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Apple Leaf Diseases Classification Using CNN with Transfer Learning

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Abstract: ***The Foliar diseases of the apple trees commonly reduce the crop Yield and photosynthesis which affects their productivity. Diagnosing foliar damage is not easy if there are no distinct patterns that would be fungal fruiting bodies it will. spread to the rest of the crops.***
The foliar disease of the apple trees is carried out due to biotic and abiotic causes, some of the biotic causes of foliar damage are - Bacterial Disease, Fungal Diseases, Viral Diseases, Insects, and Mites That Damage Foliage. some of the Abiotic causes are - Iron Chlorosis, Misapplied Herbicide, and Winter Desiccation of Evergreens. Traditional approaches rely on visual inspection by an expert and biological examination is the second choice .these approaches are time-consuming and expensive. we use machine learning methods to classify the disease in apple trees. we use some pre-trained CNN models to extract features from the dataset, we applied the CNN model and compared them with Pre-trained Models, and we achieve accuracies of over 93% with CNN, among the Models We achieved 92% with the Inception V3 model,62% with VGG16, 63% with VGG19.
Keywords: Plant disease detection; image classification; transfer learning; Deep Learning; CNN; Data Augmentation;

I. INTRODUCTION

Plant disease affects the growth and crop yield which affects their productivity. We human beings mostly depend on crops. If we diagnose the crops there are many factors to consider behind the disease. if we make the right diagnosis we have a healthy crop, but the process of diagnosis takes a longer time than we expect hiring a visual expert on the crop would be expensive. one of the common factors of crop failure is due to misdiagnosis. misdiagnosis takes place due to misuse of chemicals leading to various factors such as cost of input and emergence of resistant pathogen strains. using machine learning we can classify the disease of the crop, many machine learning methods proves the efficiency of the crop disease detection, but some factors such as the light condition of the crop images and disease detection affect the detection accuracy. To solve this problem and improve the crop yield, we decide to train apple leaves[6] to distinguish whether they are healthy, have rust are infected with scabs, and are infected with multiple Diseases. The input of our algorithm is apple leaves images, we use CNN and three deep learning methods, including VV16, VGG19, and InceptionV3 to classify the input images into four categories. Model performance is evaluated by prediction and accuracy. In the end, we compare the performance of each model to predict the best model output.

II. LITERATURE SURVEY

Leaf diseases are common diseases found on apple leaves. these are caused by a fungal pathogen. similar cases were seen in other crops like tomatoes [2]. By using this research [3]
We can make a model that solves the current problem. Farmers spend a lot of money on disease control and experts to know about the result, but in the end, the result leads to poor control of disease control and excess supply of chemicals due to inadequate information about diseases. majority of the crops today are infected by a variety of diseases. Diseases occur in crops[7] at various parts like roots, leaves, stems, and leaves are the most part where we can detect the disease. many articles deal with the disease of leaves based on size, shape, and color.it is important to know the root cause of the problem before it spread to the rest of the crop. which saves money and time. there is more research going to fine-tune the model to solve real-world problems.

III. PROPOSED SYSTEM

A CNN convolutional neural network is the most widely used method for extracting important features from huge datasets.
The architecture of the CNN used is similar to VGG16 based on the architecture we made our CNN. The pipeline of the Model Holds RGB rather than Grey Colours of the input images.

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The model consists of several layers of different types. Typically begins with the Sequential layer, followed by several layers of convolutional layers, more grouping layers, and activation layers and ends with a dense layer with filter size four to extract features from the given dataset, like - scab, rust, healthy, multiple diseases.
In the convolution layer, the convolution operation is performed to extract features, and the output is passed to another layer by the activation function, we used in our model relu as an activation function it performs well compared to other activation functions.

