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A CNN Model for Detection of Covid 19 Disease Using Lungs CT - Scan

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Abstract: *The Corona Virus Disease popularized as COVID-19 is a highly transmissible viral infection and has severe impact on global health. It impacted the global economy also very badly. Corona virus is a rapidly spreading viral infection that has become a pandemic posing severe threats around the world. It is necessary to identify the cases priory so that we can prevent the spread of this epidemic. If positive cases can be detected early, this pandemic disease spread can be curtailed. Prediction of COVID19 disease is advantageous to identify patients at a risk of health conditions. A model for COVID prediction from Lungs CT-SCAN is presented in this project. One of the possible ways of determining the patient infection to COVID- 19 is through analysing the chest CT-SCAN images. This Application for COVID detection from CT scan can be very useful, and can help to overcome the shortage of availability of doctors and physicians in remote places. In this paper, we have trained several deep convolution networks with the introduced training techniques for classifying CT-SCAN images into two classes: COVID-19 and NONCOVID-19, based on two open-source datasets. The results obtained in COVID detection using VGG-16(Visual Geometry Group), ResNet50 (Residual Networks), Xception with a Good training and testing accuracy.*

Keywords: CT-SCAN, COVID19, NON_COVID19, VGG-16, ResNet50, Xception

I. INTRODUCTION

For the last one year, we are witnessing pandemic situation throughout the world due to COVID 19, a new corona virus first observed in Wuhan, China in December, 2019 first suspected as pneumonia. Then after initial study, the virus is identified as its genesis I Severe Acute Respiratory Syndrome (SARS) and is termed as SARS-CoV-2. This virus causes respiratory infections like cold at an early stage and can lead to the most severe respiratory attacking diseases like Middle East and Severe Acute Respiratory Syndromes called MERS and SARS. The clinical features of the disease include fewer, sore throat, headache, cough, mild respiratory symptoms even leading to pneumonia.

The testing techniques that are being currently used for COVID diagnosis are Polymerase Chain Reaction (PCR) and Reverse Transcription PCR popularly known as RT-PCR. As RT-PCR tests take much time for prediction, and also due to limited availability of these test kits, early detectioncannot be done which in turn increases the spread of disease. COVID became a pandemic effectingglobally and right now there is no vaccine available to cure this. In this epidemic situation Artificial Intelligence (AI) techniques are becoming vital. Some of the applications where AI is imported are- AI is employed in cameras to trace infected patients with travel history using face recognition, robots to dis-patch food and medicines, drones to sanitize public places etc. Nowadays Artificial Intelligence is significantly being used to analyzeRNA structure of COVID-19 virus and in research for discovering its drugs and vaccine. A vast research is being carried out in using AI in health care systems widely from disease prediction, patient monitoring, analyzing RNA structures, discovering new drugs and medicines for disease cure and developing vaccines for many diseases.

Recently, many researchers widely used radiology images for COVD-19 detection. The observation from the lungs CT-Scan is a dis-criminating factor; if the lungs CT-scan is normal; patients can go home and wait for the laboratory test results, but in other case when using RT-PCR test theresults are obtained late and the patient will be quarantined until the result arrives. Thus, CT images and X-rays have vital role in prior detection of this disease which can be used as screeningtool. Therefore, simple, precise, and faster AI models are helpful to overcome the problem of delay in disease identification and help patients in early discovery and cure. Deep Learning is used in such disease diagnosis, prediction and even treatment.

In this paper, a deep learning model using CNN, that takes Lungs CT-scan as input and gives the probability of predicting the COVID-19 as output is presented and acts like an aiding tool for pathology. The results obtained in COVID detection using VGG-16(Visual Geometry Group), ResNet50 (Residual Networks), Xception with a Good training and testing accuracy.

II. PROPOSED SYSTEM

Since recent sudden surge of COVID-19 infections across the world many of them are losing their lives without proper diagnosis. Here we trained a dataset which has an ability to identify COVID-19disease. It takes input a lungs CT-Scan image and outputs a prediction among two classes: COVID19and NON-COVID-19.Independent sets were used for each training, validation, and testing phase. The training and validation data sets were extracted from Kaggle. This proposed model classifies the binary classes (COVID and NON-COVID) with 99.56% accuracy. CNN model that used COVID-19 CT-Scan Dataset and was trained to detect abnormalities in Lungs. Generally, this model was extended to detect all the CT-Scan in the dataset. The trained model predicts whether input lungs CT-Scan image is Covid-19 patient or normal.

