COVID Detection from CXR PA view Images

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***Abstract*— Because of the exponential spread of Covid-19, everyone across the globe experienced unprecedented events. For a brief period of time, the world was shut down and pushed into isolation. Diagnosis took an unusually long time, causing life-style delays. This paper examines the use of popular deep learning method CNN and transfer learning methods MobileNet, VGG16, and ResNet50 in classifying chest X-ray images into healthy regular, Covid, and Pneumonia categories by verifying patterns of virus presence in the lungs. The accuracy of these methods concludes that, though the CNNS model achieved greater than 90% accuracy, transfer learning models performed better and achieved greater than 95% accuracy. These methods may aid in the conduct of rapid testing in order to save time and effort.**

***Index Terms*— Covid-19, CXR, CNN, Transfer Learning, Image Classification**

I. Introduction

THe world has suffered greatly in recent months as a result of a novel virus that has caused a new age pandemic and has pushed the world into unprecedented times. Severe Acute Respiratory Syndrome coronavirus 2 which is commenly known as (SARS-CoV-2) is the underlying cause of this disease. It is a completely new virus enshrouded with a sizable mono RNA molecule. Given the severity of the situation, the World Health Organization (WHO) declared COVID-19 a global health emergency on January 30, 2020. [1]

The medical community has been using listed below methods to test for the presence of the corona virus in a human system. [2]

1. Computed Tomography (CT) scans-based assessment: In this process 3D radiographic images are examined to verify the virus presence, but the necessary equipment is not widely available in many hospitals, moreover this is a time-consuming process. Hence this is not the best method for practical reasons.

2.RT-PCR (Reverse Transcription Polymerase Chain Reaction) test: This test is used to confirm the presence of viral RNA in sputum or a nasopharyngeal swab. The results may take 10-12 hours to be announced. Though this is a widely used method to detect virus presence around the world, the scarcity of required equipment and false negative rates make this method less accurate and less accessible.

3.Chest X-Ray (CXR): A lung X-ray image will be analyzed using this method for the presence of virus and lung damage can provide faster results. Because the equipment required for this is not heavy and is readily available, this method is both cost and time efficient.

Majority of patients with confirmed coronavirus disease who were admitted to urgent care centers in 2019 have CXR findings that are usual or moderately unusual. [3] Covid-19 virus is quantified in a study [4] Radiographic Assessment of Lung Edema (RALE) grade. This new grade is determined by applying a specific in 0 and 4 to each lung dependent on the degree of perceivable information similar to convergence and ground glass opacities in every one of the 4 segments of the lung illustrated in fig. 1. Different severity levels are characterized by various grades. Normal is 0, Mild is 1-2, Moderate is 3-5, and Severe is 6-8.

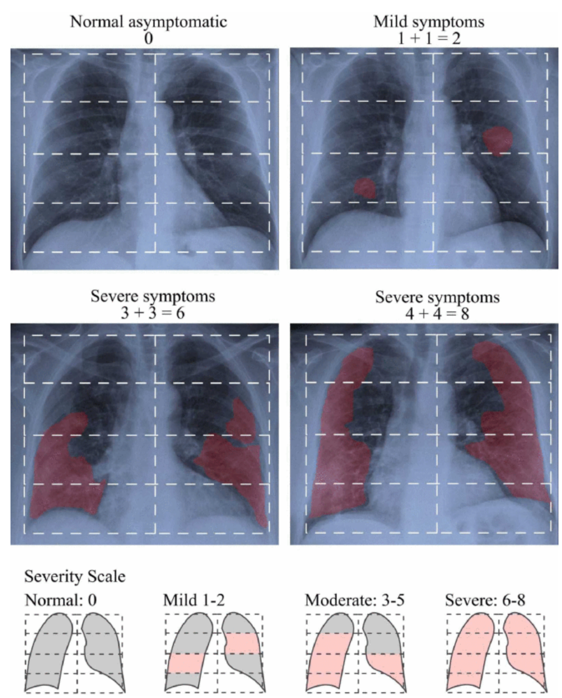

Fig. 1. Fig. 1.COVID-19 radiological severity stratification.

In this paper, chest X-rays from three different categories will be examined using CNN models to separate the X-rays from covid infected patients.

The hypotheses investigated in this paper are as follows:
1) To differentiate covid infected patients' x-ray images from normal and phenomena.
2) Examine the X-ray of the covid-infected patient for the presence of virus.
3)Compare the performance of CNNs and Transfer learning models.