A. Methodology Diagram

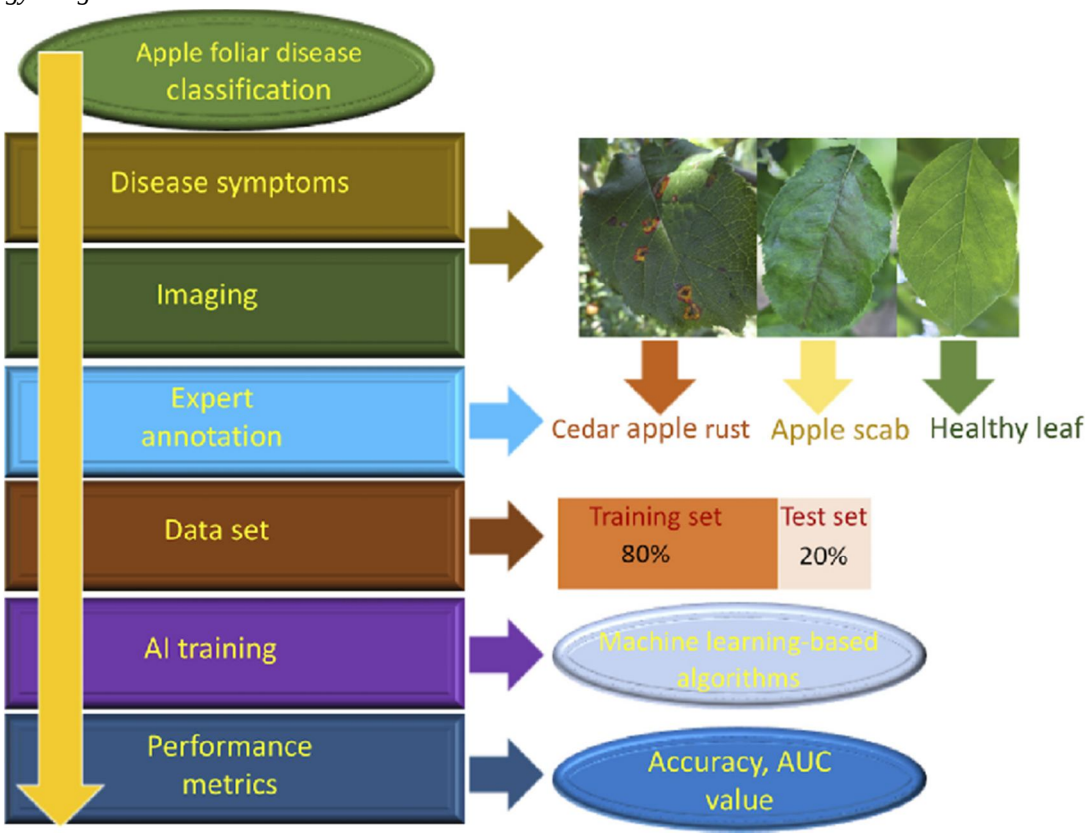


Fig 1. methodology diagram

B. Advantages

By traditional approaches, it would be more time and expensive, by hiring a visual inspection expert or performing a biological examination. Misdiagnosis of this disease can result in misuse of chemicals leading to various factors such as increased costs of input and the emergence of resistant pathogen strains. Currently, crop disease diagnosis mainly relies on farmer scouting, which is inefficient due to the difference in diagnosing experience
Making use of deep learning algorithms will solve the problem by saving time and expenses. this approach solves many real-world problems with the help of Open CV and deep-leaning algorithms.

IV. DATASET

A. Data Set Details

The dataset we used is from Kaggle plant pathology 2020-FGVC7[5], makes use of the given category of disease and dataset, we identify the category of Foliar Diseases in Apple Trees. The dataset consists of 1821 labeled training images of apple tree leaves and 1821unlabeled test images, The images are categorized into four classes which include -" healthy"," scab"," rust", and" multiple diseases". figure 2 of the pie chart shows the distribution of data where Rust holds most of the data, then Scab, followed by healthy, and with the least percentage of multiple diseases.
Once the leaves are infected fall from trees and die. The tree has orange or yellow spots on its leaves and fruit that is mottled or distorted, you are probably dealing with rust

Multiple diseases class states that the plant is from both scab and rust.

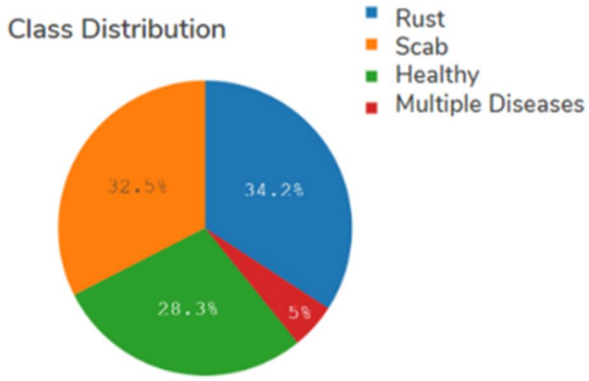


Fig 2: training data class distribution.

