Eco. Env. & Cons. 28 (October Suppl. Issue) : 2022; pp. (S405-S410)
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ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2022.v28i06s.068

Analysis of Convolution neural network algorithms for Classification of Covid-19 Computed Tomography Images

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(Received 2 February, 2022; Accepted 24 March, 2022)

ABSTRACT

The very first infected novel coronavirus case (COVID-19) was found in Hubei, China in Dec. 2019. The COVID-19 pandemic has spread over 214 countries and areas in the world, and has significantly affected every aspect of our daily lives. At the time of writing this article, the numbers of infected cases and deaths still increase significantly and have no sign of a well-controlled situation, e.g., as of 13 July 2020, from a total number of around 13.1 million positive cases, 571, 527 deaths were reported in the world. Motivated by recent advances and applications of artificial intelligence (AI) and big data in various areas, this paper aims at emphasizing their importance in responding to the COVID-19 outbreak and preventing the severe effects of the COVID-19 pandemic. We firstly present an overview of AI and big data and then identify the applications aimed at fighting against COVID-19, next highlight challenges and issues associated with state-of-the-art solutions, and finally come up with recommendations for the communications to effectively control the COVID-19 situation. It is expected that this paper provides researchers and communities with new insights into the ways AI and big data improve the COVID-19 situation, and drives further studies in stopping the COVID-19 outbreak.

Key words: *COVID-19, CT scan, Deep Learning, Convolution neural networks(CNN)*

Introduction

COVID-19 has gathered attention across the world as it has caused the global pandemic scenario. It is believed that around 70% of the world population might get infected with this dreadful disease (Hassan *et al.,* 2021). This disease began its spread and had been identified in 2019 from the City of Wuhan, the capital of Hubei province in China central. The spread of this infectious disease is global from 2019 and led to corona virus pandemic experienced till now. The spread and dreadful outbreak of the disease is affecting the global economy and poses a greatest challenge to global health care to identify and prevent the spread of this disease (Jamshidi *et al.,* 2020). The symptoms of the disease include cough, fever, difficulty in breathing, body pain and some cases includes diarrhoea and sore throat. The disease also causes pneumonia, cardio- vascular disorders and complications, respiratory failure in various range of severity. No wonder this disease was first named severe acute respiratory syndrome corona virus 02 (SARS-CoV-2) as recognized by the World Health and scan reports, deep learning meth-

ods and neural networks were involved in research. This paper discusses image data sets pre-processed for better image quality and processed for algorithms in convolution neural network approach. The comparative model hence results in better precision and accurate for early stage diagnosis of covid-19 and improved treatment methods for the same. The overall objective is hence to prove the effectiveness of the algorithmic approach and review the state of art solutions using these advanced algorithms in medical images. The advancement in medical diagnostics and the usage of CAD (Computer Aided Diagnostic) systems is much helpful for the health care professionals for prompt diagnosis of the disease.

Literature Survey

In the literature discussions on various methods proposed by the researchers implemented over traditional machine learning algorithms to detect CT scan images and the major concerns of the spread to impose improved algorithmic prediction model are highlighted (Hassan *et al.,* 2021). These studies have suggested solutions based on algorithms of deep learning. Image based diagnosis using Contract Tomography (CT) scan has unique attributes which visualizes the spread of the disease across the respiratory tract especially the amount of the lung infection. The regular swab test likely provides false negative for patients with early stage of infections (Jamshidi *et al.,* 2020) or tests are taken with low virus titre in the swab. This also causes false positive values based on human error and skills. X-ray imaging was then analysed for covid-19 detection. But the sensitivity was lower when compared to CAD and CT (Pham *et al.,* 2020). Though X rays are helpful for detecting abnormalities in the chest, CT images are preferred especially to decrease the false negative rates. With the advancement in technology AI(Artificial Intelligence), rapid diagnosis for covid-19 model emerged. The base for such image processing techniques being built with deep learning techniques along with Support vector machines used for the classification of the classes based on the marginal parameters trained (Kaur *et al.,* 2020). The decision making factors for building such prediction model is based on the table values of the confusion matrix including false positive and false negative rates. As mentioned above, false negative prediction of the patients is quiet a concerning factor for the disease spread. The comparative study also comprises of the factors including accuracy, recall, precision and the F-score values for improved results. Data sets containing CT images are taken as case study for the proposed system. Image quality is the major factor for processing the deep learning algorithm (Kumar *et al.,* 2021). The radiology images of the chest are the basic conventional method for Covid-19 spread after the first wave had its peak. This radiology frame-work is established in the health centres for diagnosing covid-19. These are much preferred as the radiology expertise team take more tests per day and independent of any testing kits or with only a limited number of kits. Further, not all hospitals have the required laboratory setup to assist in a high rate of sample testing procedures. The imaging method appears to be a valuable tool for COVID-19 clinical management and therefore can be used for the diagnosis, detection, follow-up, and evaluation of the severity of the infection. The variations in the values are tabulated as a comparative study for these approaches. The model was built with training data set with the images to detect the variations caused by covid-19 spread.

