers during model training.

If H(x) is the initial mapping, then f(x)= H(x)-x, resulting in H(x) = f(x) +x.

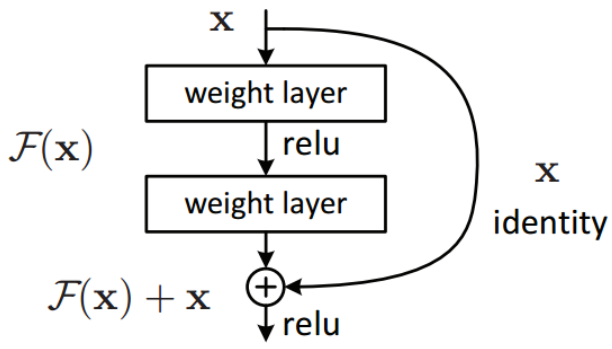


Figure 2 A Residual Block

By skipping the layers that aren't functioning well, this layer will improve accuracy. This solved the problem of the exploding gradient in this research. Resnet50 is another form of ResNet that is used to identify tomato plant diseases.

B. InceptionV3

Inception V3, a convolutional neural network with 48 deep layers, is also a type of convolutional neural network. The ImageNet dataset, which contains over one million images, is used to pre-train Inception V3. It's a requirement for both Inception V1 and Inception V2.

The Inception v1 model has 55 convolution layers, which reduces the Dimensions by a substantial number, resulting in a loss in accuracy. InceptionV2 compresses problems by reducing convolution size from 5x5 to 3x3. As a result, the accuracy improves while the computing time lowers. As a result of the convolutional size modification, the InceptionV2's performance has improved. InceptionV3 is similar to InceptionV2, but that it employs an RHSprop optimizer.

It also has Batch Normalisation in the fully connected layer. Inception V3 has 8,120 (299,299,3) input images, proving that it is more accurate than its predecessor in both classic fictions and feature extraction. It also has Label Smoothing technique to regularise components that are added to the loss formula. This InceptionV3 is used to identify disease in tomato plants, and it is chosen because of its higher accuracy, lower error rates, and shorter processing time.

C. ResNet101

In ResNet101, the postfix '101' represents the number of layers in the model, same like in the previous model. More 3D ResNets are used to build the 101-layer ResNets. This model comprises of more layers when compared to above models like Resnet50 and inceptionV3.

D. ResNet152V2

In ResNet152 v2, the postfix '152' represents the number of layers in the model, same like in the previous model. More 3D ResNets are used to build the 152-layer ResNets. The 152 has less subtleties than VGG16, even once the depth is increased.

E. Experimental Setup

Top performing keras models such as ResNet152v2, ResNet50 and Inception v3 checking the performance in identifying diseases. The model performance was checked by implementing this using Jupyter Notebook under Anaconda IDE by using Python 3.8 as a coding language. tools used for implementing the project are Code and Jupyter Notebook. This work also used a frame work called FLASK. Experiments were conducted with by applying each model with dataset separately and the accuracy and loss obtained during this experiment is compared.

F. Transfer Learning

The ImageNet dataset was utilised to pretrain the three models employed here for identifying leaf diseases. ImageNet is a big archive of pictures with over one million images. Our model takes the knowledge it has learned from ImageNet and applies it to the tomato leaf dataset. This transfer learning is utilised to improve the accuracy of identification. The three models employed in this study were all pre-trained.

G. Data set

The dataset used for the implementation of the above models consists of two sets, testing set and training set. The test set and training set consists of 10 folders. The dataset is Downloaded from Kaggle.com here the dataset comprises of 10 different kinds of diseases. Apart from this the models that we pretrained is going to read the data that is provided in the dataset and this model is going to predict whether the leaves are infected or not.

The first and foremost after pretraining of models is to divide the whole dataset into three categories i.e., training data, testing data, validation data. By using the training data, the model is going to be trained how the diseased image is going to look, how the healthy is going to look. By using testing data, it is observed that whether the model is going to predict it correctly or not. Based on this value i.e., accuracy obtained it is going to be classified whether the model is performing well or not.

