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Analysis of COVID-19 Chest X-ray Data using an Ensemble of Different Convolutional Architectures

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Abstract: ***After every 100 years, a pandemic comes and takes a great toll on the global civilization. This time its COVID-19 and the aftereffects are terrifying. As the symptoms for the disease are very common and are similar to common cold and viral influenza, the detection from symptoms is quite difficult. Although there are many methods devised but the detection of COVID-19 has been a problem since the start, and we are still struggling to identify whether a person has the disease. This study proposes a unique model to identify the positive and negative cases using X-ray images of an individual as lungs are the first and most critical body part which gets affected by the virus which causes a deprecation in oxygen saturation. The proposed model is an ensemble of different CNN architectures which are Dense Net, NasNet-Large, Resnet-50, Inception Net, EfficientNetB0 and EfficientNetB1. The results show that the model reaches an accuracy of 99.6% on the tested dataset.***
Keywords: Deep learning, Convolutional Neural Networks, COVID-19, Ensemble Learning, EfficientNet

I. INTRODUCTION

Coronaviruses are identified on basis of their structure and name means: “corona” means “crown.” The virus’s outer layers are covered with spike proteins that surround them like a crown. Coronaviruses is a type of virus. The coronavirus is identified in 2019, that caused a pandemic of respiratory illness, called COVID-19. The first case of COVID-19 was reported on Dec. 1, 2019, and the reason was SARS-CoV-2. According to some theories SARS-CoV-2 may have originated in an animal and mutated so it could cause illness in humans. In the past, there were so many diseases found to be infectious which were caused by different types of species for e.g., birds, reptiles, etc. that mutated to become dangerous to humans. For e.g., swine flu etc.

As of now, researchers know that the coronavirus is spreading through droplets when the virus particles released into the air. when an infected person breathes, talks, laughs, sings, coughs, or sneezes. so currently the way to protect the body from it is ask-wearing, hand wash with soap properly and physical distancing are essential to prevent the body from COVID-19.

COVID-19 have very harsh effects on body one of them is it can lead to respiratory failure, lasting lung and heart muscle damage, nervous system problems, kidney failure or death. When the virus gets in your body, it encounters the mucous membranes that line your nose, mouth, and eyes. The virus enters inside a healthy cell and uses the cell to make new virus parts. and then a chain reaction starts by this virus which starts infecting other cells inside the body. Let’s just Think of our respiratory tract as an upside-down tree. The trunk is your trachea, or windpipe. It splits into smaller and smaller branches in your lungs. The intake and out take of oxygen and carbon dioxide happens at alveoli which are small air sacs present at the bottom of every branch. It travels down your airways. The lining can become irritated and inflamed. In some cases, the infection can reach all the way down into your alveoli. COVID-19 is a new condition, and scientists are learning more every day about what it can do to your lungs.

Covid-19 can be detected in a body by several methods like laboratory testing, chest CT scan etc. Chest CT scan is very helpful to detect the virus in a body but not recommended on regular basis. Here we are introducing a model and algorithms to find the positive and negative cases for corona virus by using the chest CT scan. In our model we are using different convolutional architectures which are proven to be quite efficient in the past and performed very well in different use case scenarios. Many researchers have already proposed several models which performed very well in classification tasks of many covid-19 dataset but here we proposed a novel ensemble learning approach which uses the capability of several CNN architectures to their best and increases the accuracy to a near perfect score (99.6%). Our model is based on well-known CNN models which are DenseNet , EfficientNetB0 , EfficientNetB1 , MobileNet , NasNet and ResNet. Although these models performed very well and give us the score of above 95% But our proposed model exceeds those numbers a very big margin.

The next section of the research article describes the definition of all the CNN architecture used in this work. The section which follows section 2 represents the result and the analysis of experiments that were performed. The section 4 we give the all the conclusions and results that we got and all the future work that we are planning to do following this article.

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II. CNN ARCHITECTURES

Convolutional Neural Network (CNN) is an improvement upon deep learning (DL) methodology called Artificial Neural Networks. It is mainly used for image classification as CNN is used as a tool for feature extraction and ANN is the DL technology used for the classification task. A CNN architecture mainly consists of an input layer, some hidden layers which uses different activation functions as ReLU and SoftMax. For improvement in performance of CNNs, many developments have been made such as addition of normalization and dropout functions which mainly help for regularization. In the given figure, we explain the basic structure of Convolutional Neural Network.

