Deep Learning Application for Covid-19 Diagnosis using Chest X-ray Images

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***Abstract* - COVID-19 is increasing day by day from December 2019 in all over the world. The first COVID-19 Case is in Wuhan, China, on 31 December 2019. The COVID-19 virus was growing rapidly since December 2019 and now it is affecting the human's lungs rapidly. By using Deep Learning Application for Covid-19 Diagnosis using Chest X-ray Images, with the help of chest X-ray we are able to detect whether the person is infected with COVID-19 Virus. We can predict by using Deep Learning models, CNN (convolutional neural network) trained with X ray images of COVID-19. We are also using the VGG-16 model which gives the accuracy of 88.29% in the prediction of the COVID 19 from given chest X-ray of a patient.**

***Index Terms* - COVID-19, X-rays, CNN, VGG-16, Deep learning.**

I.INTRODUCTION

COVID-19 is an infectious disease caused by the newly discovered corona virus that poses serious threat to public health and the global economy. This causes cold-related respiratory infections to more serious diseases such as Middle East Respiratory Syndrome (MERS) and severe acute respiratory syndrome (SARS). Its outbreak began in Wuhan, China in December 2019 [1]. It spread mainly from person to person and to date there has been no vaccine to cure. The only way to control the spread of the disease is social distance and isolation. For Controlling its distribution among persons, the early detection is important. Symptoms of the disease include mildness, sore throat, headache, cough, shortness of breath leading even to the body. The epidemic is now affecting many countries around the world. Every day thousands of people are confirmed with a positive corona and the death is also rising. One way to detect this is to test the Polymerase Chain Reaction (PCR)[2]. It detects a specific type of coronavirus and creates many copies that can be easily detected. Along with this RT-PCR test we can use PCR retrieval test. This is done by collecting nasal samples. These test kits are available for a very small number that is not enough for the person which are residing in village areas. As the reverse transcription polymerase chain reaction (RT-PCR) test kits are also small, there is a need to explore alternative ways to identify and prioritize COVID-19 suspected cases. Otherwise, the virus will spread more easily and thus increase the number of cases [3], [4]. Therefore, in addition to these clinical trials it is good to assist computer technologies such as Deep learning, as it can play an important role. Artificial Intelligence (AI) used in cameras to track infected patients with travel history uses facial recognition so that we can easily identify other people who interact with coroners. AI has been widely used to discover new molecules that are in the process of obtaining the help of COVID-19 [5]. Many researchers use AI to search for new drugs and therapies, as well as other computer science researchers who focus on diagnosing infectious patients through medical imaging studies such as X-rays and CT scans (e.g. see [6], [7]). The sequencing of Covid's effects on the respiratory tract, shows early symptoms such as pneumonia and as doctors often use x-rays to test for pneumonia etc., identifying covid using X-ray can play a major role in corona examination. Therefore, increasing the rate of covid testing can use X-ray testing as the first test and if the AI predictive test results in the right one the patient can get a medical test. In this paper we have used the transfer of learning which is a machine learning method that focuses on storing the information obtained while solving one problem and applying it to another. A database containing chest x-ray images of Covid-19 patients and general patients is used to detect. Phase II describes some of the latest work done on Covid prediction using Deep Learning (DL) techniques. Phase III outlines our approach used to incorporate the VGG16 Covid prediction model and discusses test results.

II. LITERATURE REVIEW

Current studies have recommended that COVID-19 could be distinguished using non-invasive radiological image. For example, Computed Tomography (CT) images can be used to detect certain appearance in the lung associated with COVID-19. Huang et al. [8] found that chest CT was necessary in selecting candidates for isolation in Wuhan and other places in China. Guan et al. [9] mentioned that the majority of COVID-19-positive patients presented abnormal CT results such as ground-glass opacity and bilateral abnormalities. Li and Xia [10] observed that chest CT had a low rate of unexploited diagnosis of COVID-19 being useful as a standard method for the rapid diagnosis and improving the management of patients. Despite the arduous differentiation caused by certain similar imaging features between COVID-19 and other types of respiratory syndromes, CT breakdown could indeed serve as an effective way to screen and diagnose COVID-19 [11].

Recently, artificial intelligence (AI) model gives us a fruitful result in estimating the data in the field of medical. In fact, new machines are manufactured with latest AI models that work as good as experts in specific estimation of the tasks [14, 15]. Moreover, a concerning application is the making of AI systems that extract information's from medical imaging with the eventual purpose of creating tool/tools to reduce errors in the diagnosis, enhance the efficiency, and costs reduction. These systems are typically merged in image-oriented decisions to support systems to provide us for the aid of imaging professional [16]. Medical imaging implemented specific capability, to including the risk assessment, detection, prognosis, diagnosis, therapy response, and multi-omics disease discovery [17]. This can acquire automatic processing of fewer laboratory infrastructure and supplies, as well as less health personnel. Hence, medical imaging is beneficial in the diagnosis of Coronaviruses disease [18].