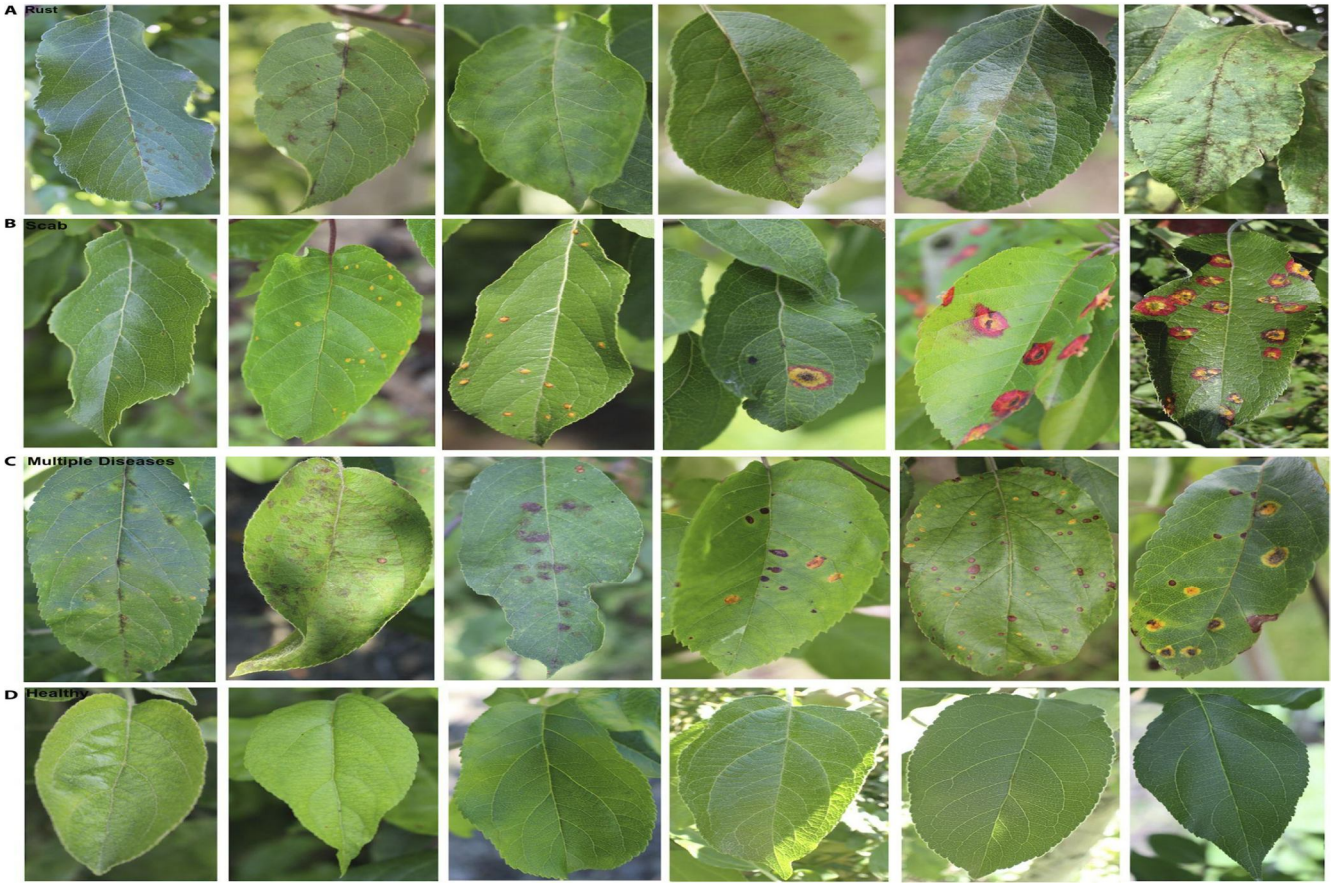


Fig 3 Sample images of the data.