2.1 Architecture of Proposed System

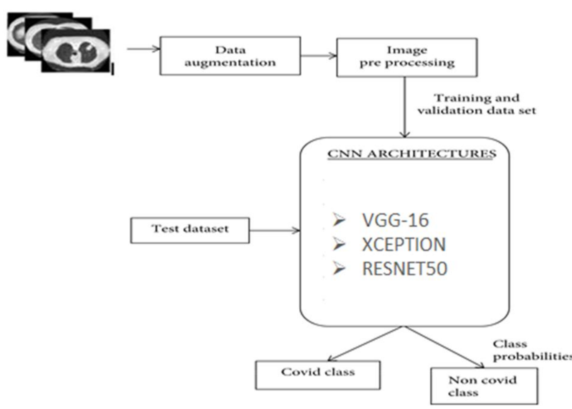

Fig 1: Architecture of Proposed System

2.2 Classification

Deep learning architectures, namely, VGG16, ResNet50 and Xception are used to classify the data. Transfer learning is used to train these models. Each model has been trained for a total of 50 epochs.

2.2.1 VGG16

VGG16 is a CNN model, and the VGG created the model at Oxford University. The network's replacement, AlexNet, was founded in 2012. VGG16 has eight layers, three completely connected layers, five max-pooling layers, and one softmax layer. As part of the Image Net competition, the architecture has been designed. The convolution blocks' width is set to a low integer. The width parameter is expanded by two after each max-pooling operation till it reaches 512. The VGG16 is given an image size of pixels 224x224. Spatial padding was used to maintain the image's spatial resolution. The VGG16 network has been released as open-source so that similar operations can be carried out. The model may also be used for transfer learning because specific frameworks, like Keras, provide pre-trained weights that can be utilized to construct custom models with minor alterations.

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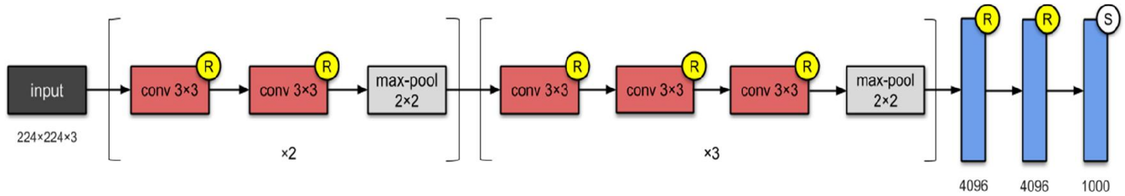

Fig 2: Model Architecture of VGG16

2.2.2 Xception

The Xception network has replaced the Inception network. Extreme inception is often referred to as Xception. Instead of typical convolution layers, the Xception network uses depth-wise separable convolution layers. Xception includes mapping spatial and cross-channel correlations, which in CNN feature maps can be completely dissociated. The underlying Inception architecture survived longer than Xception. The 36 convolution layers in the Xception model can be separated into 14 different modules. After the first and last layers are removed, every layer has a continuous residual link around it. The input image is converted into spatial correlations within each output channel to obtain the cross-channel correlations in an input image. After that, a depth-wise 1x1 convolution method is performed. Instead of 3D maps, the relationships may be viewed as 2D+1D map. In Xception, the first step is to do a 2D space correlation, followed by 1D space correlations.