The image quality was enhanced and resolution of the image was also modified to construct covid-19 prediction model. The approach using construction of deep neural network is also proven to be having accuracy of more than 90%. The functioning neural network algorithm is similar to that of the human cerebrum. The preferences on medical image processing using neural networks have gained significance as it is considered to be more reliable for pattern recognition (Tan *et al.,* 2020). The interpretation of medical CT images is achieved in a much faster.

The basic model consists of input layer, hidden layers and an output layer. They are adapted and suitable for various applications and currently in analyzing the medical images for Covid-19 prediction by using the morphological patterns. From the onset of the disease the image characteristics of covid-19 infected patient results show variations from the normal levels. This is determined by patch consolidated over the chest and lung area . The image from the CT scans of the infected patients reported to have ground-glass opacities (GGOs), crazy-paving appearance, air- space consolidation, bronchovascular thickening, and traction bronchiectasis (Shi *et al.,* 2020). The AI researchers moved on to Deep learning strategies as the architecture were modelled accordingly for different data sets. Domestic datasets (including CT and X-ray images) or public datasets have been extracted with

studies with proper segregation of training and testing datasets to validate the results.

Improved strategies have also been proposed with implementation of Generative Adversarial Network (GAN). But the disadvantage is that more number of training models to be built and testing requires the action to be carried out as per the results else the model is again tested. This difficulty cannot be revoked for the model.

The Convolution neural network (CNN) has been proven a nominal type of neural network extensively applied in medical image processing of data sets comprising of X-ray and CT images for diagnosing COVID-19 pandemic (Soares *et al.,* 2020). This paper highlights the application of CNNs for improving the image quality the detection, classification, and segmentation of COVID-19 images. The systematic approach comprises of steps including pre-processing of the image data set, extraction the attributes involved in the algorithm, selection and classification results to categorize the persons who are infected or non- infected by the virus. For those infected, the severity of the spread is also to be analyzed.

Proposed Work

Computed Tomography (CT) is a matured diagnostic technique that reconstructs the cross sections of patient body and providing detailed characters about anatomy of organs and their functionalities. CT images are relatively easy and low cost procedure majorly used in all countries for recognizing COVID-19 infection level in human lungs. In case of COVID-19 it is better to use CT images instead of using X-ray images to detect infection level at early stages using deep learning approaches. These images show different characteristics and that differentiate COVID 19 from other infections like influenza.

Convolutional Neural Networks (CNN)

Convolutional Neural Networks (CNN) is the type of Deep Learning that takes an image as input, doing the feature extraction from the image automatically through filters. They are similar to neural networks as they are consists of neurons with learnable weights and biases. When compare to neural networks CNN architectures is make implicit assumption on feature extraction over input images. Most importantly, convolutions fetch translation invariance (Zheng *et al.,* 2020). This makes the feed forward function more efficient which reduces the number of parameters of input data and makes the network more optimizable. CNN consists of sequence of layers where each layer output is transformed as input to the next layer with another different function applied over that. The most common layers in CNN architecture are convolution, pooling and fully connected layers. These layers are the resemblance of feature extraction, dimensionality reduction and fully connected layers of conventional models (Zhao *et al.,* 2020). Among a filter over the input data. The filter slides over the input data and calculates the activation map of the filter by doing a dot product. During the convolution operation the network identifies some useful information like edges or patterns from the input data. The step size the filter moves through the image is called stride. If the stride value is greater than one it downsize the output image. If the stride size is one, the output image size remains the same as input. Consider the input image is denoted by f and filter is denoted by g and the row column index is considered as r and s. Then the convolution operation is given by the following equation (1).

$$G[r, s] = f * g[r, s] = \Sigma_i \Sigma_j \, g\,[i, j]\, f[r-i, s-j] \quad .. (1)$$

After convolution pooling takes place which is a down sampling operation doing spatial invariance. Two major pooling operations max and average pooling where maximum or average value is considered, respectively. Mostly, max pooling uses stride 2 with kernel or filter size 2 which partitioning feature map to square blocks and making maximum of input feature.