B. Rust, B-Scab, C-Multiple Diseases, D-Healthy

Challenges We Faced

This Dataset is full of apple leaves images, even background images of any samples are also left .which is hard to classify other objects in the image. by looking at to picture an Expert can identify the scab which is generally yellow leaves, when it comes to multiple diseases it is hard to distinguish from a single disease in a single image

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C. Data Augmentation

We shuffled data images randomly and split the dataset into training and validation sets of a ratio of 80:20. for detection of disease using deep learning requires huge data, but it is difficult to obtain. So we applied data Augmentaionto solve this problem by following methods:

1) shear_range=0.2
2) zoom_range=0.
3) horizontal_flip=True
4) vertical_flip=True

For our neural network to work with less complexity and time, we resized all images of the dataset to 224*224.

D. Feature Extraction

In this project, we use CNN and use other pre-trained models to extract features from images.
In pre-trained model have different architecture and different activation functions.
In our model, we remove the top layer of the pre-trained model and add several fully connected layers after the pre-trained model, to classify the class of the input image.

V. METHODS

We used one CNN model and three pre-trained models, all the layers in the neural network take RGB images and make use of the model to distinguish the image class.

A. Transfer Learning

1) CNN Model

CNN is a type of neural network model which allows us to extract higher features for the image content[4]. CNN takes the image's raw pixel data, trains the model, then extracts the features automatically for better classification. It is generally formed by a stack of layers.

a) The Cov2D layer processes the data received[8].
b) Max pooling is a pooling operation that selects the maximum element from the region of the feature map covered by the filter.it contains the feature of the previous output layer.
c) ReLU activation function makes neurons not activate all neurons at the same time. it converts all negative inputs to zero and makes neurons doesn't get activated. This is very computational efficient as few neurons are activated per time.
d) A fully Connected Layer is simply, a feed-forward network where the input layer is fully connected to the output layer.

2) Convolutional Layer

This layer takes input image data and performs mathematical operations to extract features. the input image is reduced using filter size. we used a filter size of 3x3. The input image is reduced starting from the top left corner of the image, at each step, which is multiplied by the values of the filter and formed into a new matrix which is the smaller size of the input image.

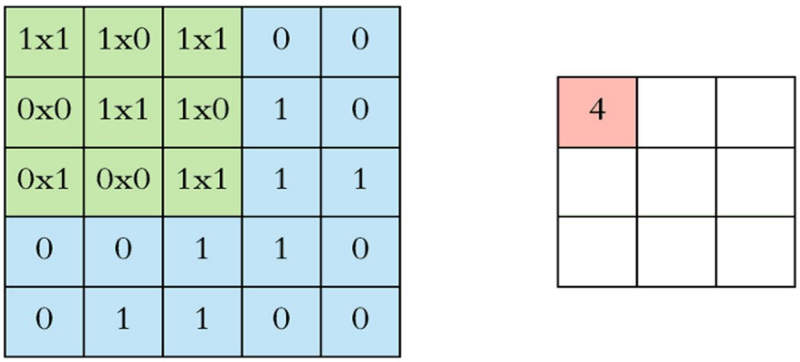


Fig 4. working of conv2d layer

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3) Max-Pool Layer

This layer is applied after the convolution layer. the output matrix size obtained from the convolutional layer is reduced in this layer, which reduces the features in images, our model user filter size of 3x3 size .max pooling is done by selecting the largest value in the sub matrix is transferred to a new matrix.

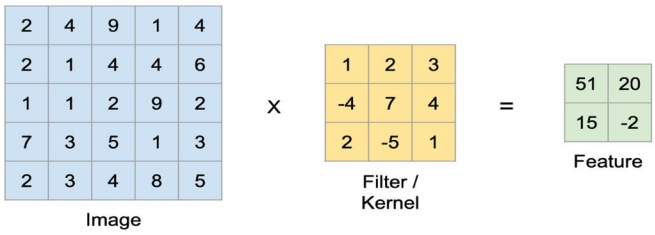


Fig 5. Working of max-pooling layer

4) Activation Layer

In a neural network, the activation function provides a curve relationship between the input and output layer. The performance of the network depends on this activation function. when compared to other activation functions like a linear, sigmoid, hyperbolic, and tangent, we consider the nonlinear relu activation function where it doesn't trigger the neuron to the other layer if the values are less than zero

$$f(x) = \begin{cases} 0, & \text{if } x < 0. \\ x, & \text{otherwise.} \end{cases}$$

5) Fully Connected Layer

In this layer, the neurons have a complete connection of all activations from previous layers. This activation can be helpful in feature classification. this layer takes the output of the earlier layers, "flattens" them, and turns them into a single vector that can be an input for the next stage.