The motivation for using deep neural network is: DNN

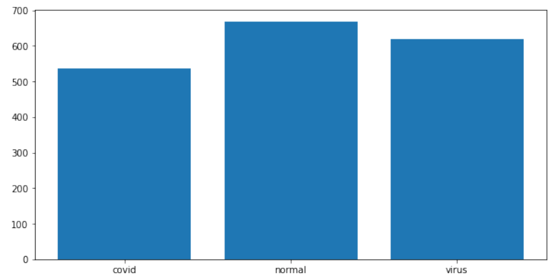

Fig. 2. The distribution of categories count.

has produced outstanding results in a variety of fields in recent years, including computer vision, medical imaging processing, natural language processing, and robotics. With the advent of advanced computing power and efficient graphical processing units, Neural networks are able to solve complex problems. Neural networks are created by drawing inspiration from neurons in the human brain. The efficiency of CNNs stems from their self-optimization capability and ability to extract features and classify images with greater accuracy. Furthermore, CNNs can produce precise output with a limited amount of output.

II. Dataset Description

This dataset contains 1823 annotated posteroanterior (PA) views of Chest X-ray images. For viral pneumonia and healthy cases, labeled Optical Coherence Tomography (OCT) and CXR images are taken into consideration. The dataset includes 536 COVID-19 images, 619 viral pneumonia images, and 668 images of regular healthy cases. The Carona virus infected cases in the dataset range in age group between 18 to 75 years. The data set is freely accessible on kaggale. The URL to access the dataset is https://www.kaggle.com/sid321axn/covid-cxr-image-dataset-research . Coronavirus infected displays ground-glass opacification and consolidation in the right upper lobe and left lower lobe, while viral pneumonia (center) shows a much more amorphous ”interstitial” structure in two lungs. The image of normal lug shows no unusual opacification particulars. [8]

III. Methods

A. Data Preparation

70% of the data from the total available data, to train the CNN model and 15% for testing, and the rest of the 15% was utilized to validate the model.

COVID19 images have a significant difference in measurements when compared to other image classes, with more height and width. Thus causing the difference in the size of the images when compared with other class images. Before processing the data, all the data images should be of same size. Moreover increasing the data set by adding more samples will increase the accuracy in results. This is achieved by using Image augmentation.

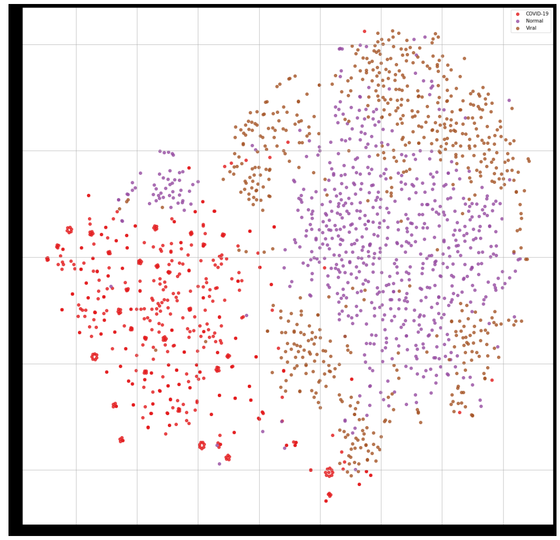

Fig. 3. The t-SNE plot illustrates the dataset's spread of different types of input image information.

Fig. 4. X-rays of healthy lungs, as well as lungs affected with Viral Pneumonia and Coronavirus

Image Class	Min. width	Max. width
Normal	1040	2628
Covid-19	240	4095
Pneumonia	384	2304

Image Class	Max. height	Max. height
Normal	650	2628
Covid-19	237	4095
Pneumonia	127	2304

Image augmentation is a technique for increasing the size of an image data set by creating different variations of the images, which aids in enhancing the knowledge gained from the images by the fit models. This is accomplished by flipping, shifting, and changing the brightness and zoom properties of the specific image. This work employs the keras deep learning library ”ImageDataGenerator” to augment images. This function is applied to all three data sets (train, test, and validation).

B. Models

Data bricks provides integrated and secure environment with impeccable velocity to analyze huge volumes of data sets. Additionally data bricks provide work place facilities of deployment version control for real world problem solving. Spark‘s read function lets image to be loaded into a data frame which further can be converted into pandas data frame. The same functionally can be achieved by using cv2.imread() method, which loads an image from the specified file.

