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Chest Computed Tomography Scan Images for Classification of Coronavirus by Enhanced Convolutional Neural Network and Gabor Filter

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Abstract — Coronavirus pandemic disease is caused by severe acute respiratory syndrome coronavirus 2. Generally RT-PCR or other Nucleic testing is used in order to detect covid19. In computed Tomography Scans, it can be clearly viewed that to how much extent the virus has damaged the Lungs. Computed Tomography gives the result in 15 minutes, whereas RT PCR takes 24 hours. PCR only checks whether virus is in nose or throat but the proposed model checks in lungs which is most accurate. The utilization of computed Tomography Scans will give us better and accurate results. The proposed novel model helps to recognize the corona virus in Lungs Computed Tomography Scans and achieved an accuracy of 0.93 with Gabor filter and 0.85 without Gabor filter. The existing models VGG16, VGG19, ResNet50 and Mobile Net achieves an accuracy of 0.89,0.91,0.91,0.91 respectively using Gabor filter and 0.78,0.71,0.81 and 0.89 without using Gabor Filter. Gabor filter will help to remove the noise from the data, it is linear filter and orientation sensitive. Our model achieves an accuracy 0.93 which is better than VGG16, VGG19, ResNet50, Mobile Net models using Gabor Filter.

Keywords—Deep Learning, Computed Tomography, Gabor Filter, covid19

I. INTRODUCTION

Covid19 known as coronavirus disease 2019 is ongoing pandemic and caused by severe acute respiratory syndrome ccoronavirus2.By march15 2021 there are more than 120 million cases has been confirmed and with more than 2.65 deaths which makes it the deadliest pandemic. The symptoms of covid19 are dry cough, fever, tiredness, difficulty in breathing, sore throat, headache, loss of taste and smell. This virus is spread when an infected person coughing, sneezing and when the infected regions are touched. Computed Tomography Scans is a medical imaging technique that uses computed processed x rays which are taken at different angles and produce a tomographic image of body which helps the doctor to see inner parts without cutting. VGG16 is a convolutional neural network which achieves an accuracy of 0.927 for

ImageNet. ImageNet contains over 14 million images of 1000 classes. VGG19 is a trained convolutional neural network which has 16 convolutional layers and 3 fully connected layers. ResNet50 contains 50 Residual Network. Residue means subtraction of features from the layer it gets input. Mobile Net provides an efficient model for cell phone and installed applications, uses depth wise separable convolutions. A simple and efficient convolution neural network and changed pre-trained Alexnet on the Computed Tomography Scan and X-Ray dataset gives an Accuracy of 0.98 by using pre-trained and 0.941 by using modified CNN[1]. A three stages detection model in order to divide the Computed Tomography scan to covid19 class and non-covid19 class. In phase1 data augmentation using stationary wavelets is done. In phase2 transfer learning architectures Resnet18, Resnet50, Resnet10 and Squeeznet where Resnet18 shows highest classification accuracy for validation 0.97 and training is 0.9982. In phase3 with Resnet18 covid19 location is located on CT scan [2]. A hierarchical classification in order to detect covid19 in chest x-ray images, the classifications used are multiclass classification and hierarchical. A convolutional neural network tailored network which collectively test both CT and CXRS, accuracy obtained is 0.9628 [4]. Truncated Inception Net is a deep learning CNN model achieved an accuracy of 0.9982 on covid19 positive cases from combined pneumonia, tuberculosis and healthy CXR datasets. This model is better than Inception Net v3 model [5].
A multilayer perceptron convocational neural networks for different data achieves an accuracy of 0.9630 and 0.954 for small and structured data and large and unbalanced respectively. Optimization Rmsprop outperforms for large and unbalanced whereas Adam outperforms well for small and balanced [6]. An optimized vgg19 model obtained accuracy of about 0.86, 0.1, and 0.84 for X-rays, Ultrasounds and CT scan

respectively [7]. a Decompose, Transfer, compose model to recognize covid19 in chest X-ray images and obtained an accuracy 0.931 [8]. A model ChexNet is a type of CNN Model, which uses dataset chestXray14 and is used to recognize the covid19 in chest x-ray. This model classifies into covid19 and normal with an accuracy of 0.999 [9]. a shuffled residual CNN which contains a unique filter patterns for same type of pneumonia obtained an accuracy of 0.9980. This model uses dual residual skip connections and channel shuffling for learning the tough features [10]. covid19 Generative adversarial network (GAN) is used to do data augmentation on chest x-rays. with GAN the achieved accuracy is 0.95 and without GAN is 0.85 [11].