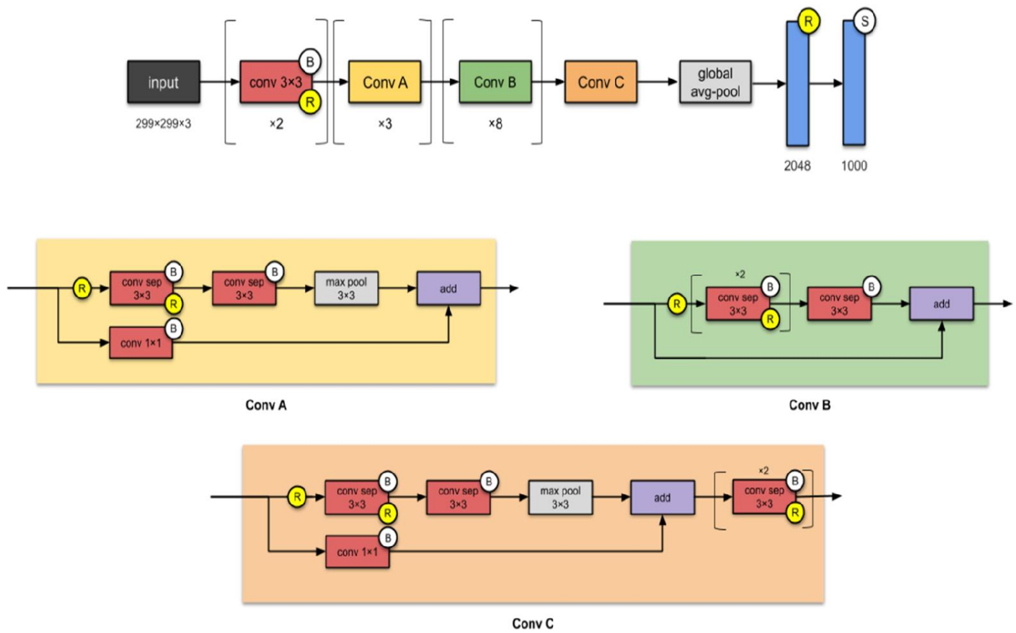

Fig 3: Model Architecture for Xception

2.2.3 ResNet50

Deep residual network like the popular ResNet-50 model is a convolutional neural network (CNN) that is 50 layers deep. A Residual Neural Network (ResNet) is an Artificial Neural Network (ANN) of a kind that stacks residual blocks on top of each other to form a network.

ResNet50 is a variant of ResNet model which has 48 Convolution layers along with 1 MaxPool and 1 Average Pool layer. It has 3.8 x 10^9 Floating points operations. It is a widely used ResNet model.

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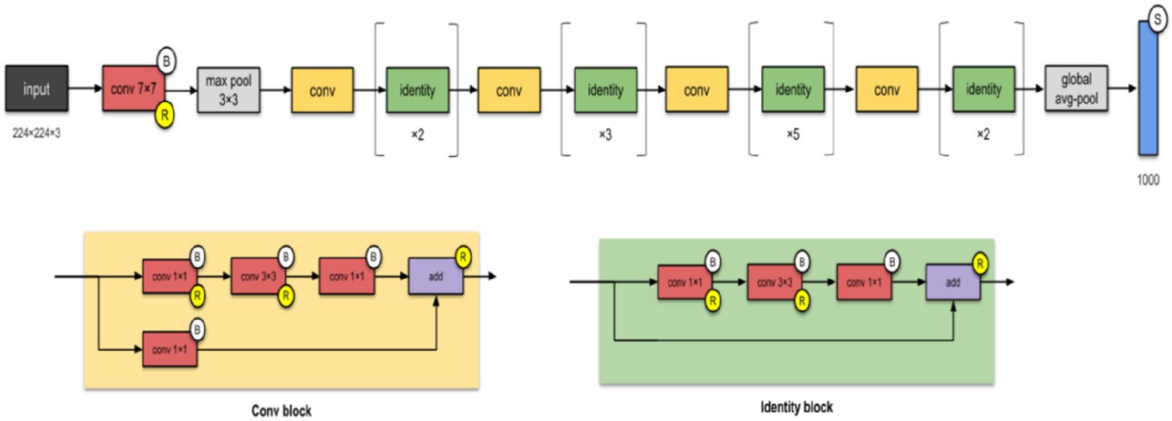

Fig 4: Model Architecture of ResNet50

III. IMPLEMENTATION

Artificial intelligence techniques that resemble how humans acquire knowledge and deep learning are similar to machine learning techniques. Data science, which covers statistics and predictive modeling, includes deep learning as a critical component. In deep understanding, a convolutional neural network is a kind of deep neural network used to analyze visual imagery. A deep learning method, CNN takes an input image and assigns weight to various objects in the picture, allowing it todifferentiate between them. Because of its great accuracy, CNN is used to classify and identify images.

3.1 Data Set Description

The 2019 novel coronavirus (COVID-19) presents several unique features. While the diagnosis is confirmed using polymerase chain reaction (PCR), infected patients with pneumonia may present on chest X-ray and computed tomography (CT) images with a pattern that is only moderately characteristic for the human eye Ng, 2020. COVID-19's rate of transmission depends on our capacity to reliably identify infected patients with a low rate of false negatives. In addition, a low rate of false positives is required to avoid further increasing the burden on the healthcare system by unnecessarily exposing patients to quarantine if that is not required. Along with proper infection control, it is evident that timely detection of the disease would enable the implementation of all the supportive care required by patients affected by COVID-19. SARS-CoV-2 CT scan dataset, containing 1252 CT scans that are positive for SARS-CoV-2 infection (COVID-19)and 1230 CT scans for patients non-infected by SARS-CoV-2, 2482 CT scans in total. These data have been collected from realpatients in hospitals from Sao Paulo, Brazil. The aim of this dataset is to encourage the research and development of artificial intelligent methods which are able to identify if a person is infected by SARS-CoV-2 through the analysis of his/her CT scans.As baseline result for this dataset we used an eXplainable Deep Learning approach (xDNN) which we could achieve an F1 score of 97.31%.