B. Transfer Learning with CNN

The reuse of a previously learned model on a new problem is known as transfer learning, using these pre-trained learning models we need not build from scratch to make a model. A machine uses the knowledge learned from the previously trained data and increases the prediction of new tasks in transfer learning. Transfer learning has several advantages, one of the most important is to offer reduced training time. improved neural network performance and in the absence of a large amount of data

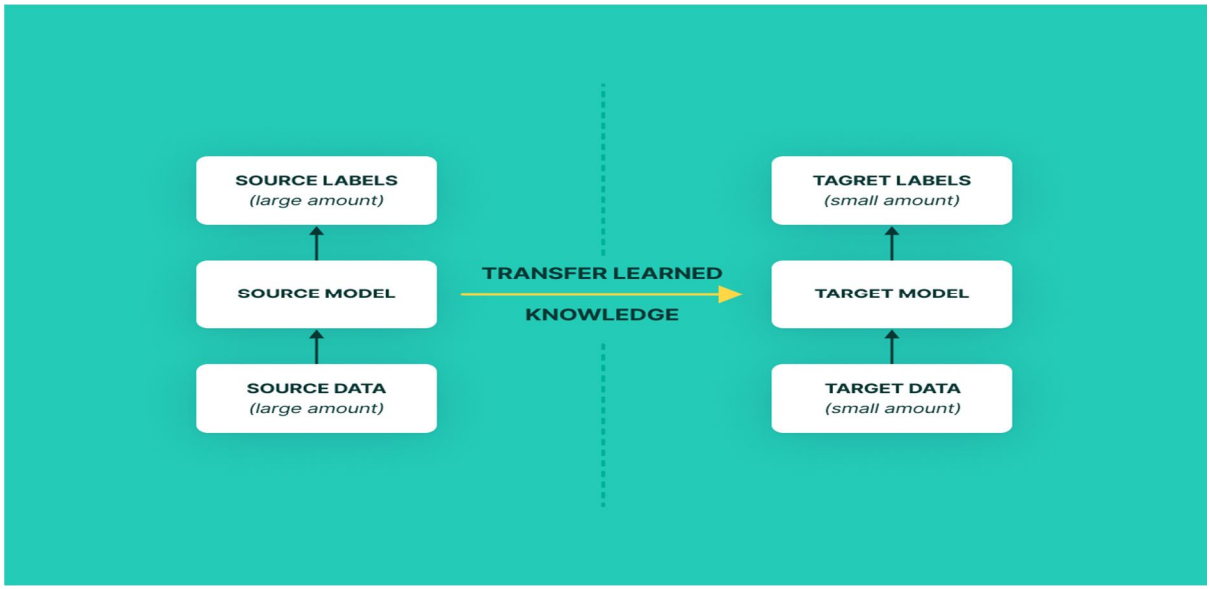


Fig 6. model of transfer learning

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For the image classification problem, we build a transfer learning model by following steps:

1) Extract all the layers of the pre-trained model and discard the top layer of the model.
2) Add the custom layer to form classify the new problem-based dataset.
3) Make pre-trained model layers non-trainable and train the model with new data.

- VGG16

  The VGG16 model has 16 layers that have weights. In VGG16 there are 13 convolutional layers,5 Max pooling layers, and 3 dense layers.in our model, we use all layers of the VGG16 model and add an output layer of 4 outputs append to our model.

  - VGG19

    The Vgg19 model is a Variant of the VGG model which consists of 19 layers.
    This model is similar to VGG16 and consists of 18 convolutional layers,3 fully connected layers, 5 MaxPool layers, and 1 SoftMax layer, in our model we make use of all layers, and replace the top layer with 4 dense layers as per our data.

