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CNN Analysis for the detection of SARS-CoV-2 in Human Body

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Abstract

The Novel Coronavirus or SARS-CoV-2 is perhaps the world's biggest threat in the present scenario. Machine learning and deep learning techniques are widely used worldwide in the medical field for the detection and diagnosing purpose against most of the infectious diseases. Considering the potentials of Deep learning and Convolutional Neural Network or CNN, this is study developed a model of CNN in order to detect and classify COVID- 19 infections in the human body efficiently. Solution for many daily life problems are developed with the help of deep learning technique and Artificial Intelligence. The detection model developed in this study can be very useful especially considering the pandemic situation worldwide. Datasets were trained to develop a CNN which gives excellent accuracy with minimal loss percentage. The study demonstrates that the CNN can be used to effectively for the detection of SARS-CoV or novel-Coronavirus in human body since the trained model has been with accomplished high accuracy in image classification.

Keywords: *SARS-CoV-2, COVID-19, CNN, Deep learning, Artificial Intelligence*

1. Introduction

The entire world is surprisingly under quarantine due the outbreak of the pandemic virus SARS-CoV-2 also known as novel corona virus from last four months. Till the date, more than 7 million of the whole world's population got affected with the pandemic virus outbreak epic entered from the city of Wuhan, China on December 2019. The pandemic has escalated the death toll to a million. Most of the worlds biggest economies collapsed with the lockdown that extending from weeks to months. This virus belongs to the family of coronaviruses and to the genera Technically named as the sars-CoV-2 named by the Taxonomy Institute [1]. Researchers have told that the disease has its origins from bats or pangolins and possibly spread from a wet market in the city of Wuhan. The first reported case was diagnosed on 8th December 2019 and from then to till the date, the entire world is somehow affected with the pandemic virus and its related impacts. The symptoms shown by a COVID-19 patient is similar to other respiratory and infectious diseases and it create much difficulties for the health workers to detect and diagnose the patient at right time. Mild symptoms of corona include respiratory illness, cough, fever, etc., and can cause multiple organ failure and result in death. Four kinds of common coronavirus that causes infections in humans are 229E, NL63, OC43, and HKU1 [2]. With the recent development of Computer Aided Design (CAD) tools becomes the most important field of research in artificial intelligence and machine learning. CAD systems has proven in facilitating the medical field such as breast cancer detection, classification of disease using mammograms, lung cancer detection, etc. CAD system is an applicable instrument in use today for diagnosis and classification of diseases in medical imaging.[3].

Machine learning techniques proved to be excellent in the detection and diagnosing of the pandemic virus infection as the developed model gives good results. Experimental analysis of various models used in the study gives a better understanding for the detection and diagnosis of the virus. Neural networking is way which the computer enables to analyses any image [4]. Due to the factors like faster computing and ability to handle big data, neural networking methods are gaining huge demands and

acceptance worldwide in the field of computation and medical science. The large nodes in the network is trained enough to analyse the images that are being provided as inputs. The capability of Convolutional Neural Networks (CNN) has been utilized for the study in order to reduce the complexity of the model [5] Development of efficient detection systems is necessary considering the threat of the pandemic virus world-wide. Since millions of world population is affected by the viral diseases which at its earlier stages wasn't expected to have a human to human communal spread but by the passage of time it has been observed that social distancing is the best practice that could be adopted in order to escape from the viral disease. With the improvement in the field of computation and technology, efficient detection and diagnosing system can be developed and in this study also we intended to develop similar system which may serve the society for a good cause. Several architectures are available in computing for the prediction and detection purposes. and the optimization of hyper-parameters should also be considered to improve the accuracy of the model. This study or similar studies will definitely will help the medical work force to better in decision making and also for the real-time application.

2.Methodology

Deep learning and Convolutional Neural Networks (CNNs) try to imitate the structure and function of the human visual processing system by implementing a hierarchical layer of feature representation. This multi-layer representation approach allowed the automatic learning of different image features, enabling CNNs to outperform handcrafted features. As in other fields, deep learning techniques employed in recent years continue to show remarkable success in the field of medical image processing. Image and signal data analysis is done using deep learning [6] models that use medical imaging techniques such as magnetic resonance imaging (MRI), computed tomography (CT), and X-ray. These analyses are useful for the detection and diagnosis of diseases such as diabetes mellitus, tumour, skin cancer, etc.

A properly trained CNN can provide fast and accurate segmentation automatically, sometimes within seconds, and reduce the medical imaging costs. Segmentation CNNs may use kernels with 2D or 3D convolution to predict the segmentation map. 2D CNNs map chopped one by one to construct a full volume while 3D CNNs use voxel information to predict volumetric patch segmentation maps. Although this requires higher computation, using the context of the interslice can improve performance.

