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Coronavirus Disease (COVID-19) detection from frontal chest X-ray images using deep convolutional neural network

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ABSTRACT: *Coronavirus disease (COVID-19) is one of the most contagious diseases in the world. The early diagnosis of this disease is very important because of its infectious nature. The various tests are performed to detect the COVID-19 virus in humans on sputum or blood samples using reverse transcriptase polymerase chain reaction (RT-PCR) and this is the main diagnosis technique for most of the country. The results for these tests are available within a day but the problem faced by the most of the country is the lack of kits. On the other hand, the X-ray machine is available in most of the hospitals and clinics and the X-ray images are also available within a few minutes. The COVID-19 infected patients have abnormalities in the chest which can be identified by examining the chest X-ray. The aim of this study is detection of the COVID-19 from frontal chest X-ray images using the proposed deep convolutional neural network (CNN) model. In this paper, a thirteen layers deep CNN model is proposed which can detect the Covid-19 using chest X-ray images with higher performance classification and hopefully it will be very helpful to make the early diagnosis of COVID-19 cases.*

KEYWORDS: *Coronavirus, COVID-19, RT-PCR, Frontal Chest X-ray images, Deep Convolutional Neural Network (CNN).*

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I. INTRODUCTION:

The novel coronavirus COVID-19, the infectious disease has spread worldwide from China and the world has been facing a pandemic situation. As of 6 october 2020, there are 35,347,404 confirmed cases reported with 1,039,406 deaths according to the world health organization (WHO) [1]. The first step to mitigate the spreading of COVID-19 is the effective detection of infected people and then isolate them with proper treatment. Now the worldwide main screening system used for detecting COVID-19 is real time reverse transcriptase polymerase chain reaction (RT-PCR) testing which can detect COVID-19 in human's respiratory specimens [2]. The coronavirus COVID-19 is spreading rapidly worldwide, there is a lack of RT-PCR kits in most of the country and the sensitivity of RT-PCR is variable which depends on how the specimens are collected. Since the coronavirus initially affects the human respiratory system, the major abnormalities present in chest radiography images of those are infected with COVID-19 [3]. That's why chest radiographs like X-ray or CT scan images can be used as primary tools for screening the COVID-19 disease.

The X-ray imaging is widely available and easily accessible for most of the hospitals and it will be the best choice for primary assessment. Although the chest X-ray and CT scan is used for COVID-19 screening in hospitals for admitted patients [4]. The CT scanner machine is not portable and also not widely available in most of the hospitals. So to mitigate the spreading of COVID-19 virus, the X-ray imaging can be used for primary assessment.

In this study, we used X-ray images for detecting coronavirus disease (COVID-19) using a proposed deep convolutional neural network model. The manuscript is organized as follows: Dataset processing is described in section II. The proposed methodology is clearly explained in section III. Result and performance analysis is described in section IV and finally concludes the whole study in section V.

II. DATASET PROCESSING:

The chest X-ray dataset was collected from the kaggle repository which was uploaded by Wei Hao Khoong [5]. Wei Hao Khoong transformed the X-ray data from the main source github repository [6,7]. Since

COVID-19 disease is a new case in the world, there are a limited number of organized chest X-ray of COVID-19 patients available in different online repositories. In this dataset contains a total 188 frontal chest X-ray images belonging to two classes Normal and COVID-19 Pneumonia. There are 148 chest X-ray images for training data with 74 Normal and 74 COVID-19 Pneumonia and 40 chest X-ray images for validation data with 20 Normal and 20 COVID-19 Pneumonia. Figure 1 and Figure 2 shows the frontal chest X-ray images of normal and COVID-19 infected peoples respectively.

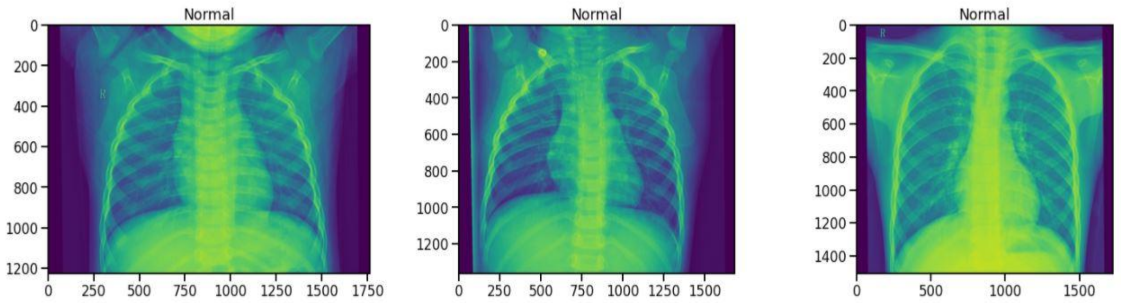

Figure 1: Chest X-ray images of normal peoples.