3.2 Data Augmentation

Data augmentation is a technique that can significantly increase the data instances of a dataset to train a model. In the case of image datasets, the technique uses the basic image processing operations, such as flipping, rotating, cropping, or padding for augmentation. The dataset is then extended by these transformed images resulted from the existing image set, which increases the size of dataset to train the neural networks. To solve the problem of the availability of a small size dataset that was affectingthe performance of the proposed CNN, the data augmentation method has been used in this study. This technique increased thesize of the dataset; in addition, it provides more learning features to the learning model. Two image processing operations, flipping and rotation have been used in this study for data augmentation. In the first phase of data augmentation, the 90 Lungs CT-scan images have been flipped to get extra 90 images. The resulted dataset was increased to contain 180 images after applying this operation. In the second phase, the original 90 images have further been rotated by 90°angle to get 90 more images and then rotated by 180°angle to get 90 more images, and finally, the original 90 images were further rotated by 270°angle to get more 90 images. These operations resulted in a dataset containing 450 COVID-19 lungs CT-scan images.

3.3 Methodology of CNN:

The CNNs are inspired by visual system of human brain. The idea behind the CNNs thus is to make the computers capable of viewing the world as humans view it. This way CNNs can be used in the fields of image recognition and analysis, image classification, and natural language processing. CNN is a type of deep neural networks which contain the convolutional, max pooling, and nonlinear activation layers. The convolutional layer, considered as a main layer of a CNN, performs the operationcalled "convolution" that gives CNN its name. Kernels in the convolutional layer are applied to the layer inputs. All the outputsof the convolutional layers are convolved as a feature map. In this study, the Rectified Linear Unit (ReLU) has been used in the activation function with a convolutional layer which is helpful to increase the nonlinearity in input image, as the images arefundamentally nonlinear in nature. Thus, CNN with ReLU in the current scenario is easier and faster.

A. Convolutional Layer

A convolutional layer is the main building block of a CNN. It contains a set of filters (or kernels), parameters of which are to belearned throughout the training. The size of the filters is usually smaller than the actual image. Each filter convolves with the image and creates an activation map. For convolution the filter slid across the height and width of the image and the dot productbetween every element of the filter and the input is calculated at every spatial position.

Step1: Let us take an example; we selected a small part from the original image

0	0	0	1	0	0
0	1	1	1	1	0
0	1	1	0	1	1
0	1	1	0	1	0
0	1	1	0	1	1
0	1	1	0	0	1

Fig 6: Small Part from Image

Step 2: Add the filter matrix and multiply with the image,

For example 0*1+0*0+0*-1+ 0*0+1*0+1*-1+0*-1+1*0+0*-1 = -1

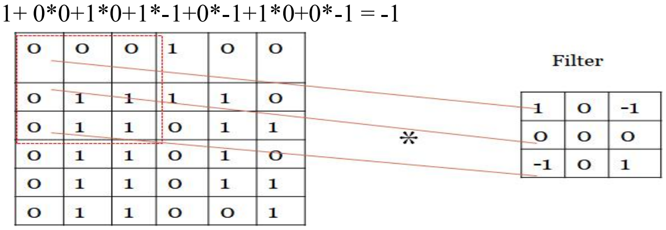

Fig 7: Multiplication with the filters

Step 3: Then, we get a 4x4 matric in the result

-1	**-2**	**0**	**2**
1	**1**	**2**	**1**
1	**1**	**2**	**1**
1	**1**	**1**	**1**

Fig 8: Result

Step 4: It interspersed nonlinearity between many of the convolutional layers. In a nutshell, ReLU is used for filtering information that propagates forward through the network. It takes an element-wise operation on your input and basically if your input is negative,it's going to put it to zero and then if it's positive, it's going to be just passed through its identity. This is one that's prettycommonly used because it doesn't saturate in the positive region.

Step 5: Pooling layers are used to reduce the dimensions of the feature maps. Thus, it reduces the number of parameters to learn and the amount of computation performed in the network. The pooling layer summarizes the features present in a region of the feature map generated by a convolution layer. So, further operations are performed on summarized features instead of precisely positioned features generated by the convolution layer. This makes the model more robust to variations in the position of the features in the input image.