  - inceptionV3

    This model has 42 layers and a lower error rate than its predecessors. in the inception v3 model, several techniques for optimizing the network have been put suggested to lower the computation and classify with less error rate.
    The Techniques include:
    1)Factorized convolutions,
    2)Regularization,
    3)dimension reduction
    4)parallel computations
    In our model, we use layers to train the model and replace the top layer with 4 dense layers as per our dataset.

VI. EXPERIMENTS AND RESULTS

A. Experimental Setup

All the experiments are completed in jupyter notebook with GPU support, we used the python3 programming language with TensorFlow 2.2 installed. the transfer learning model was implemented using Keras.

B. Metrics

The main metric used to evaluate the model is classification accuracy on test data.in the Kaggle dataset, we have images of 1821 unlabeled images to evaluate the model and test accuracy is calculated based on test images.

C. CNN

Our model acquired the best results by training 30 epochs. the learning rate is set to 0.001, and the optimizer used is Adam. the training results are shown in fig

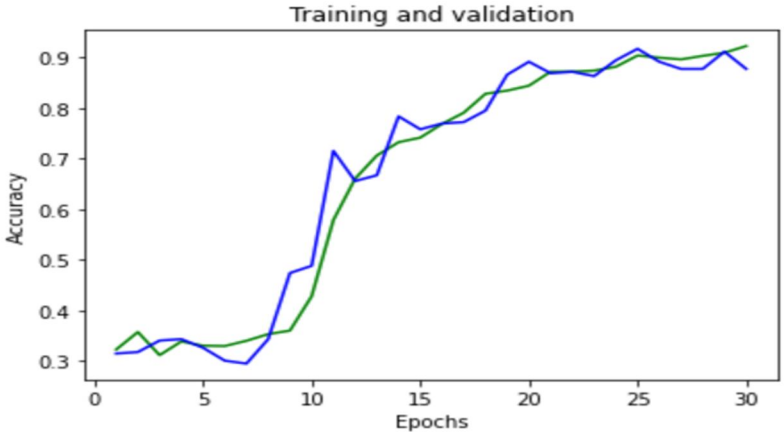


Fig 7. CNN model accuracy

D. VGG16

Our model acquired the best results by training 30 epochs. the learning rate is set to 0.001, and the optimizer used is Adam. the training results are shown in fig

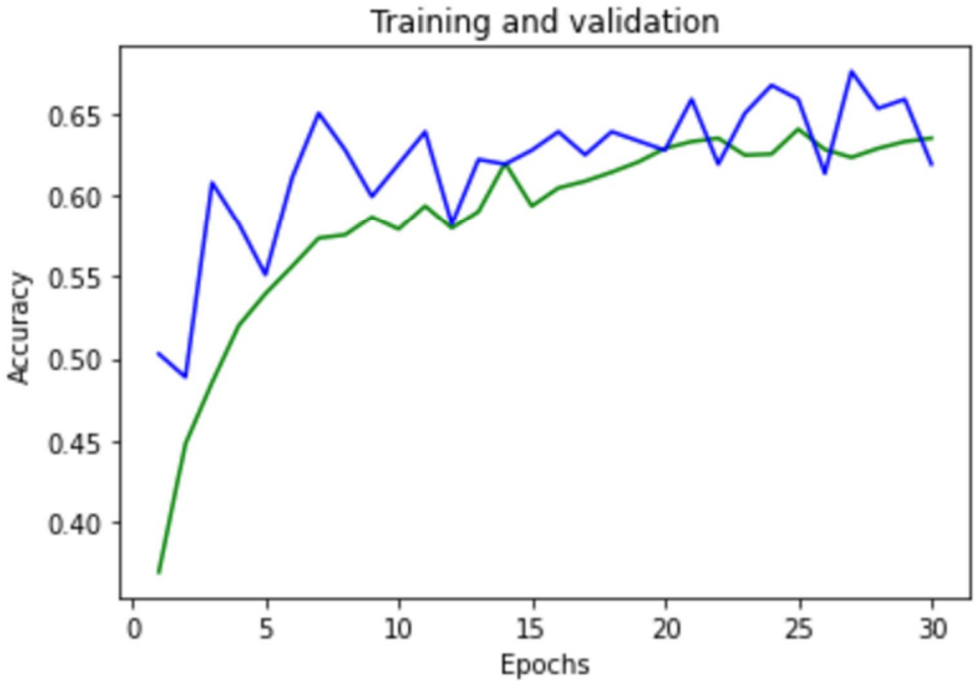


Fig 8. VGG16 model accuracy

E. VGG19

Our model acquired the best results by training 30 epochs. the learning rate is set to 0.001, and the optimizer used is Adam. the training results are shown in fig