The covid19 Computed Tomography scan dataset is publicly available in Kaggle platform which 3 categories positive covid19, Negative covid19 , uncertain data. Firstly, the images are converted into jpeg format and resized them in to 128x128 pixels. The images are classified in to train set and test set in the ratio 80 and 20. The Gabor Filter is applied on train and test sets of data in order to remove the noise from images. Gabor filter is a linear filter and orientation sensitive. The proposed Novel model is trained using train set and is validated with test set and achieves an accuracy of 0.93 using Gabor Filter.VGG16, VGG19, ResNet50 and mobile Net are also trained with train set and validated with test set and achieves an accuracy of 0.89, 0.91,0.91,0.91 respectively using Gabor filter.

II. Related Work

Dibagsingh at el.[12] proposed a multi objective differential evolution CNN which outperforms ANN,ANFIS and CNN models on the basis of accuracy,F-measure and sensitivity by 0.1978,0.2092,0.182 respectively. To eliminate overfitting 20-fold cross validation is used. Majid Nour [13] proposed an automated covid19 recognition system based on CNN with rich filter families, abstraction and weight sharing options on chest X ray images and obtained an of 0.9897 accuracy. TooYan at el[14] proposed a multi scale convolutional neural networks to detect covid19 on CT scans. This model evaluates the CT scan at both slice and scan level. Aryan Mobiny at el[15] proposed a detail oriented capsule network which is of 3 stages, First uses Dynamic Routing Mechanism which increases stability of model, second peekaboo training which is of 2 stages one is to drop and other is to crop strategy. At last data Augmentation Generative adversarial network is used in order to eliminate the problem of scarcity of data, model obtains 0.8431 precision and 0.915 recall. Harsha panwar at el[16] proposed a deep transfer learning algorithm which detects covid19 in CT scan and x rays images, Grad Cam is used to get an accuracy of 0.936.Kaiming He at el[17] proposed mask R CNN which detects the objects in a image by segmentation mask in each instance . Mask R CNN is easy to train and is running at 5 frame per second.

MuhammadFarooq at el[18] proposed covid19 Resnet which is a 3 step model to fine tune a pretrained ResNet so to improve the performance and to reduce training time obtains an accuracy of 0.9623 on covidx dataset. N R Raajan at el[19] proposed a model that utilizes a Resnet architecture CNN for training the CT Scan to recongnize the covid19 and obtained an accuracy of 0.9509 and sensitivity 0.1 .Deng ping Fan at el[20] proposed a model InfNet which will automatically detect covid19 infected regions of CT images. InfNet uses a parallel partial encoder to combine features at high level and generate a map. Ross Girshick at el[21] proposed a fast region based convolutional network method for object detection . It trains the VGG16 network which is 9 times faster than and 213 faster at test time. Xien He at el[22] proposed an automated model design for covid19 detection in chest CT scans. In this work he proved that 3D CNN outperforms the 2D CNN. He designed a light weight MNas3DNet41 that obtains an accuracy of 0.8714 which is on same level with existing pre trained models.