Even though previous works have developed AI-based architecture to identify COVID-19 in patients with CT scan images or CXR images, most of them have restriction such as:

1. Use of personal data preventing duplicability.
2. Design based on a few databases, which may not be multiple enough to truly predict properties from COVID-19 and another sickness; and
3. Not being flexible enough to totally exploit images of high quality.

Therefore, we offer here a larger discussion about the importance of adequately using different datasets to feed the AI architecture and the implementation of data augmentation (DA) for classes with a little amount of data (images related to COVID-19). Thus, we expect to avoid the influence of the model towards detecting datasets due to the representative features of each data source as well as fully exploiting images from COVID-19 cases, which are still rare.

Precisely, in this paper, we developed a model based on a convolutional neural network (CNN) that distinguishes healthy patients from infected patients for COVID-19 through radiological images (i.e., CXR) available from our dataset. They allowed screening features well-suited with COVID-19 infections and expanded the forms of detection of COVID-19 to support the more accurate diagnosis. After training, the classification model should correctly differentiate patients in new and unseen images within seconds or less. Also, the proposed model can be part of a computer-aided diagnosis (CADx) and a computer-aided detection (CADe) framework [17]. Definitely, our models do not hinge on previously trained models and therefore are not constrained to predefined image dimensions before training.

III. METHODOLOGY

Dataset: The dataset was taken from Kaggle, it was made by a team of researchers from Qatar University, Doha, Qatar, and the University of Dhaka, Bangladesh who have created a database of the chest X-Ray images for COVID-19 positive cases along with Normal and Viral Pneumonia images.

Methods: The main purpose of the project was to diagnose the presence COVID-19 virus in the person from the given chest X-ray images with better efficiency and accuracy [8]. To achieve that we required a process or a method that easily determine and differentiate between the patterns of spread of virus inside a patient’s lung and the patterns present in a healthy (normal) person’s lung. For this we use a

Deep learning algorithm, Convolution Neural Network also known as CNN or ConvNet.

ConvNet has the capability of taking an image as an input and then assign key points (such as learnable, weight, and biases) to various aspects in the given image and being able to differentiate them from each other. The architecture of a ConvNet is similar to that of the connectivity pattern present in Neurons inside the Human Brain. It was inspired by the arrangement of the Visual Cortex. An individual neuron responds to stimuli only in a limited region of the visual field known as the Receptive Field, collection of such fields overlaps to cover the entire visual area.

The main role of ConvNet here is to reduce or remove unwanted parts from a CXR image to a form that will be helpful for getting the expected output and retaining its important features. The ConvNet architecture consists of different layers that are Convolution layer, Pooling Layer, and Fully connected layer (or classification layer).

Convolutional Layer: The kernel/filter is the first part of the convolutional layer, this is usually represented as the letter, K. It is normally a matrix that is smaller than the image. It is responsible for performing convolution operations, and its objective is to extract the high-level features like fibrous structures present inside lungs from the given CXR images.

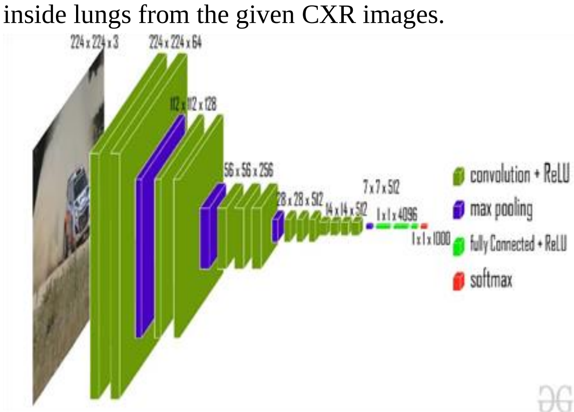

FIG 1: VGG16 Architecture [19]

Pooling Layer: The Pooling layer is also responsible for decreasing the spatial size of the convolved feature. This is to reduce the computing power required in order to process, data through dimensionality reduction. In this layer the pooling operation takes place. The pooling operation includes a sliding two-dimensional filter, which slides over each channel of the feature map and summing up the features lying within the region covered by the filter.

For a feature map having dimensions h x w x c, the dimensions of output obtained after a pooling layer is

(h – f + 1) / s x (w – f + 1)/s x c

where,

h – height of feature map

w – width of feature map

c – number of channels in the feature map

f – size of filter

s – stride length

Fully Connected Layer: It is the final layer and is the one where the image is finally flattened into a column vector. This flattened output is then fed to a feed-forward neural network (ANN) and backpropagation applied to every iteration of training. Over a large number of epochs, the model starts distinguishing between dominating and certain low-level features in given images and classify them using the SoftMax Classification technique.

IV. IMPLEMENTATION

Since the images to train the model were too many so they were divided into two separate folders for training and validation of the model, but the images were randomly distributed between the two folders.

The Project uses a 2d convolutional layer or kernel which is also called convolutional matrix that is used for blurring, sharpening, and more.

In this project we are using Max Pooling which is a type of pooling operation, it selects the largest element present in the region of the feature map covered by the filter. Thus, the resultant feature map will only contain the element that has the most influence on the previous feature map. Since our classification was binary our activation function was sigmoid.