2.1 Proposed CNN

In this study we designed a CNN model for COVID-19 detection from x-ray images in the chest, accompanied by the fact that COVID-19 is properly classified and detected. Radiologists will also distinguish between COVID-19 X-rays and regular Xray in the chest first and especially the pneumonia cases. On this basis, we had designed a CNN with two scenarios: a) prediction on Pneumonia affected X-ray images and b) prediction on COVID-19 affected X-ray images. It mainly consists of 5 convolution layers with one fully connected layer. Figure (figure.1) depicts the entire structure of CNN. Convolution layer is the layer that develops an idea of the features for each input image to be extracted. Batch normalization and rectified linear unit (ReLU) are then applied to the transformed images and to the next two separate forms of pooling operation, which are the average pooling and the maximum pooling. The reason for using different number of filters is to detect local features and global features in such a way as to detect what the other filters are missing.

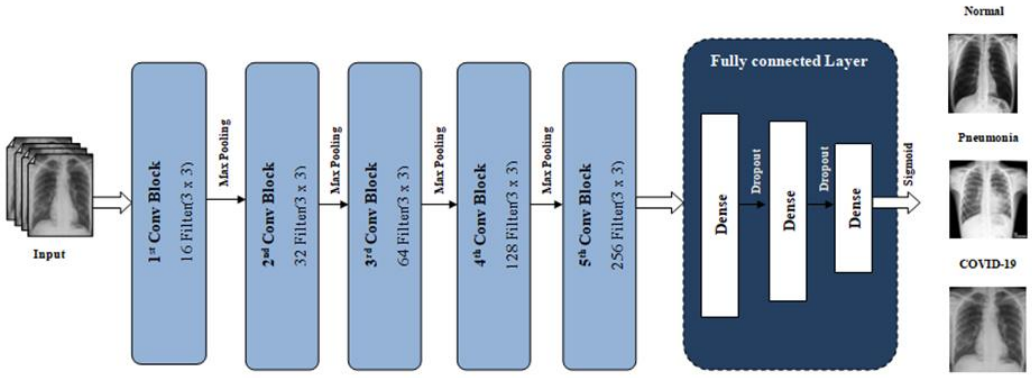

Figure.1: (Structure of CNN)

Various pooling operations used to further decrease the dimensionality of the function maps. With pooling operations, stride of size (3 x 3) is taken here to further reduce the dimension of the resulting feature maps, taking into account the fact that the images contain redundant details. Feature map for determining an input contains specific details of the original image information. The feature map with ReLU activation is then sampled down by reducing any negative values to zero and others remain intact. Max pooling layer is a layer that operates on the principle of temporal pooling, by selecting max values from the kernel matrix to reduce the values to half of their original value. The output layer uses the sigmoid function. A sigmoid function is a type of activation function, defined as a squashing function more specifically. Squashing functions restrict output to a range between 0 and 1, making these functions useful when predicting probabilities. In Neural Networks, output changes very slowly with input. A perceptron may suddenly have the outputs flipped with a small change in the input value, leaving the learning puzzled. In order to observe the small changes in output to the correct input value, we need to apply a function to the point product of weights and a bias value so that the overall output is smooth. The reason the sigmoid function is chosen is that exponential functions are generally similar to mathematically handled, and since learning algorithms involve a lot of differentiation, it is quite good to choose a function that is computationally cheaper to handle.

2.2 Dataset Description

We used X-ray images collected from 2 publicly available sources to evaluate and test CNN architectures. First dataset is a collection of Pneumonia X-ray images collected by Paul Mooney [7] with a size of 1.15 GB. It consist of two categories named Normal (234 files), Pneumonia (390) images for training, testing and validation set. Second dataset is a collection of chest X-ray images of confirmed COVID-19 viral infections from Wei Hao Khoong [8]. Specifically, the images are divided into two classes as follows: normal (94 cases) and confirmed COVID-19 (94 cases) with pneumonia. All of these datasets are available under the Kaggle data.

Figure.2 (Samples of Chest X-rays used)

A) Normal Chest X-ray B) Pneumonia Chest X-ray C) COVID-19 Chest X-ray

3. Result

All images from the training and testing sets are resized to the appropriate dimensions that the architecture has designed for. For CNN architecture training parameters are as follows: number of epochs = 10, batch size = 32. To measure CNN classification performance, two metrics were recorded which are model accuracy and model loss during training. We looked at our model 's performance on the dataset for pneumonia and covid-xray data set. Figure (figure3.1, 3.2 pneumonia) plots the model accuracy and the model loss during training process. As shown, the X axis represents the number of epochs and the Y axis represents the accuracy and loss rate respectively for training and validation. With epochs of 10, the model achieved an accuracy of 87.5 percent and a train loss of 0.455.