Suren Makaju at el[23] proposed a model which is used to detect the cancer cells in CT Scans with an accuracy of 0.92 in detection .This model uses water shed segmentation for detection, svm for classification of the cell as not harmful and spreads , classification achieves an accuracy of 0.86.Xuehai He at el[24] proposed one is to create a own dataset from chest Ct scans and other is to create an efficient self-trans neural network which achieves an FI of 0.85 and AUC of 0.94.Laurent Zieleskiewicz at el[25] proposed that lung ultrasound is better than computed Tomography Scan in the assessment of Covid19.The Lung ultrasound has a predictive by chest CT. M Qjidaa at el[26] proposed a intelligent decision clinical support system for the recognition of covid19 outperforms,DenseNet121,VGG16,VGG19,Inception ResNetV2,Xeception , MobileNet,InceptionV3 and achieves with test accuracy of 0.99.Smaran S Rao at el proposed a Dynamic Reconfigurable processor technology to process the image capture distance, computation time and memory usage and reduces cpu ram utilization from 1-2 GB to 2 MB.

III. Proposed Work

A. Model description

The objective of our research is to propose a Novel model in order to detect covid19 in computed Tomography Scans. The dataset is publicly available in Kaggle platform which contains negative covid19, positive covid19 and uncertain categories of images. Each category contains approximately 5000 images Firstly all the images are resized in to 128x128 pixels and converted them into jpeg format. The images are classified into Train and Test set in the ratio of 80 and 20. Next we have applied Gabor Filter in order to remove the noise from the dataset. The Proposed model contains six convolution layers, one dense layer and six pooling layers. The activation function used in output layer is softmax. The Softmax function takes the vector and rescales them into probability function in order to get the output in interval (0,1).

Step 1: The images in the dataset are resized in to 128x128 pixels
Step 2: The dataset is divided into Train and test set in ratio of 80 and 20.
Step 3: Gabor filter is applied on Train and Test sets.
Step 4: Now the proposed model is trained with train set and validate it with test set.
Step 5: VGG16, VGG19, ResNet50, Mobile Net are trained with train set and validate it with test set.

B. Gabor Filter

Gabor Filter removes the noise in image in specific direction only. The main limitation of this filter is Orientation Sensitive.

Complex

$$GF(a,b;p,q,r,s,t) = \exp\left(\frac{-(a')^2 + s^2(b')^2}{2p^2}\right).\exp\left(i\left(2\pi\left(\frac{a'}{r}\right)+t\right)\right)$$

Real

$$GF(a,b;p,q,r,s,t) = \exp\left(\frac{-(a')^2 + s^2(b')^2}{2p^2}\right).\cos\left(2\pi\left(\frac{a'}{r}\right)+t\right)$$

Imaginary

$$GF(a,b;p,q,r,s,t) = \exp\left(\frac{-(a')^2 + s^2(b')^2}{2p^2}\right).\sin\left(2\pi\left(\frac{a'}{r}\right)+t\right)$$

Where,
p=standard deviation
q=orientation of parallel strips pf Gabor function to normal
r=wavelength of sinusoidal factor
s= spatial aspect ratio
t=phase offset

$$a' = acosq + bsinq$$
$$b' = -asinq + bcosq$$

a, b = size of kernals

C. Algorithm

Input: Dataset contatining images of covid19
output: Classify the input into positive or negative or uncertain
Begin
if size(covid19_Dataset[ ] ≠ ∅) th_{en}
for all images in covid19_Dataset
JPG(covid19_Dataset [ ], JPG)
Covid19_Dataset[ ] = *GaborFilter(covid19_Dataset[])*
Resizing(covi19_Dataset [ ], 128, 128)
Endloop
Endif
Covid19_Dataset_CNN(covid19_Dataset [ ])
Training_Dataset, Testing_Dataset → Split(covid19_Dataset[ ], 80, 20)
Shuffle(Training_covid19, Testing_covid19)
Covid19_Dataset_CNN → Covid19_Dataset_CNN (Training_covid19)
Evaluation → Covid19_Dataset_CNN (Testing_covid19)
Return positive/negative/uncertain
End