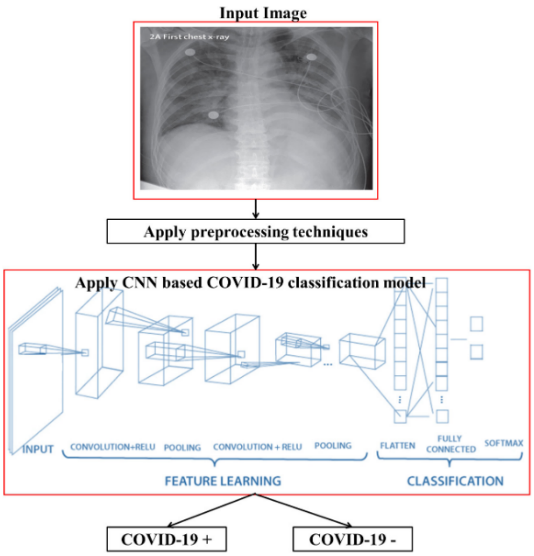

Fig. 5. Schematic diagram of CNN-based COVID-19 classification.

The classification of the images is done using convolutional neural network(CNN) as they are quite success full in doing the medical image processing in the current years. The CNN used here is made up of three layers, with 'Relu' as the activation function in each. The input shape of the image for the input layer is '224,224,3'. At the end of the hidden layers a fully connected dense layer is implemented with 'softmax' activation function and 'adam' optimizer. [5]

Convolution, a mathematical operation is used by CNNs.These networks analyze visual imagery using a shared weight architecture rather than matrix multiplication, as simple neural networks do.

The network's convolution layer extracts features from images by sliding through them. To get the features from the corners and edges, the weighted values are passed through an activation function and padded. [7]

The layer employs a pooling layer to reduce computation complexity through dimension reduction. To reduce the size of the data, mean sampling, maximum sampling, and probability sampling are commonly used. [6]

The issue with deep learning networks is that they require massive amounts of data to train in order to produce accurate results. Transfer Learning (TL) is a better option for producing accurate results with less data. The central idea behind transfer learning is to take advantage of a deep learning model's knowledge by training on a significantly larger data set.

These networks aid in lowering training costs in terms of data size and time. These TL models have been pre-trained on benchmark computer vision data sets like image net.

Mobilenet, ResNet50, and VGG16 are used to classify the X-rays of the chest infected by coronavirus in this case. These TL models can be found in keras.applications.

MobileNets are built with a streamlined architecture that employs depthwise separable convolutions to create a light weight deep neural network. The hyper parameters allow you to select the best-sized model for your application.

ResNet-50 is a convolutional neural network with 50 layers

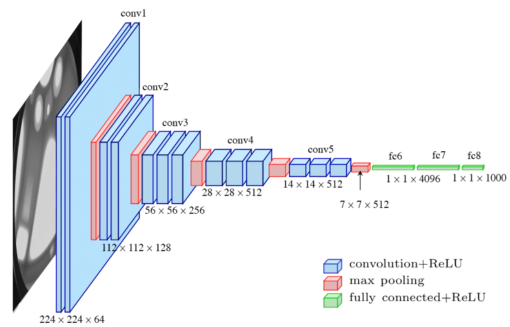

Fig. 6. VGG architecture

that has been pre-trained on millions of images from the ImageNet database and is capable of multiclass classification into 1000 classes. The network's typical input size is (224,224,3).

VGG-16 is a CNN configuration that ended up winning the 2014 ILSVR (Imagenet) contest. It is considered to be one of the efficient vision models. Throughout the architecture, this model is composed of convolution and max pool layers.

IV. Results

CNNs performed well in categorizing picture data into three categories (Covid, Normal, and Virus), but the drawback was an excessive amount of training time.

Accuracy and F1-Score information are provided below.

Class	Precision	recall	f1 Score
0	0.98	0.98	0.98
1	0.91	0.98	0.94
2	0.98	0.91	0.95

	Covid	Normal	Virus
Covid	106	2	0
Normal	1	126	2
Virus	1	10	117

Despite the fact that the scores appear to be impressive, there are only a few covid cases that have been identified as non-covid. This is risky, as the disease is contagious. As a result, false negatives have the potentiality to spread the disease further in areas where it should be quarantined. False positives cannot be harmful because they will only spend time in isolation and will not spread disease even if they do.

TL methods solve the problem of false negatives. TL MobileNet has a total of 0 false negatives.

	Covid	Normal	Virus
Covid	102	1	5
Normal	0	127	2
Virus	0	4	124

Furthermore, the Mobilenet has a lower training and validation loss. The images below explain the Loss for both the CNN and Mobilenet models. Perhaps because Mobilenet is a pre-trained network, the loss was reduced in the early stages.

VGG16 and ResNet50 accuracy values are identical to Mobilenet accuracy values. The diagrams below show the accuracy of the TL models VGG16 and ResNet50.