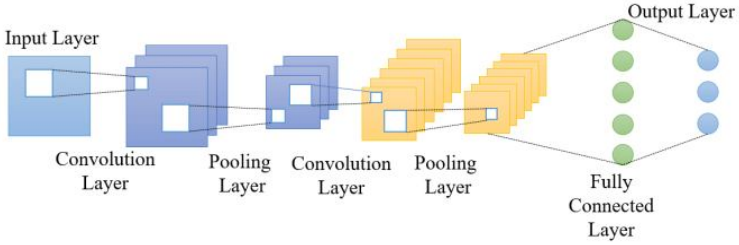


Fig 1: Basic CNN architecture

A. ResNet

In ResNet, residual networks are used in this architecture as vanishing gradient/exploding gradient problems were not solvable in normal CNN architectures. Residual networks use a methodology called “Skip Connections” which helps the network to skip few middle layers and connects them directly to the output layer.

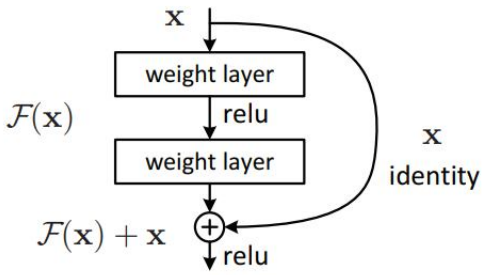


Fig 2: Residual Network Block

The main advantage of skipping several connections is that it helps to skip all the layers which affect the performance of the whole network by serving as the regularizing method. It helps to train deep networks and helps us to get back at vanishing gradients.

B. DenseNet

DenseNet very similar to Residual Net aside from a few variances. In case of ResNet we use addition method which basically merges the previous layer with the next layer apart from which in Densenet we use concatenation between the previous and next layer.

DenseNet also helps us to resolve the vanishing gradient problem. In this research work we use DenseNet-121 architecture.

There are 5 convolutional and pooling layers with 3 transition layers of size 6,12 and 24. It also has one classification layer of size 16 followed by 2 dense blocks of size 1x1 and 3x3 conv. Upon calculation, we get 121 layers in total(5+(6+12+24+16)*2).

C. Mobile Net

MobileNet makes use of depth wise separable convolution. It mainly reduces the total number of parameters while comparing with the normal convolutional network which have the same depth. This makes the architecture into lightweight DNN (Deep neural Network). A depth wise separable convolution is made up of depth wise convolution and pointwise convolution. In depth wise convolution, a single convolution map is applied on every input channel individually. In pointwise convolution, a 1*1 conv is applied which combines the features given by the depth wise operation.

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D. Nas Net

NasNet uses reinforcement learning to find out the best CNN architecture. The main idea of this model is to hunt the best amalgamation of parameters of a known search space of number of layers, filter sizes, strides, output channels, etc. In this Reinforcement Learning setting, the reward after each search action was the accuracy for the searched architecture on the given dataset.

E. Efficient Net

Efficient Net provides better accuracy by increasing the efficiency of the models by decreasing the number of parameters and Floating-Point Operations Per Second (FLOPS) manifold. The major contribution of this model is to provide an efficient method for compound scaling to increase the size of the model to maximize accuracy. Two major architecture, EfficientNet-B0 and EfficientNet-B1 are used in this paper.

F. Proposed Method

An ensemble of all the above architectures is made. It is shown in the figure below.

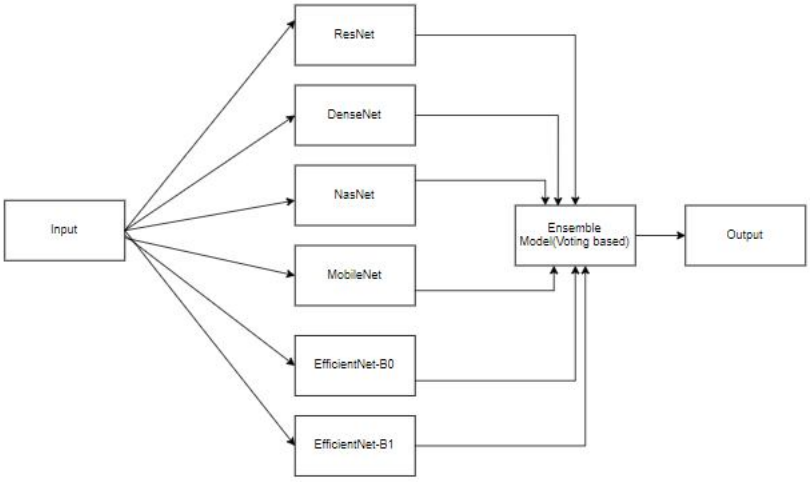


Fig 3: Ensemble Model

III.RESULTS AND ANALYSIS

A. Dense Net Results

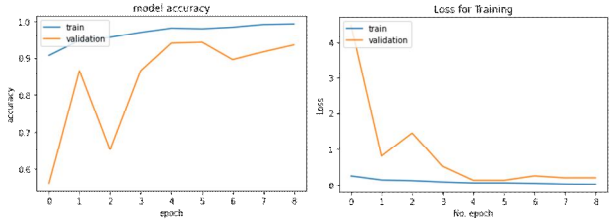


Fig 4: Accuracy and loss curves for Dense Net

The accuracy and loss curves with number of epochs of Dense Net is given in the above figure. The accuracy achieved by the model is 95.3%. The confusion matrix is given below.