Validation data is nothing whenever a user wants to test whether the given image is correctly predicted or not. Here the user gives the image through API and this API is going to respond by collecting information from the trained model and gives the user a message like the leaf is healthy or the leaf is infected.

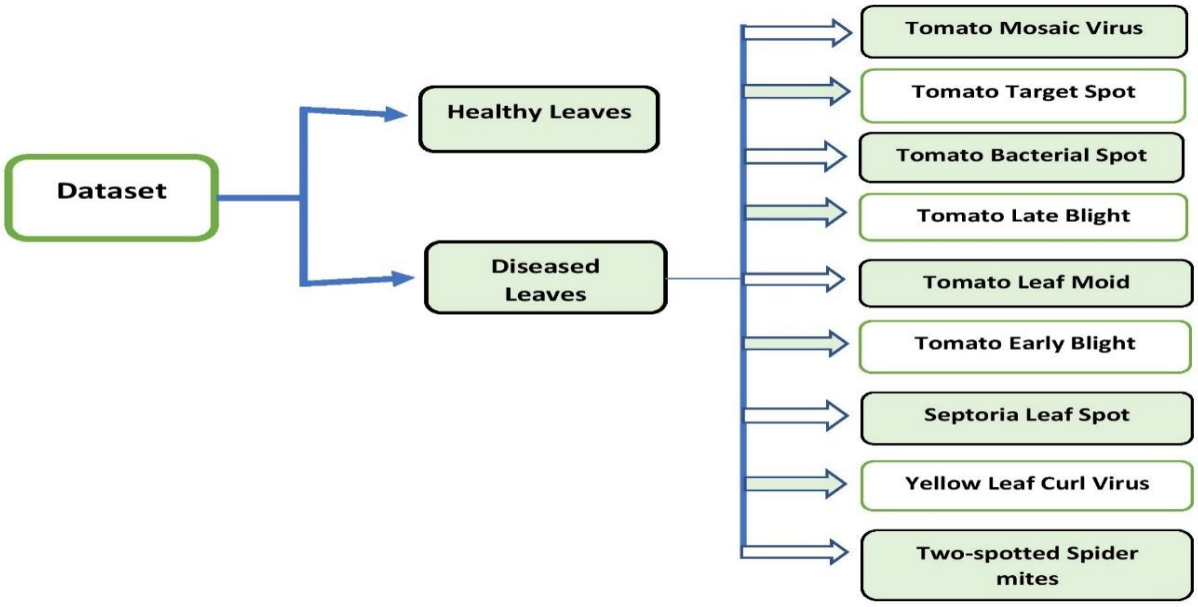


Figure 3. Dataset Description

Before going to the results and discussion let us a look about the dataset what kind of the data comprising of and what are the folders that the dataset has in a pictorial representation. The above figure is going to describe the categories in the dataset and what are the types of diseases that are considered in this dataset.

The following table comprises of four section two sections of Qty which is going to describe the count of particular diseased image that are considered for training and testing the model

TABLE 1: DATASET DESCRIPTION

Training set	Qty	Testing set	Qty
Tomato Bacterial spot	1000	Tomato Bacterial spot	100
Tomato Early blight	1000	Tomato Early blight	100
Tomato healthy	1000	Tomato healthy	100
Tomato Late blight	1000	Tomato Late blight	100
Tomato Leaf Mold	1000	Tomato Leaf Mold	100
Tomato Septoria leaf spot	1000	Tomato Septoria leaf spot	100
Tomato Spider mites Two-spotted spider mite	1000	Tomato Spider mites Two-spotted spider mite	100
Tomato Target Spot	1000	Tomato Target Spot	100
Tomato mosaic virus	1000	Tomato mosaic virus	100
Tomato Yellow Leaf Curl Virus	1000	Tomato Yellow Leaf Curl Virus	100

4. Results and Discussions

This section of paper is going to describe about the results that are obtained by the implementing the deep learning models with the given dataset. Also, this section is going to show you the accuracies obtained by different models and the results that are obtained while we are changing the image size of the high accurate model.