Fully connected layer takes n input dimensions and m output dimensions where the output is determined by the weight matrix $\in$ Mm,n (R) , where m rows and n columns with b = Rm is the bias vector. The output is considered as

$$F(x) = f\,(Wx + b) \in R^m \quad .. (2)$$

Fully connected layer used as a final layer in this classification problem, where the output flattened and viewed as a single vector. Rectified Linear Unit (ReLU) is an activation function g applied over all elements to introduce non linearity. In ReLU function the output is 0 when the input is negative.

$$g(x) = \max(0, x) \quad .. (3)$$

Where g(x) is the output and x is the input. ReLU function leads to quick convergence compared to other non-linearity functions like sigmoid and tanh.

Dataset for Analysis in the Proposed work

We have used datasets collected from publicly available online repositories. COVID-19 diagnostics done over two datasets training and testing. Training dataset has 1433 COVID and 1229 NON COVID CT images taken from Testing dataset has 349 COVID and 397 NON COVID samples from [11]. In all the existing approaches the severity prediction is still open for research. In our research we performed the severity prediction of COVID -19 with the available dataset. All the images in the dataset has been through a pre-processing step like noise removal and image resizing where each image has the size of 300 X 300 pixels. Figure 1 show the sample of Non COVID images and Figure 2 shows the sample of COVID images.

Experimental Results

S veral deep learning architec tures are available for classification problems. We explored the performance of three models VGG19, Res Net-50 and Inception V3. Each model composed of basic CNN with recurrent network model. Figure 3 shows the CNN model of image classification. The three layers convolutions, pooling and fully mappings. All models were implemented in Google connected are connected and taking CT images as input. As the feature extraction done automatically in convolution layer, no need to have separate feature extraction layer. Among different architecture ResNet-50 is identified as excellent generalization performance with fewer errors. Res Net-50 model needs about 200 m epochs for optimum performance. Rectified Linear Unit (ReLU) is the activation function used for complex mappings from input to output functional Colaboratory with Python Kera library.

Figure 4 shows the ReLU activation function. From the graph the output will be zero for the input less than or equal to zero. When the input greater than zero the output equals the input. Figure 5 shows the accuracy of different CNN architecture. Among all ResNet 50 architecture gives 95.4% accuracy in predicting COVID -19 positive cases. Sensi-