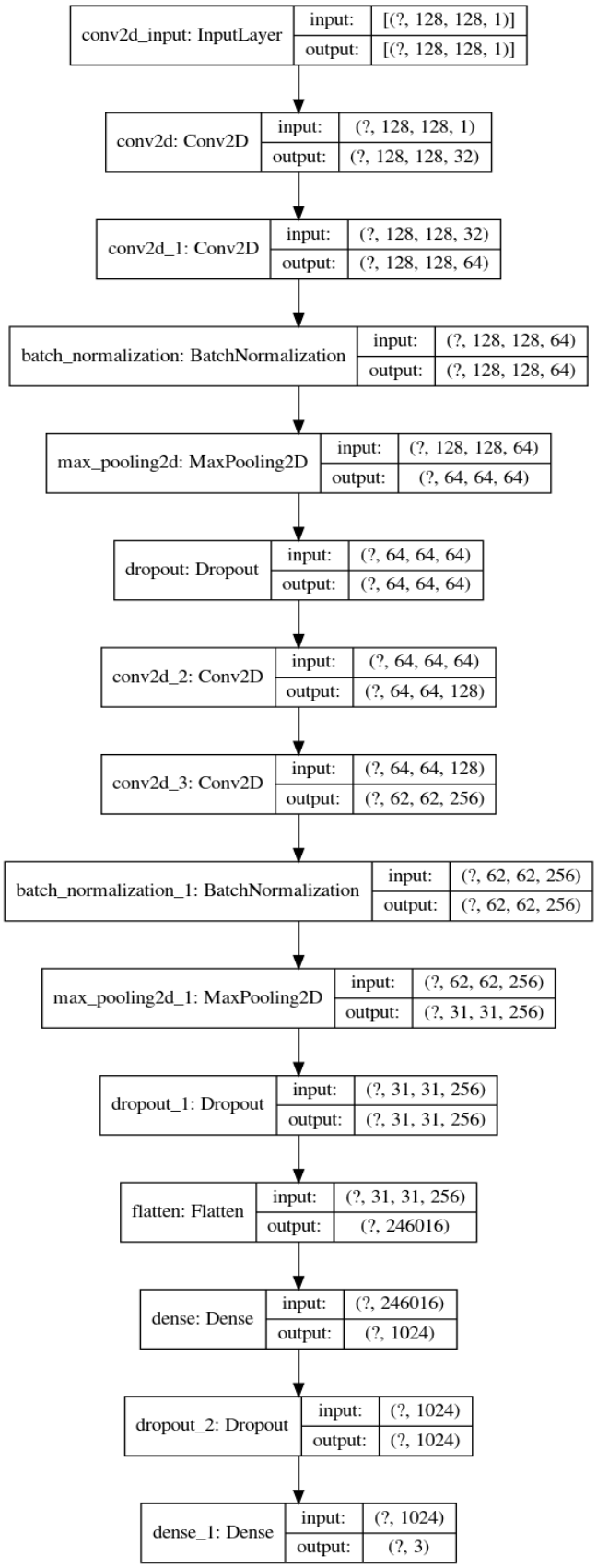

Fig. 1, Architecture of above proposed convolutional neural network model.

IV. EXPERIMENTAL RESULTS

In this paper, we proposed a Novel convolutional neural network model in order to detect the covid19 in Computed Tomography scans. The model is implemented in 4 stages (1) pre-processing (2) classification (3) models Implementation (4) Validation. In pre- processing stage images are converted in to jpeg format and resizing them into 128x128 pixels. Gabor filter is implemented in order to remove the noise from Computed Tomography images. In classification stage, the dataset is split in to training and testing sets in the ratio of 80,20 respectively. Thirdly Novel convolutional neural network, Resnet50, VGG16, VGG19, Mobile Net are trained using training sets. In Validation Phase all models are validated using test set. Without using Gabor filter, the Novel convolutional neural network achieves an accuracy of 0.85 with train loss 0.04 and test loss of 0.60, Resnet50 achieves an accuracy of 0.81 with train loss 0.05 and test loss of 0.22, VGG16 achieves an accuracy of 0.78 with train loss 0.05 and test loss of 0.22, VGG19 achieves an accuracy of 0.71 with train loss 0.16 and test loss of 0.17, Mobile Net achieves an accuracy of 0.89 with train loss 0.07 and test loss of 0.12.