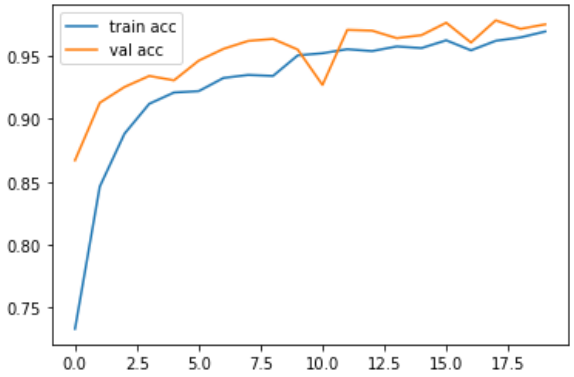
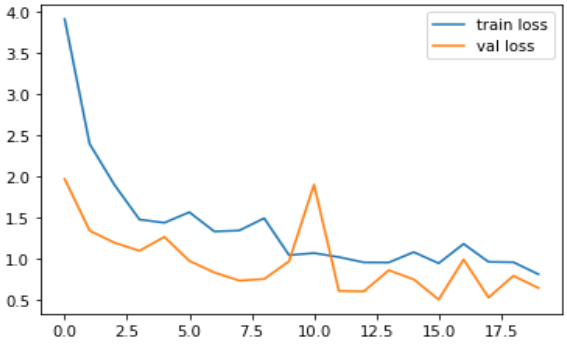


Fig.4 a) Accuracy Graph of Inception V3



b) Loss Graph of Inception V3

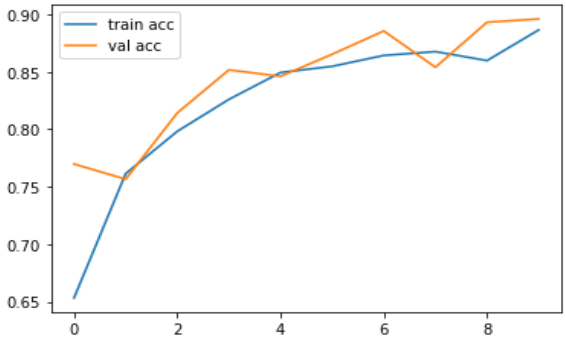
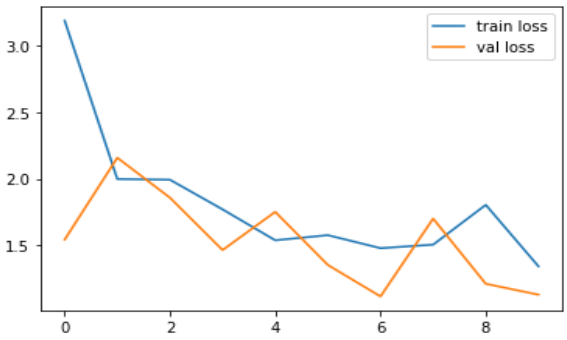


Fig. 5 a) Accuracy Graph of ResNet 152V2



b) Loss Graph of ResNet 152V2

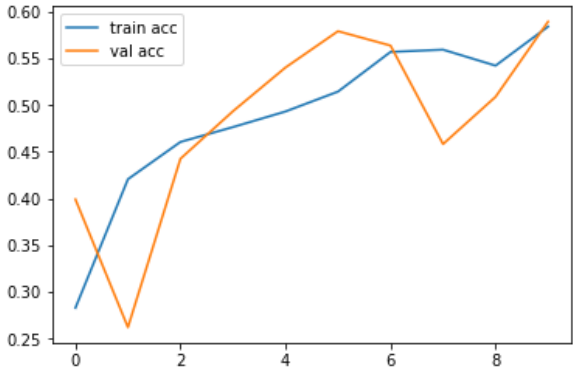
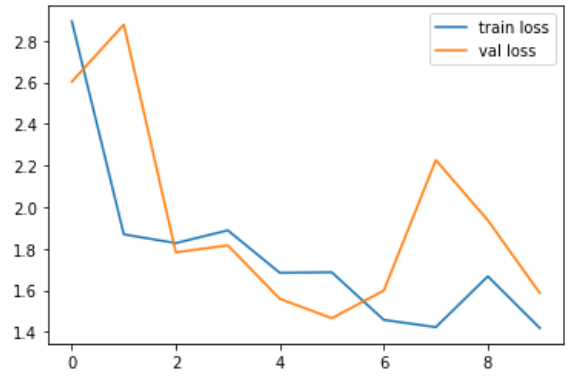