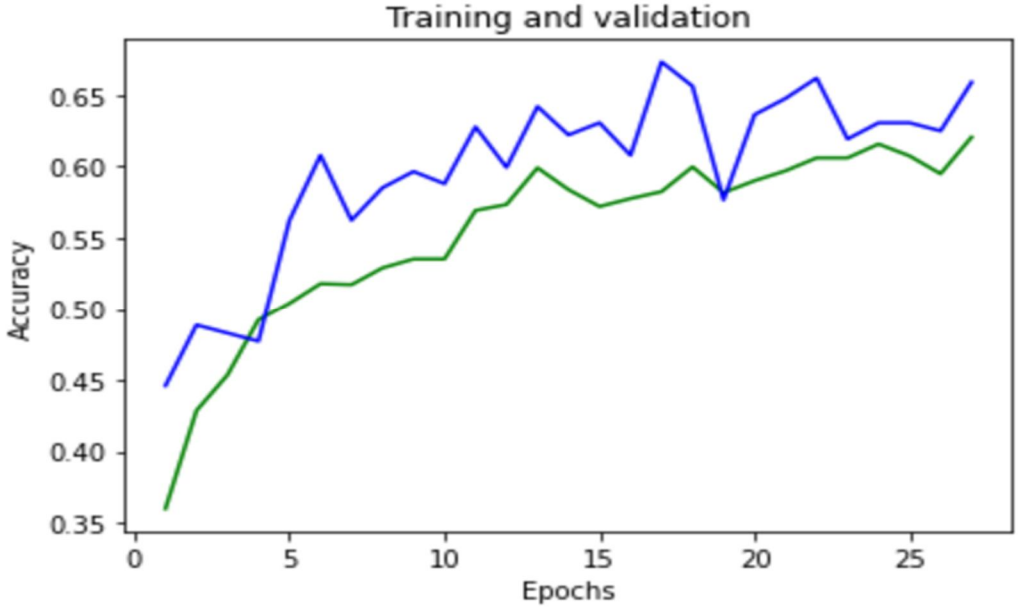


Fig 9.VGG19 model accuracy

F. Inception V3

Our model acquired the best results by training 30 epochs. the learning rate is set to 0.001, and the optimizer used is Adam. the training results are shown in fig

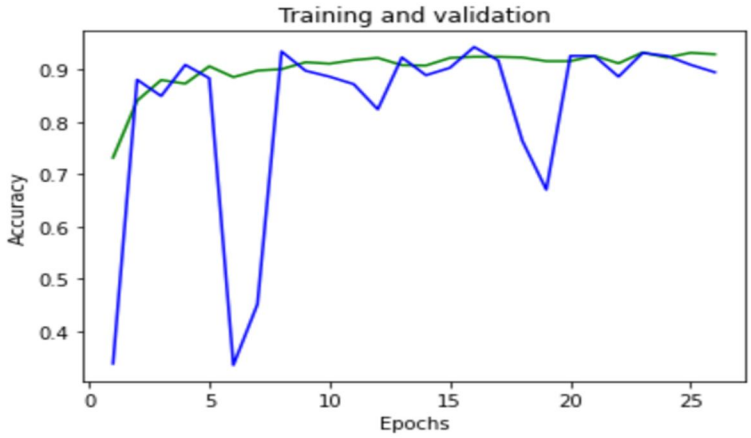


Fig 10.InceptionV3 model accuracy

Performance of comparison of the proposed model with the transfer learning model

Model	Test Accuracy	Val Accuracy
CNN	93.34	91.76
VGG16	96.64	89.81
VGG19	89.64	88.15
Inception V3	90.53	87.05