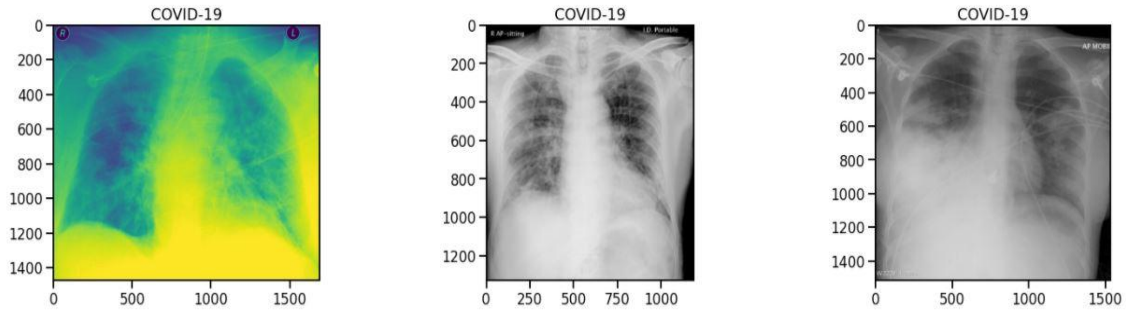

Figure 2: Chest X-ray images of COVID-19 infected patients

III. PROPOSED METHODOLOGY:

There many works are done to detect the COVID-19 Pneumonia on chest X-ray images using different deep learning built in image classification network models [8,9]. These are actually done using the transfer learning system. But in this study we actually built our own model to classify the chest X-ray images into two classes of normal or COVID-19.

In this section, we explained our proposed deep convolutional neural network model and the implementation process with training and validation steps.

A. Proposed Deep Convolutional Neural Network:

To classify the chest X-ray images, we proposed a deep convolutional neural network model of total thirteen layers. Our proposed model consists of a total three convolution layers with ReLu activation function followed by three MaxPooling layers. Three convolutional layers extracting 16, 32 and 64 numbers of filters respectively. There is a BatchNormalization layer after the first convolutional layer to enhance the stability of the neural network. We used two Dropout layers at the rate of 0.2 to prevent the network from overfitting.

After that, flatten the feature map to a single dimensional tensor to add the fully connected layer. Then added a fully connected dense layer with ReLu activation function and 512 hidden units. Finally the output layer with sigmoid activation function to classify the chest X-ray images into two classes. This model contains the total numbers of 9,494,625 parameters with 9,494,593 trainable parameters and 32 non trainable parameters. Table I shows the architecture of the proposed model.

Table I: Architecture of proposed model

Layer	Operation	Output Shape
01	Input Layer	[(None, 150, 150, 3)]
02	Conv2D	(None, 148, 148, 16)

03	BatchNormalization	(None, 148, 148, 16)
04	MaxPooling2D	(None, 74, 74, 16)
05	Conv2D	(None, 72, 72, 32)
06	MaxPooling2D	(None, 36, 36, 32)
07	Conv2D	(None, 34, 34, 64)
08	MaxPooling2D	(None, 17, 17, 64)
09	Dropout	(None, 17, 17, 64)
10	Flatten	(None, 18496)
11	Dense	(None, 512)
12	Dropout	(None, 512)
13	Dense	(None, 1)

B. Training and Validation Process:

The dataset contains the total number of 188 images, for training purposes we used 148 images and for validation 40 images. Before the convolution layer, each image is reshaped into a size of (150, 150) pixels with 3 channels for RGB colors. The ReLu activation function is used in each convolution layer and the sigmoid activation function used in the final output layer as it is a binary classifier model. By varying the learning rate of the optimizer, finally selected the proper rate at which it shows the better learning curve. The RMSprop optimizer with the learning rate of 0.001 and binary cross entropy as the loss function are used in the model. The image batch size of 20 is used for the training and validation process. The training and validation process runs with 10 epochs to fit the model. Figure 3 shows the learning curve of the proposed model.

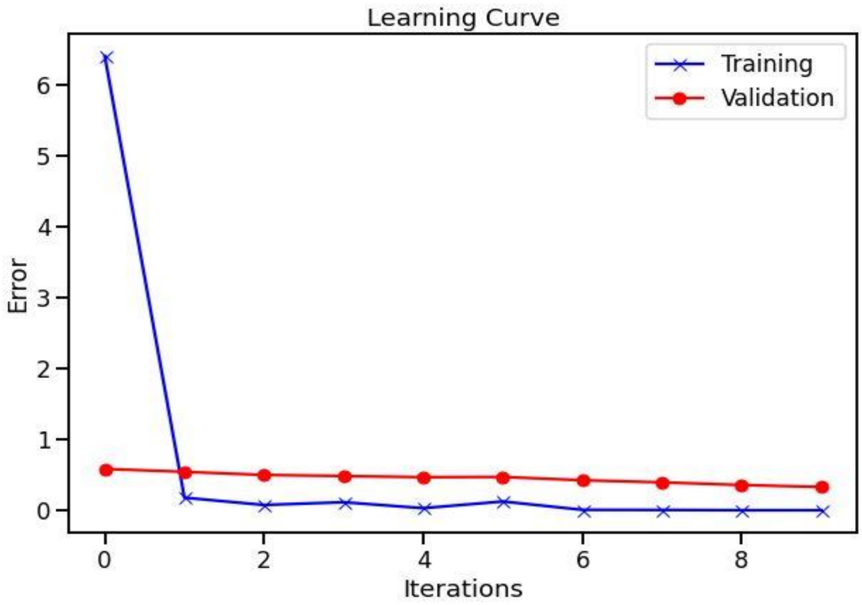

Figure 3: Learning curve of the proposed model.