-1	-2	0	2
1	1	2	1
1	1	2	1
1	1	1	1

-1	-2	0	2
1	1	2	1
1	1	2	1
1	1	1	1

Fig 9: ReLU Layer

Types of Pooling Layers

1. **Max Pooling**

Max pooling is a pooling operation that selects the maximum element from the region of the feature map covered by the filter. Thus, the output after max-pooling layer would be a feature map containing the most prominent features of the previous feature map.

0	**0**	**0**	**2**
1	**1**	**2**	**1**
1	**1**	**2**	**1**
1	**1**	**1**	**1**

1	**2**
1	**2**

Fig 10: Max pooling

2. Average Pooling

Average pooling computes the average of the elements present in the region of feature map covered by the filter.Thus, while max pooling gives the most prominent feature in a particular patch of the feature map, average pooling gives the average of features present in a patch.

0	**0**	**0**	**2**
1	**1**	**2**	**1**
1	**1**	**2**	**1**
1	**1**	**1**	**1**

0.5	**1.25**
1	**1.25**

Fig 11: Average pooling

Step 6: Flattening Layer:

Flattening is converting the data into a 1-dimensional array for inputting it to the next layer. We flatten the output ofthe convolutional layers to create a single long feature vector. And it is connected to the final classification model, which is called a *fully-connected* layer.

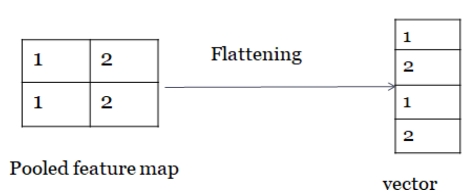

Fig 12: Flattening layer

Step 7: Fully Connected Layer is simply, feed forward neural networks. Fully Connected Layers form the last few layers in the network. The input to the fully connected layer is the output from the final Pooling or Convolutional Layer, whichis flattened and then fed into the fully connected layer

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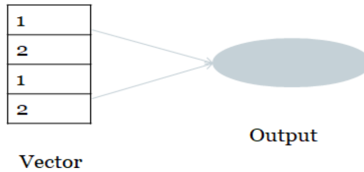

Fig 13: Fully connected layer

VI. RESULTS

We are selecting an image from the testing data and then click the solve button and then it will display that there isCovid or not. In below diagram we have Covid infected lungs

4.1 Result Page for Covid

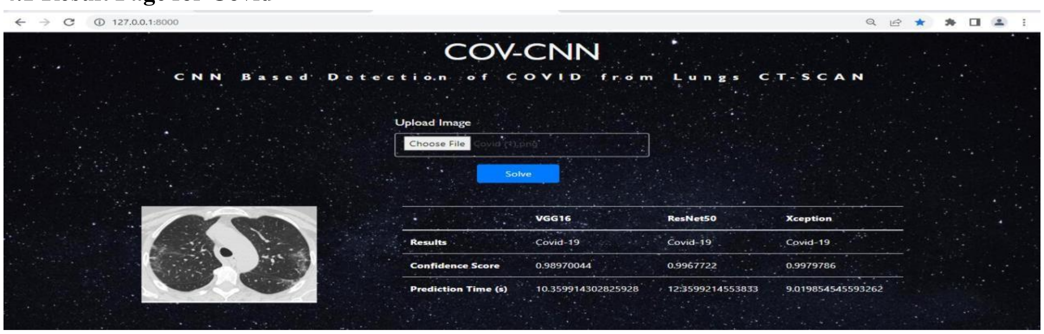

Fig 14: Result for Covid

4.2 Result page for non-Covid

We are selecting an image from the testing data and then click the solve button and then it will display that there is a Covid or not. In below diagram we have non- Covid

Fig 15: Result page for non-Covid

V. CONCLUSION

In this paper, a deep learning concept of transfer learning to detect COVID-19 was proposed. This model shows that computer vision has the power to bring about radical changes in the analysis of radiological images. Hence a time efficient solution can be designed for identifying and isolating infected patients. With a small dataset, the proposed model results in an exceptional result with a validation accuracy of 93% comparing to 71% in the InceptionV3 model. This model also outperforms all other models worked with X-raydata (previously 79%). It's because of the combination of InceptionV3 model and the customized Deep Neural Net Work(DNN) model that enables this model to outperform all the model that have been proposed based on CT scan images. Moreover, day by day the size of such dataset will increase and so the model will be more accurate and robust.

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