For a fully connected layer the project uses VGGNet Architecture, it is also called the OxfordNet model. We are VGG16 where 16 is the number of layers that have some weight. It always uses a 3 X 3 kernel for convolution. It has a pool size of 2 X 2 for all layers. It has an accuracy of 85% - 92%. The input to this model is 224x224x3, then we get two convolution layers with each 224 x224x64size, then we have a pooling layer which reduces the height and width of the image to 112x112x64.

Then we get two conv128 layers with each 112x112x128 size after that we have a pooling layer which again reduces the height and width of the image to 56x56x128.

Then we get three conv256 layers with each 56x56x256 size, after that again a pooling layer reduces the image size to 28x28x256.
Then again, we get three conv512 layers with each 14x14x521 layers, after that, a pooling layer with 7x7x521, and then we have two dense or fully connected layers with each of 4090 nodes. and at last, we have a final dense or output layer with 1000 nodes of the size which classify between 1000 classes of image net.

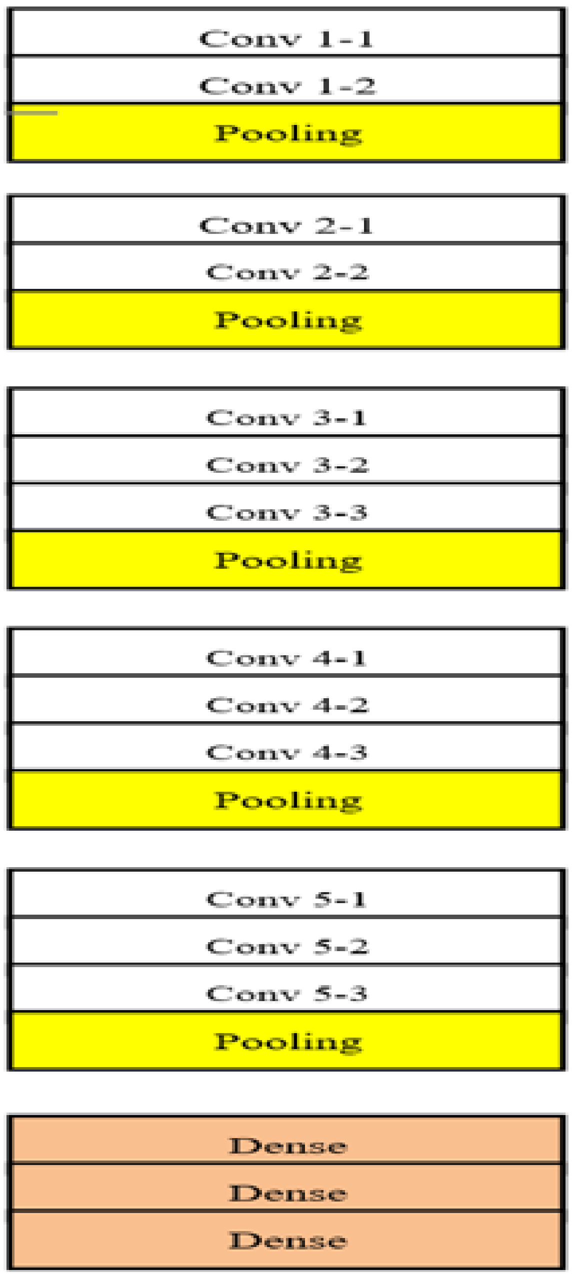

FIG 2: VGG16 architecture map

Now when the training dataset set is fed to the VGG16 architecture the CXR images goes through different layers, of ConvNet where images are filtered to extract their high-level features and the max pool ensures that the final feature map is only having the elements with the most prominent effect on the image. Once all the filtration is completed, we have converted our input image into a suitable form, then we flatten the image into a column vector.
The flattened output is provided to a feed-forward neural network and backpropagation applied to every iteration of training. After going through a series of epochs, the model is able to differentiate between dominating and certain low-level features in images and classify them using the SoftMax Classification technique.

V. CONCLUSION

Detection of COVID-19 from CXR images is of vital importance for both doctors and patients to decrease the diagnostic time and reduce financial costs. In this study, several experiments were performed for the high-accuracy detection of COVID-19 in CXR images using VGG16(Keras) architecture. When the number of images in the database and the detection time of COVID-19 (average training time = 580 sec). We considered using VGG16(Keras) architecture, it can be suggested that the considered architectures reduce the computational cost with high performance. The results showed that the convolutional neural network with VGG16(Keras) minimized convolutional and fully connected layers is capable of detecting COVID-19 from CXR images with accuracy 88.29%. In the future, we can increase the accuracy either by increasing the images in the data set or by using VGG19 architecture.
Therefore, the use of AI-based automated high-accuracy technologies may provide valuable assistance to doctors in diagnosing COVID-19.
Further studies, based on the results obtained in this study, would provide more information about the use of CNN architectures with COVID-19 CXR images and improve on the results of this study.

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