IV. RESULT AND PERFORMANCE ANALYSIS:

We used python code on google colab platform using the python's keras and tensorflow libraries to run the proposed model. It was connected to the "Python 3 Google Compute Engine Backend" in the runtime session using the intel core i3 PC. Python's Matplotlib Library is used to visualize the experimental results. After the training phase with 10 epochs the validation accuracy reached to 99.5% where training accuracy was close to 100%. The trained model was tested with randomly selected chest X-ray images of normal or COVID-19 and the model showed the accurate results. Figure 4 and figure 5 shows the model accuracy and model loss with the number of epochs respectively.

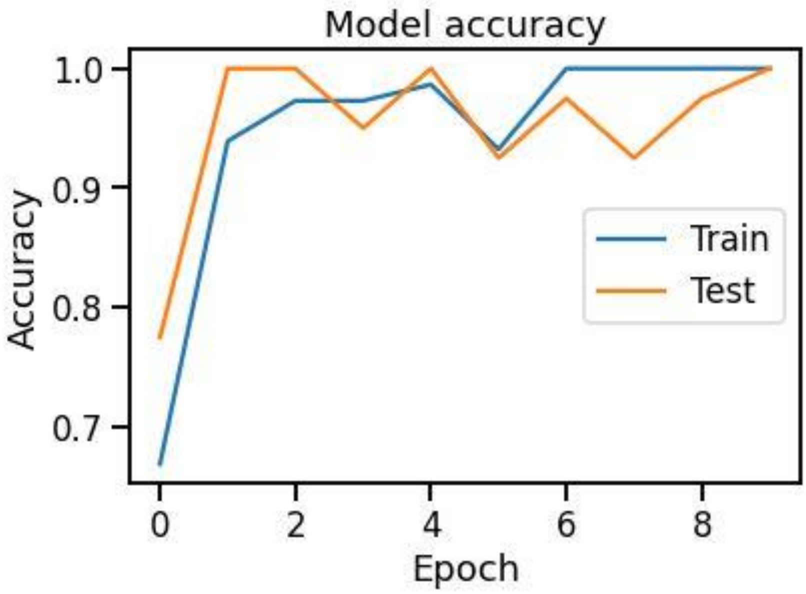

Figure 4: Model Accuracy with number of epochs

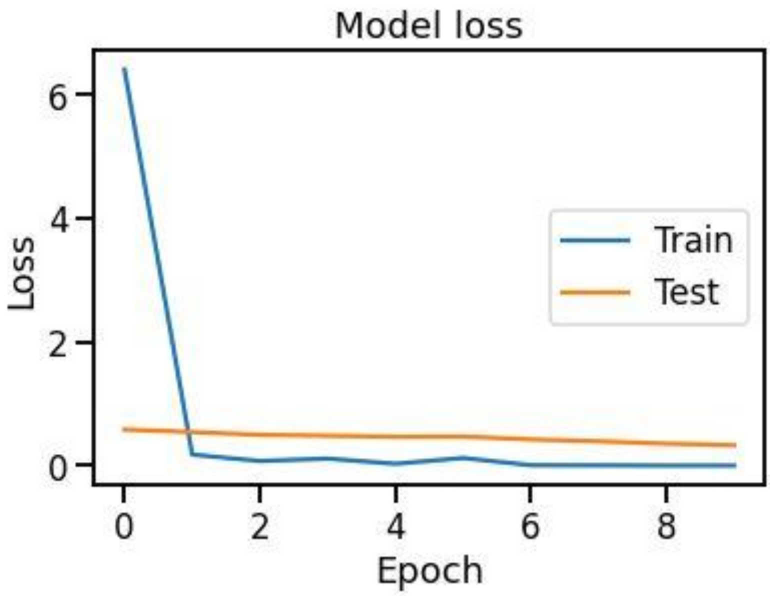

Figure 5: Model loss with number of epochs

Since we used 148 images for training this proposed model, the accuracy of the model reached close to one because of more parameters than it requires. The is validated with 40 images and that's why the loss decreased to very lower value within the small number of iterations.

V. CONCLUSION AND FUTURE WORK:

In this paper, we used a deep convolutional neural network model to classify the frontal chest X-ray images into two classes of normal or COVID-19 and proposed a lightweight deep CNN model with approximately 9.5M parameters. The proposed model ran with the validation accuracy of 99.5% with only ten epochs. Since our dataset contained a small number of chest X-ray images, the model required only ten epochs to reach the higher accuracy.

In future we will run this proposed model with a large number of frontal chest X-ray images and achieve the higher accuracy performance by tuning the different hyperparameters of the model.

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