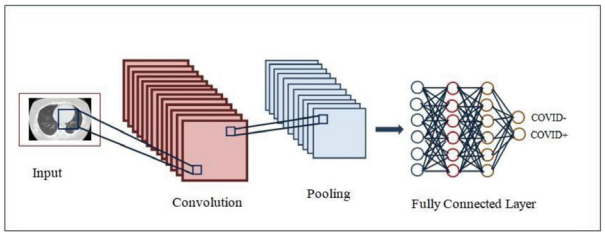

Fig. 3. CNN Model for COVID-19 Prediction

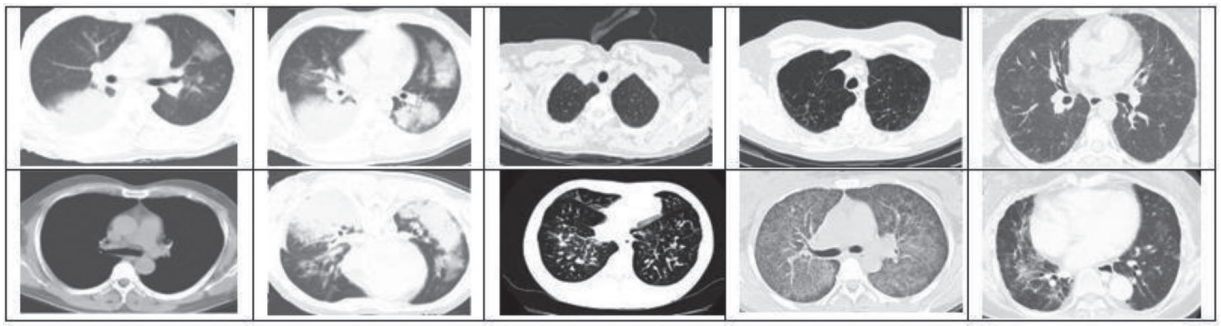

Fig. 1. Non COVID images from CT scan Dataset

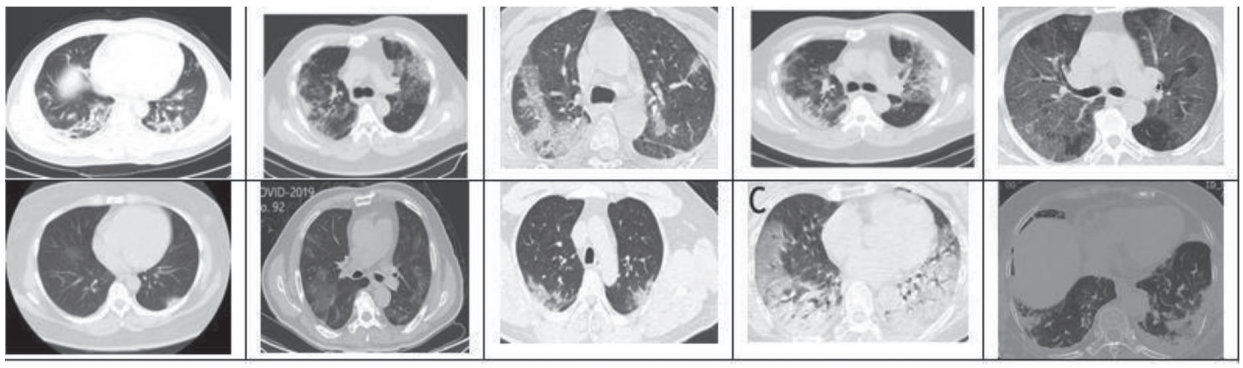

Fig. 2. COVID affected images from CT scan Dataset

tivity measures the performance of the CNN models over COVID positive cases only. Figure 6 shows the sensitivity of different CNN classification models.

Conclusion

In this paper COVID-19 affected patients CT images are analysed using different CNN models to predict the infection. The models are carefully experimented to provide accurate predictions over the infected patients CT images. VGG-19, Inception V3 and ReNet-50 are the models experimented with the available dataset. The parameters like accuracy and sensitivity are analysed for the above models. In this research existing dataset is used for classification. In future real dataset may be used aiming for more accuracy and data augmentation also incorporated to increase the size of the dataset. This model provides more opportunities for AI and Deep learning researchers to automate the diagnosis for Covid-19 provided the improved strategies are proven in the findings.

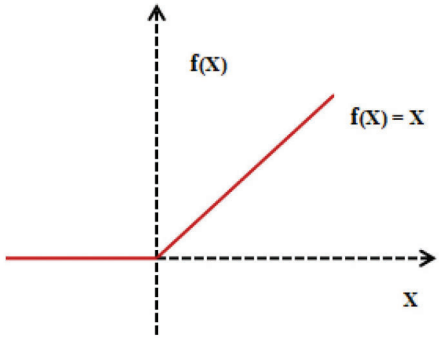

Fig. 4. ReLU Activation function

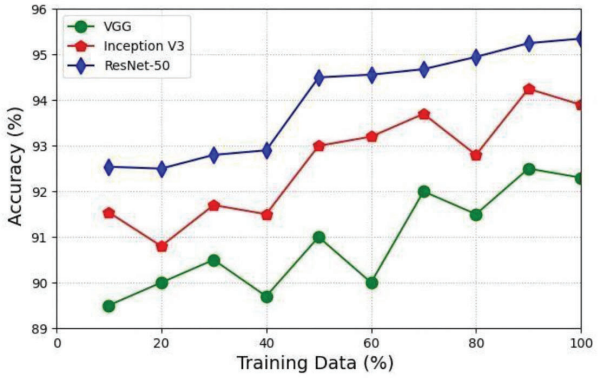

Fig. 5. Accuracy of different CNN Architecture for COVID-19 Dataset

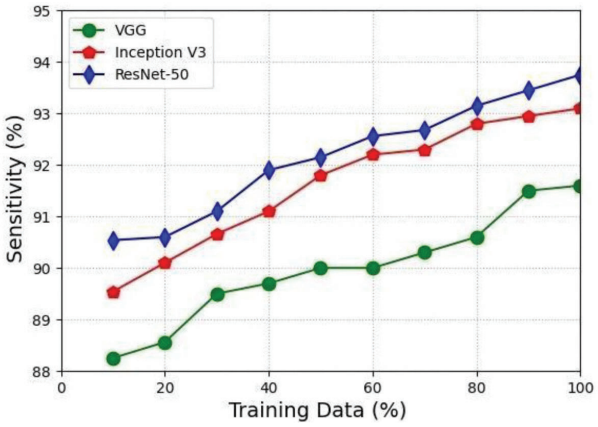

Fig. 6. Sensitivity analysis of various classification Models

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