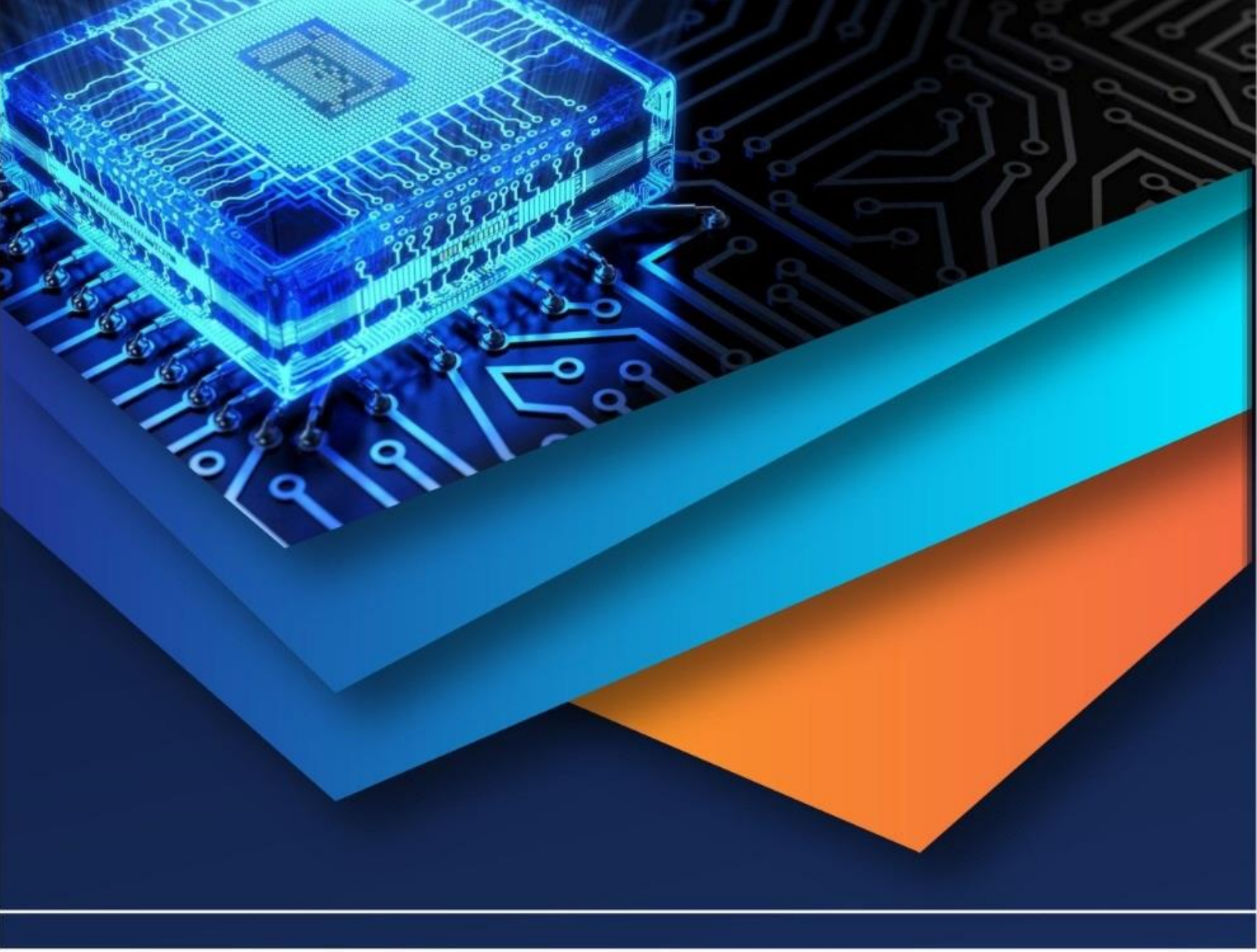
All the models worked well on the given problem. Most of the models classify the classes of rust, scab, and healthy, when it comes to the classification of multiple disease learning models makes it the worst classification.
Several adjustments can be made to the algorithm so that multiple regions of disease can be detected before the classification.

VII. CONCLUSION

We make use of three transfer learning algorithms and the CNN model. the transfer learning models
Include VGG16, VGG19, and Inception V3.To find the best model among the models we considered the Test Accuracy into account, the experimental results of the models Among the models VGG16 with 96% when compared to inception v3 which is so close with 90% Accuracy. these models have low accuracies to classify multiple diseases.

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