Using Gabor filter, the Novel convolutional neural network achieves an accuracy of 0.93 with train loss 1.48 and test loss of 1.73, Resnet50 achieves an accuracy of 0.91 with train loss 0.06 and test loss of 0.27,VGG16 achieves an accuracy of 0.89 with train loss 0.28 and test loss of 0.30,VGG19 achieves an accuracy of 0.91 with train loss 0.21 and test loss of 0.23,MobileNet achieves an accuracy of 0.91 with train loss 0.09 and test loss of 0.26.The Proposed model classify the Computed Tomography Scan to positive covid19 or Negative covid19 or uncertain to determine. After analysing the performance metrics the proposed model gives better results when they are compared with ResNet50, VGG16, VGG19, Mobile Net models.

In Fig-2 with an increase in epoch the accuracy is also improving. From 20 to 60 epochs the model loss is drastically decreasing which states that the proposed model is learning at faster rate and from 60 epoch there is very less reduction of model loss. In Fig-3 the proposed model using Gabor filter accuracy is increasing with an increase in epoch and is better than Fig-2. with a increase in epoch the model loss is decreasing. In Fig-4 the resnet50 without using Gabor filter accuracy is increasing with an increase in epoch. from 10 to 50 epochs model loss is almost same which states that the model is learning at faster rate. In Fig-5. the resnet50 using Gabor Filter the accuracy is increasing drastically with an increase in epoch and is better than Fig-4. The Validation accuracy is increasing with an increase in epoch which states that the model is validating the test set at better rate. The train loss is reducing at constant rate from 30 to 70.

In Fig-7 the validation and train accuracy at epoch 70 is same and shows better validation accuracy when compared in Fig-6 and validation loss at each epoch is reducing and is better than the vgg16 without Gabor Filter. In Fig-8 with an increase in epoch the accuracy is improving and from 10 to 70 epochs the model accuracy is strictly increasing, and train loss is decreasing. In Fig-9 from epoch 30 there is an overlap of train accuracy and validation accuracy which states the model had trained and tested very well and there is no problem of overfitting and underfitting and it is better than VGG19 without using Gabor Filter Fig 8. From epoch 30 The model loss is almost overlapping with validation loss. From epoch 0 the validation loss is less when compared it with the train loss. In Fig-10 from epoch 10 the validation accuracy is more than the train accuracy. validation and train loss are almost overlapping from epoch 30 which states that there is no problem overfitting and under fitting. In Fig 11 using Gabor Filter the train accuracy is better than validation accuracy which states that model had trained very well and train loss is better than validation loss and Mobile Net using Gabor filter gives better results than using Mobile Net without using Gabor Filter.

The future scope of this work is to design a hybrid filter, which is a combination of different types of filters. For example, a hybrid filter can be designed by combination of gaussian filter and bilateral filter, which might work better than the traditional filtering methods for classification of coronavirus. The only limitation of this work is that the model is not accurate in classification of uncertain images.

A. Dataset Execution:

The proposed model and ResNet-50, VGG16, Resnet50, VGG19, Mobile Net models are implemented in Kaggle platform. 13GB Gigabytes of RAM and 16GB GPU and 3 CPUS are used for execution of these models. The datasets that are used in this work are publicly available covid19ComputedTomography Scan datasets. The datasets are split into training and testing sets in the ratio 80:20. The average time taken per each epoch for proposed model is 7seconds and average time taken per each epoch for ResNet-50 model is 8seconds, VGG16 is 9 seconds, VGG19 is 10 seconds and Mobile Net is 8 seconds.