Fig. 6 a) Accuracy Graph of ResNet 50



b) Loss Graph of ResNet 50

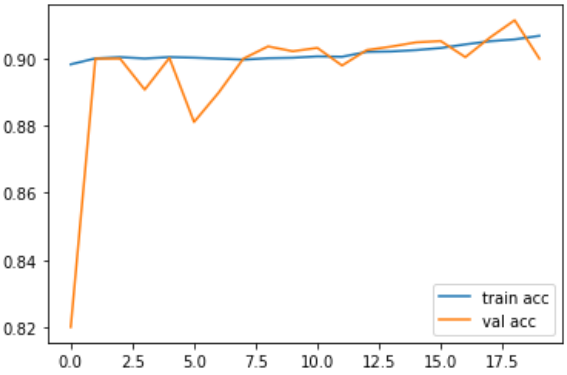
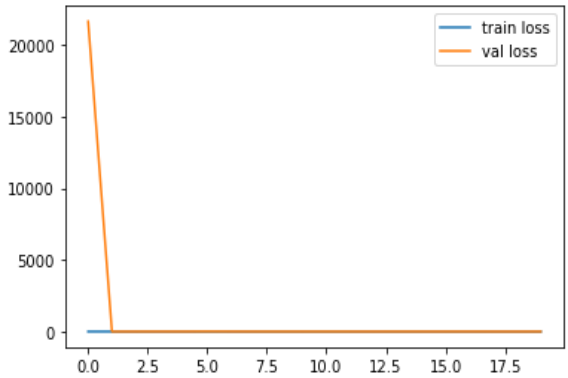


Fig. 7 a) Accuracy Graph of ResNet 101



b) Loss Graph of ResNet 101

The above figures 4a, 5a,6a,7a describes about the training and the validation accuracy of the model. Here x axis represents the epoch count whereas y axis represents the accuracy of the model. In the above figures 5a, 6a, 7a blue line indicates about the training accuracy and orange line indicates the validation accuracy.

Whereas figures 4b, 5b, 6b,7b describes loss graph of the InceptionV3, ResNet152V2, ResNet50. Here also x axis represents epoch count and y axis represents loss values. In the above figures 4b, 5b, 6b blue line indicates about the training loss and orange line indicates the validation loss.

After experiments were conducted, results that ResNet152V2 achieves an accuracy of 95.08%, InceptionV3 achieves an accuracy of 84.33% and ResNet50 achieves an accuracy of 48.35%.

Table 2: Comparison Table for CNN Models

Model	InceptionV3	ResNet50	ResNet101	ResNet152V2
Number of layer	48	50	*101*	152
Number of paramet	23,851,784	25,636,712	*49,49,751*	60,380,648
Accuracy	84.33%	48.35%	*90.02%*	95.08%

The above table given details to describe about the models how they trained, how many layers are used and the accuracy obtained whey they trained the model. Here from the above three models ResNet152V2 has got better accuracy when compared to other models. The number of layers and parameters for ResNet152V2 is more when compared to ResNet50 and InceptionV3.