Figure.3.1 (Train loss vs Validation loss)

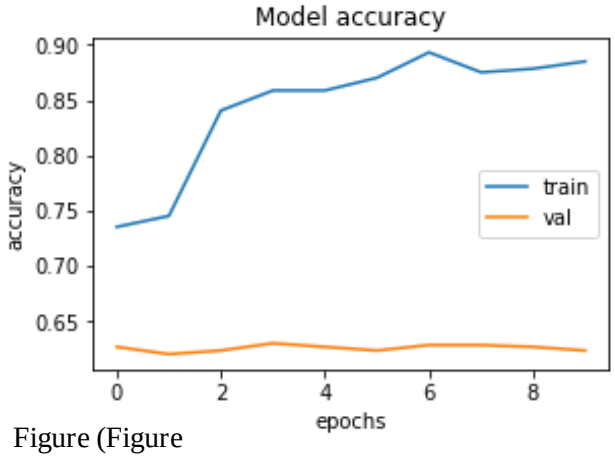

Figure.3.2 (Model Accuracy)

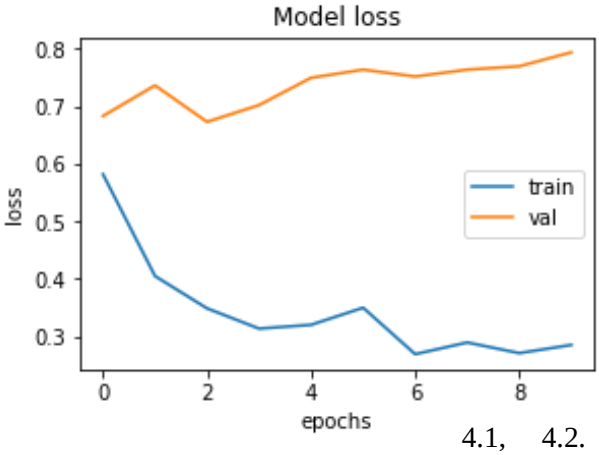

Figure (Figure 4.1, 4.2. covid) describes the behaviour of the model while training the covid-dataset. The X axis represents the number of epochs and Y axis represents the accuracy and loss rate for training and validation set. The model performs better here than in the previous case where it acquires 90.49 accuracy over 10 epochs with a train loss of 0.2846.

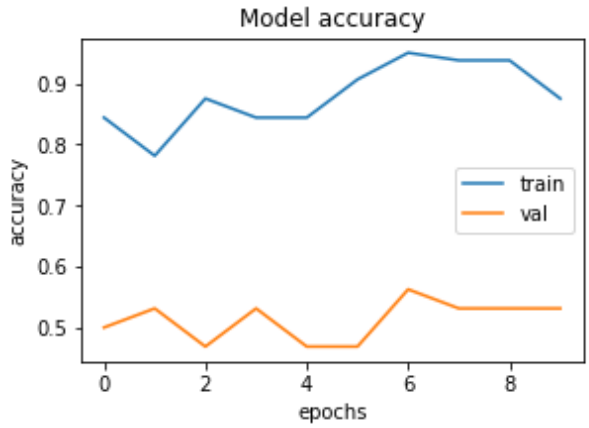

Figure.4.1 (Train loss vs Validation loss)

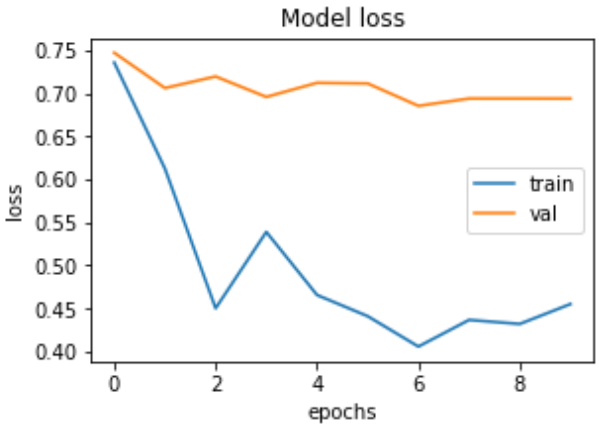

Figure.4.2 (Model Accuracy)

4. Conclusion

This work focus on deep learning approach for the detection of SARS-CoV-2, ie. Novel corona virus using Convolutional Neural Network. The developed model significantly gives better results with various datasets [10] during the different phases of the study. Chest X-ray datasets were acquired from Kaggle dataset repository and were processed with deep learning perspective. The model performed well enough with normal chest X-ray, Pneumonia X-ray and COVID-19 X-rays. [11] This work or similar approaches can be used for several medical services and it can be used for distinguishing and detecting the pandemic virus. It can serve the society in much better way for the rapid detection and diagnosing of the virus disease. For future studies, this model can be modified along with improving some measures to increase the accuracy. Several architectures are available in computing for the prediction and detection purposes. and the optimization of hyper-parameters should also be considered to improve the accuracy of the model.[12,13] This study will help medical work force in their decision making for a real- time application of the use of accurate model in detecting Covid-19 and discover the potential of diagnosing Covid-19 using deep learning.

5. Future work

We will investigate more medical potentials of CNN, and also look at the security implications of CNN. We will also try to improve the accuracy percentage of the modelled architecture.

6. Acknowledgments

We are grateful to all those who provided insights or contributed in one way or the other towards the success of the study.

7. Declaration of Conflicting Interests

We declare that there is no conflict of interest.

8. Data Availability Statement

All relevant data are within the paper.

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