B.Comparsion table

Table 1. Comparison table of accuracy and loss without using filter

S.NO	Model	Train Accuracy	Test Accuracy	Train Loss	Test Loss
1	Proposed Model	0.99	0.85	0.04	0.60
2	VGG16	0.98	0.78	0.15	0.19
3	VGG19	0.96	0.71	0.16	0.17
4	Resnet-50	0.99	0.81	0.05	0.22
5	MobileNet	0.95	0.89	0.07	0.12

Table 2. Comparison table of accuracy and loss using Gabor Filter

S.NO	Model	Train Accuracy	Test Accuracy	Train Loss	Test Loss
1	Proposed Model	0.99	0.93	1.48	1.73
2	VGG16	0.90	0.89	0.28	0.30
3	VGG19	0.92	0.91	0.21	0.23
4	Resnet-50	0.98	0.91	0.06	0.27
5	Mobile Net	0.97	0.91	0.09	0.26

C.Graphical Representation

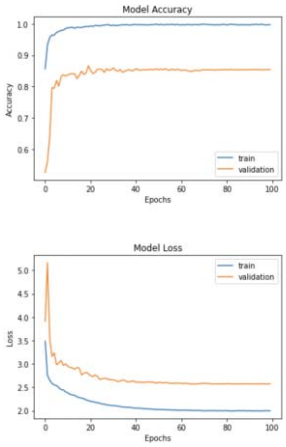

Fig .2, Accuracy and loss of proposed model without using Gabor filter

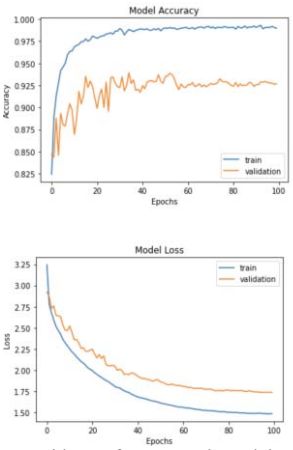

Fig.3, Accuracy and loss of proposed model using Gabor filter

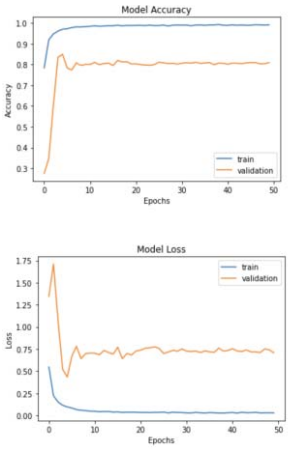

Fig .4, Accuracy and loss of resnet50 without using Gabor filter

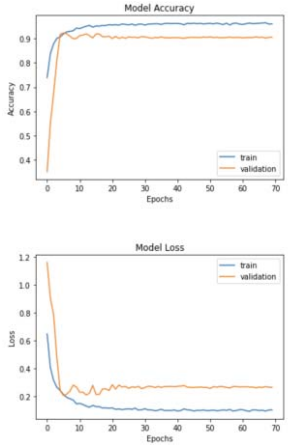

Fig.5, Accuracy and loss of resnet50 using Gabor filter

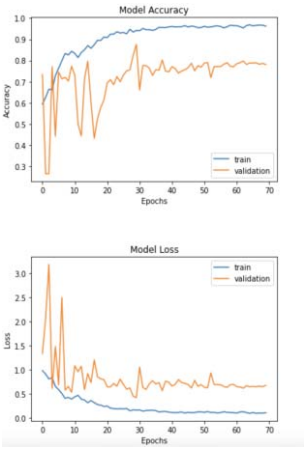

Fig .6, Accuracy and loss of VGG16 without using Gabor filter

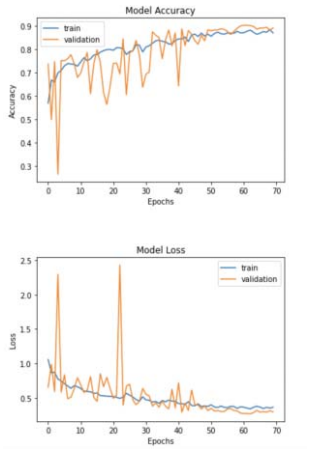

Fig.7, Accuracy and loss of VGG16 using Gabor filter

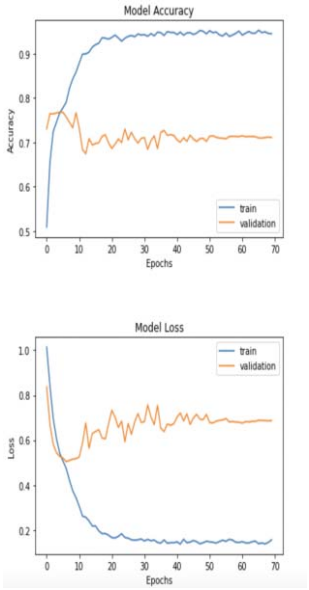

Fig .8, Accuracy and loss of VGG19without using Gabor filter

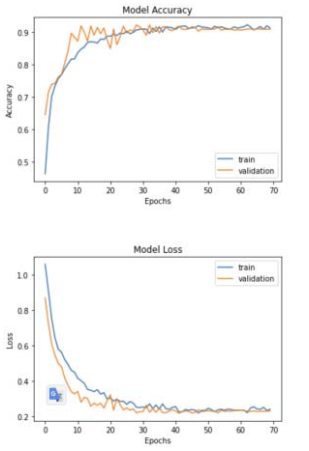

Fig.9, Accuracy and loss of VGG19 using Gabor filter

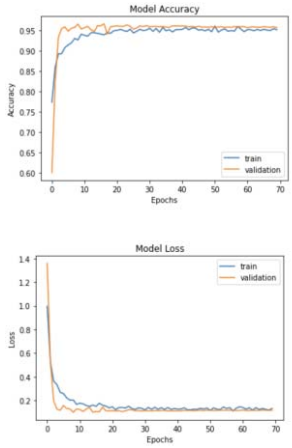

Fig .10, Accuracy and loss of Mobile Net without using Gabor filter

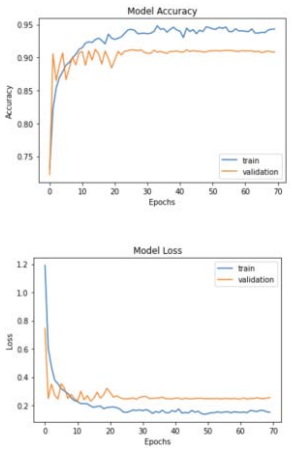

Fig.11, Accuracy and loss of Mobile Net using Gabor filter

V. CONCLUSION