The accuracy graph for InceptionV3, ResNet50 and ResNet152V2 models is shown below:

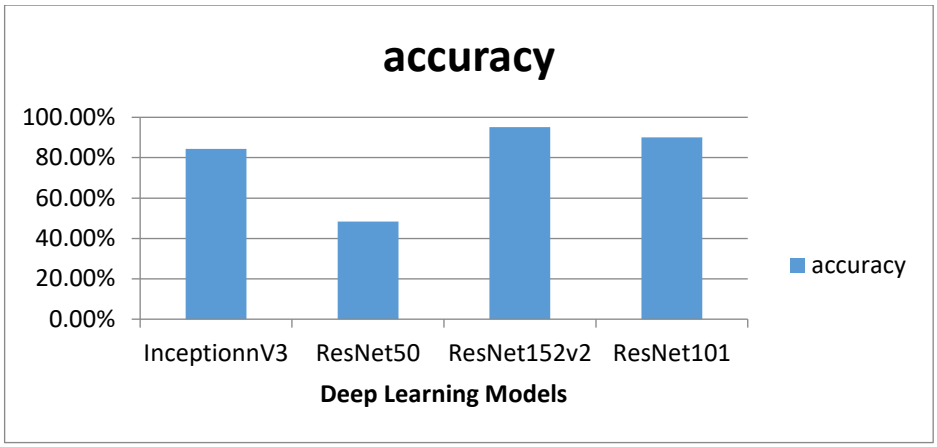


Figure 8. Accuracy Graphs for the CNN models

Figure 8 described about the accuracy that is obtained while training the models on the above dataset mentioned. Here the results shows that ResNet152V2 achieves an accuracy of 95.08%, ResNet101 has got an accuracy of 90.02%, InceptionV3 achieves an accuracy of 84.33% and ResNet50 achieves an accuracy of 48.35%. from the above graph we can say that ResNet152V2 has got higher accuracy when compared to other existing models.

The above table 2 and fig 8 shows that the ResNet 152v2 had got the highest accuracy. ResNet152V2 model has got following accuracies when we change the image sizes like 32*32, 64*64, 128*128, 256*256, 512*512.

Table 3. Comparison of Accuracies with Images Sizes

Model Name	Image Resolutions	Accuracy
ResNet152V2	32*32	37.10%
	64*64	79.73%
	128*128	88.65%
	224*224	95.08%
	256*256	94.43%
	512*512	95.75%

The above table 3 is going to describe about how ResNet152V2 model is going to perform when we give different image sizes and the accuracy obtained by the models with the tomato leaf dataset by changing the input size image for the model. Apart from the accuracies we also obtained that whenever the size of the image increases.

The following bar graph represents the accuracies of ResNet152V2 when we change the image sizes

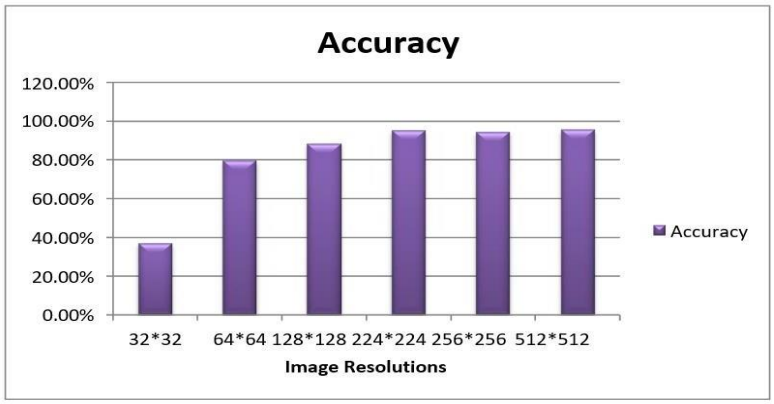


Figure 9: Graph of accuracies with different image sizes

The above fig 10 is going to describe about the accuracies that is obtained when the Resnet152V2 model is trained with different image sizes with described dataset as mentioned above. ResNet152V2 model has got following accuracies when we change the image sizes like 32*32, 64*64, 128*128, 256*256, 512*512. Among those ResNet152V2 has got better accuracy when the image size is 512*512 then the desired input size for ResNet152V2 model. Hence, we are going to use ResNet152V2 model with 512*512 for tomato leaf disease detection.