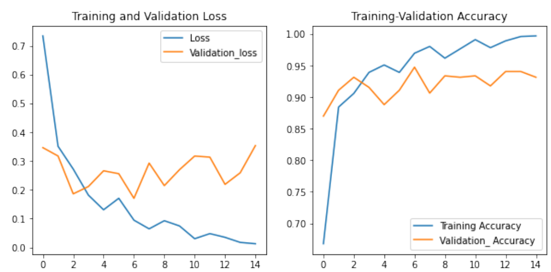

Fig. 7. Training Loss for CNN

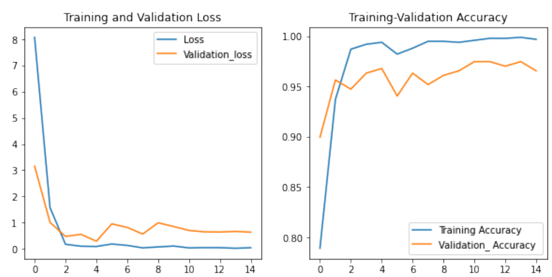

Fig. 8. Training Loss for MobileNet

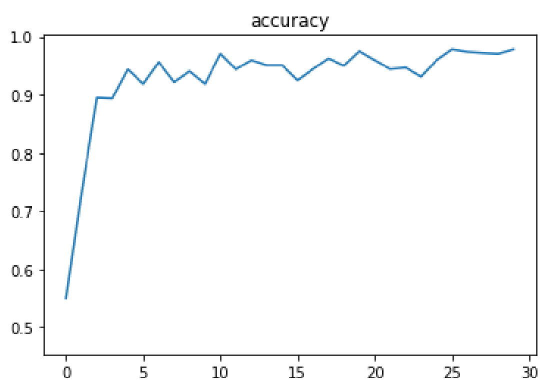

Fig. 9. VGG16 accuracy

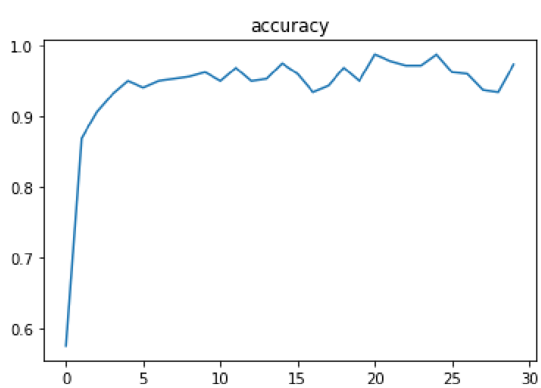

Fig. 10. ResNet50 accuracy

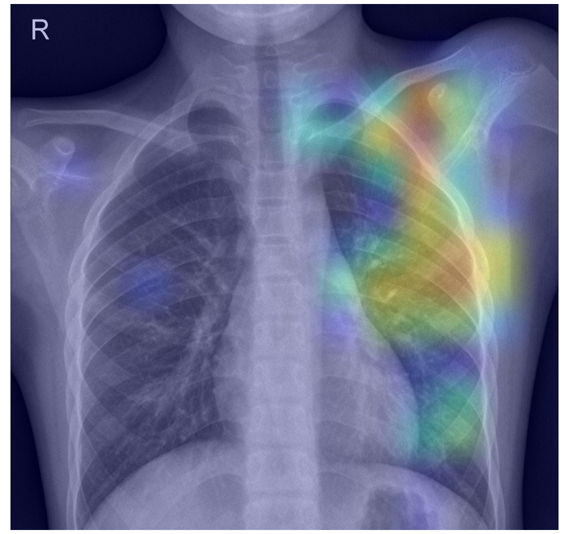

Fig. 11. Heat map using Gram cam for the virus infected area

V. Discussion

With the rapid speed of covid -19, it is critical to test the and announce the results at a rapid pace and with accuracy. As AI methods have advanced medical image processing, using neural networks to detect and classify Covid virus presence in X-ray images will assist the medical community and the general public in taking preventative measures to halt the virus's spread.

A. Hypotheses testing

First Hypothesis: all the methods used here are success in classifying covid x-rays from the other group of x-ray images.

Second Hypothesis: using the Grad cam visualisation the infected parts of the x rays are highlighted using the heat maps as shown in the fig 11. (Gradient-weighted Class Activation Mapping (Grad-CAM) generates a coarse localization map that highlights the crucial portion of the image for forecasting the feature by inputting the gradients of the target feature into the final convolutional layer.)

Third Hypothesis: CNNs took a reasonable amount of time to train and produced good results. Though not perfect, these results are reliable because the accuracy percentage level is greater than 90. MobileNet, VGG16, and ResNet50 transfer learning models produced more accurate results with no false negatives. The accuracy of these models is greater than 95 percent. To summarize, these DL methods can aid in the diagnosis of disease at a lower cost and in less time.

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