	Covid-19	Normal
Covid-19	97.8%	2.2%
Normal	7.2%	92.8%

Table 1: Confusion Matrix for DenseNet

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B. ResNet Results

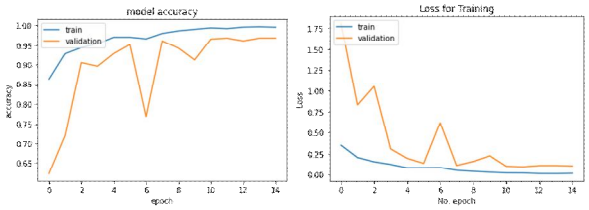


Fig 4: Accuracy and loss curves for ResNet

The accuracy and loss curves with number of epochs of Res Net is given in the above figure. The accuracy achieved by the model is 99%. The confusion matrix is given below.

	Covid-19	Normal
Covid-19	99.4%	0.6%
Normal	1.4%	98.6%

Table 2: Confusion Matrix for Res Net

C. NasNet Results

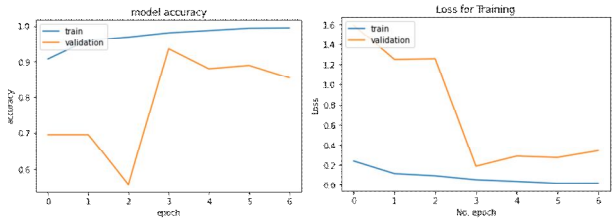


Fig 4: Accuracy and loss curves for Nas Net

The accuracy and loss curves with number of epochs of Nas Net is given in the above figure. The accuracy achieved by the model is 96.8%. The confusion matrix is given below.

	Covid-19	Normal
Covid-19	96.7%	3.3%
Normal	3.1%	96.9%

Table 3: Confusion Matrix for Nas Net

D. Mobile Net Results

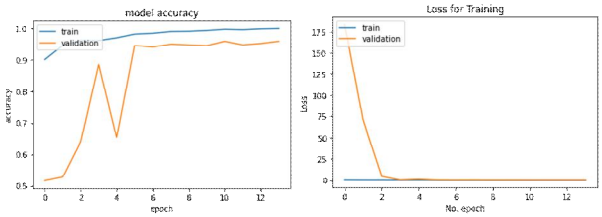


Fig 4: Accuracy and loss curves for Mobile Net

The accuracy and loss curves with number of epochs of Mobile Net is given in the above figure. The accuracy achieved by the model is 97.4%. The confusion matrix is given below.

	Covid-19	Normal
Covid-19	95.1%	4.9%
Normal	0.3%	99.7%

Table 4: Confusion Matrix for MobileNet

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E. Efficient Net-B0 Results

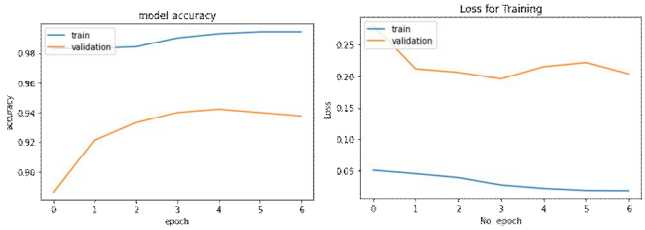


Fig 4: Accuracy and loss curves for Efficient Net-B0

The accuracy and loss curves with number of epochs of Efficient Net-B0 is given in the above figure. The accuracy achieved by the model is 96.5%. The confusion matrix is given below.

	Covid-19	Normal
Covid-19	98.2%	1.8%
Normal	5.2%	94.8%

Table 5: Confusion Matrix for Efficient Net-B0

F. Efficient Net-B1 Results

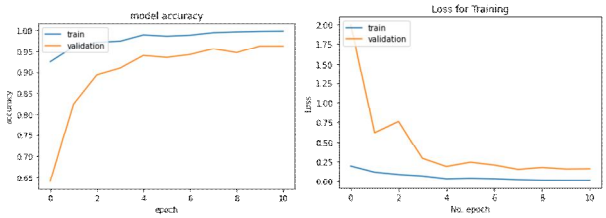


Fig 6: Accuracy and loss curves for Efficient Net-B1

The accuracy and loss curves with number of epochs of Efficient Net-B1 is given in the above figure. The accuracy achieved by the model is 99.3%. The confusion matrix is given below.