The dataset is publicly available in Kaggle platform which contains Negative covid19, Positive covid19 and uncertain categories of images. Each category contains approximately 5000 images Firstly all the images are resized in to 128x128 pixels and converted them into jpeg format. The images are classified into Train and Test set in the ratio of 80 and 20. The proposed, Novel convolution Neural Network model detects covid19 in Computed Tomography Scans which contains six pooling layer, one dense layer and six convolution layers. The pooling layer summarizes the features by reducing the dimensions of feature map. The convolution layer will generate the feature map. In pre-processing stage, the computed Tomography Scans are resized into 128x128 pixels and converted them into jpeg format.

Using Gabor filter, the Novel convolutional neural network achieves an accuracy of 0.93 with train loss 1.48 and test loss of 1.73, Resnet50 achieves an accuracy of 0.91 with train loss 0.06 and test loss of 0.27, VGG16 achieves an accuracy of 0.89 with train loss 0.28 and test loss of 0.30, VGG19 achieves an accuracy of 0.91 with train loss 0.21 and test loss of 0.23, Mobile Net achieves an accuracy of 0.91 with train loss 0.09 and test loss of 0.26. Without using Gabor filter, the

Novel convolutional neural network achieves an accuracy of 0.85 with train loss 0.04 and test loss of 0.60, Resnet50 achieves an accuracy of 0.81 with train loss 0.05 and test loss of 0.22,VGG16 achieves an accuracy of 0.78 with train loss 0.05 and test loss of 0.22,VGG19 achieves an accuracy of 0.71 with train loss 0.16 and test loss of 0.17,MobileNet achieves an accuracy of 0.89 with train loss 0.07 and test loss of 0.12.On applying Gabor filter we are getting better results on all models. clearly our model Novel convolution Neural Networks outperforms the existing models ResNet50, VGG16, VGG19 and Mobile Net.

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