Here are some of the sample images of the output when a user gives you a sample image of leaf it is going to identify the disease whether it is infected or healthy. If it is infected then it is going to give you the name of the disease as the output.

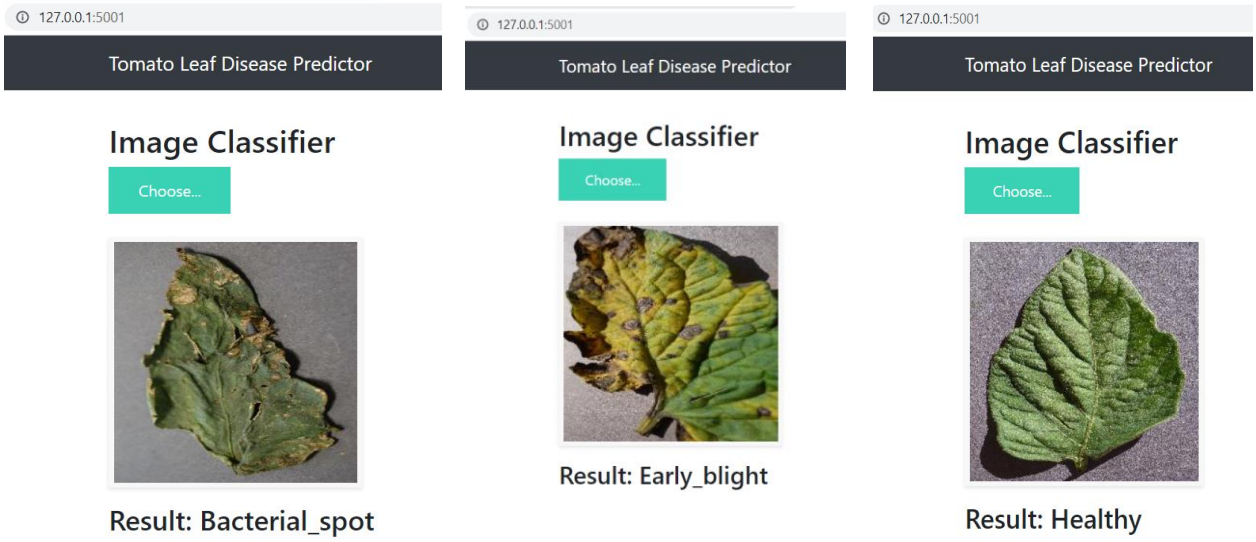


Figure 11: Sample Output Images

These are the sample images of output that are obtained when a user gives you the sample images of the leaf it is going to identify the disease as shown in the figures above.

Apart from this we also found that whenever a model is trained with high image resolutions the rate of learning of the model is always time taking when compared to images with low resolutions. Another important thing is that when the image size is low the accuracy value of

the model is also low. After careful studying image with medium size provides best accuracy when compared to high and low resolution images

5. Conclusion and Future Enhancement

This research is focused on a method for detecting tomato plant leaf disease. The leaf of the tomato plant is the primary source of infection. The human eye is incapable of distinguishing colour and texture changes on tomato leaves. As a result, a different method for identifying plant diseases is necessary. Transfer learning models were used to classify illnesses in tomato leaves in this paper. When compared to existing methods in the literature, this method was implemented using three separate keras models. The three models are Inception V3, ResNet50, ResNet101, and ResNet152V2, and their accuracies are 84.33 percent, 48.35 percent, 90.02 percent, and 95.04 percent, respectively, when applied to the same data sets. ResNet 152v2 with parameters 60,380,648 was the most accurate of the three models. As a result, this concept of applying a transfer learning approach helps in better results. In this paper another important point to conclude is that whenever the size of the image is high, the training time of the model also taking more time. When the size of the image is low training time of the model is taking less time and the accuracy of the model is also low due to less resolution. This paper also concludes that when size of the image is medium it is performing better when compared to high- and low-resolution images.

This research work focused only on the tomato plant diseases. But the disease detection approach is necessary for every crop. So, this idea can be further enhanced for classifying diseases in various plants which will be very helpful for agriculture sector.

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