	Covid-19	Normal
Covid-19	99.5%	0.5%
Normal	0.9%	99.1%

Table 2: Confusion Matrix for Efficient Net-B1

G. Proposed Ensemble Model

The proposed model increases the accuracy to 99.6%. The confusion matrix is given below.

	Covid-19	Normal
Covid-19	100%	0.0%
Normal	0.8%	99.2%

Table 2: Confusion Matrix for Proposed Model

IV. CONCLUSION

After careful examination of rising covid cases its very difficult to determine whether a person is affected by covid or not. There are some post covid side effects too which are hard to examine or predict. So, for that we proposed a CNN model which focuses on the most affected body part covid which is lungs, so we are taking the dataset of Chest X-ray lungs images and predicting even if there are no symptoms in the covid affected body, then also we are examining whether the covid affected the lungs of the body or not.

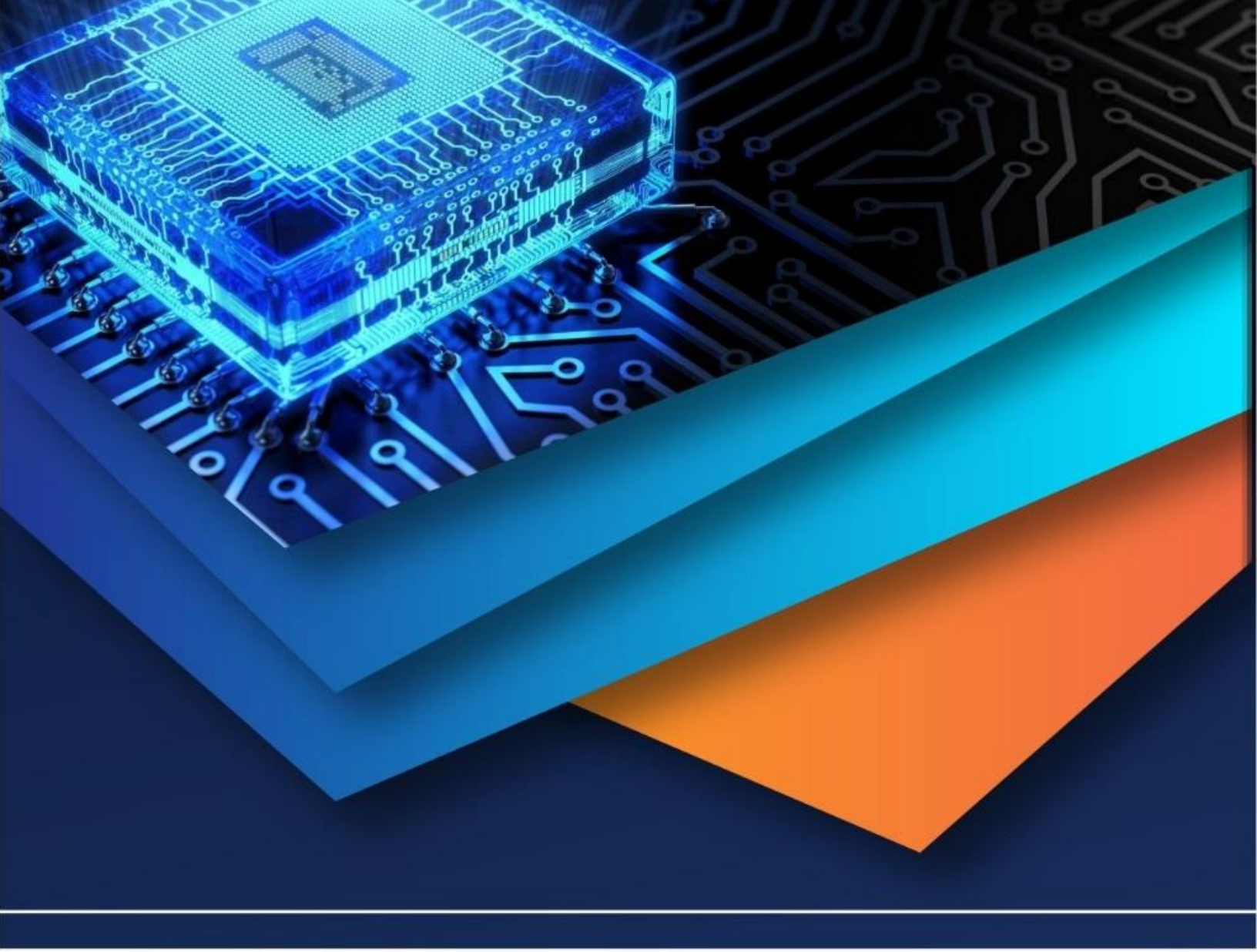
But still a lot of research still needs to be done regarding prediction of the how much of the lungs that Covid has affected in percentage. We are continuing our research for more accurate models for three-class and four-class datasets which can even predict if the lungs have pneumonia or not.

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