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A binary classification model of COVID-19 based on convolution neural network

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ABSTRACT

The outbreak of the new coronavirus (COVID-19) had resulted in the creation of a disaster all over the world and it had become a highly acute and severe illness. The prevalence of this disease is increasing rapidly worldwide. The technology of deep learning (DL) became one of the hot topics in the computing context and it is widely implemented in a variety of the medical applications. Those techniques proved to be sufficient tools for the clinicians in automatic COVID-19 diagnosis. In the present study, a DL technology that is based on convolution neural networks (CNN) models had been suggested for the binary COVID-19 classification. In the initial step of the suggested model, COVID-19 data-set of chest X-ray (CXR) images have been obtained then preprocessed. Whereas in the second stage, a new CNN model has been built and trained for diagnosing COVID-19 data-set as (positive) infection or (negative) normal cases. The suggested architecture had a success in classifying COVID-19 with the training model accuracy that had reached 96.57% for the training data-set and 92.29% for validating data-set and could reach the target point with a minimal learning rate for training this model with promising results.

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1. INTRODUCTION

Since Dec. 8th, 2019, a cluster of acute lung infections which are known as the corona virus disease 2019 COVID-19 has been reported in Wuhan, China [1]. COVID-19-infected patients had died due to the pulmonary edema, severe pneumonia, or multiple organ failures. By Apr. 2nd, 2020, China had confirmed 82,735 COVID-19 cases, with 3327 Chinese people dying as a result of the illness [2]. COVID-19 had affected over 200 countries and areas worldwide (with 858,473 total confirmed cases and 44,064 death cases). World Health Organization (WHO) [3] had declared in March that the COVID-19 outbreak is pandemic due to the virus's rapid spread worldwide [4].

Reverse transcription-polymerase chain reaction (RT-PCR) [5] is now regarded as the gold standard for the diagnosis of COVID-19 infections [6]. The results of RT-PCR [7], [8] can however be influenced by sampling errors and low viral loads. Which is why, those tests have high probability of the false negative cases and could require being repeated a couple of times before final confirmation. Numerous articles have recommended chest scanning images as one of techniques for the early detections of COVID-19. Since the discovery of the COVID-19, it has caused a worldwide pandemic [9]. At the same time, hospitals and healthcare staff have found it difficult to manage the large number of cases. Therefore, artificial intelligence (AI) [10] plays a highly important role in providing assistance to the medical personnel in detecting and diagnosing

COVID-19 with the highest speed [11], [12], while also reducing risks that face the medical personnel, saving time and efforts, and presenting highly accurate in diagnoses. Deep learning (DL) has been found as the most effective approach in the area of medical sciences [13]. It is a quick and accurate approach for diagnosis and prediction of the diseases. This work proposed DL approach based on convolution neural networks (CNN) technique for classification and early detection for COVID-19 based upon chest X-rays (CXRs) as datasets. CNN architecture consists of various kinds of the layers (which are: convolutional layer, pooling layer, flatten, and fully connected layer) [14], [15] each type is responsible for specific action. The convolutional layer is the first layer which is utilized for the extraction of different features from input images followed by pooling layer that has been used in order to reduce the convolved feature map size to cut computational cost, while fully connected layer is used for classification [16].

2. RELATED WORK

Developing an automated system to classify lung X-ray images has proven challenging, due to the complexity of detecting infectious and inflammatory lung diseases visually [17]. According to Yadhaf and Jadhaf [18], pre-trained transfer learning-based VGG-16 and Inception-V3 were used for the detection of the cases of COVID-19 from CXR data-set, and support vector machines (SVMs) were used to improve classification performance. Researchs by Choi *et al*. [19] employ a hybrid model for detection of cases of COVID-19 with the use of the CXR images, based upon ML and DL algorithms like the Softmax classifier and CNN. While according to Hemdan *et al*. [20] have suggested an architecture for COVID-19 classification that is based upon CXR images which included 7 classifiers referred to as the COVIDX-Net of images with a high 90% accuracy performance for VGG-19 classifiers and DenseNet-201 [21]. Finally, according to Xu *et al*. [22] a new CNN architecture based on the Keras library presented involuntary detection of COVID-19 in the augmented and raw CXR images with higher accuracy is 92.10% and 93.08% for the testing and the training datasets, respectively.

3. METHOD AND MATERIALS

This section describes the sources, amount, and preprocessing of the datasets used in our study and gives the details of the structure and parameters of the proposed model. The proposed model is implemented on one type of dataset with tuning parameters. The future sections will discuss and evaluate the results and the performance of the model.

3.1. Datasets

The dataset used in the present study was digital X-ray images which were obtained from 2 different publicly available sources on Kaggle. First, collected by a team of researchers from University of Dhaka, Bangladesh and Qatar University, Doha, along with their collaborators from Malaysia as well as Pakistan in a collaboration with the medical experts had created a CXR data-base for the positive cases of COVID-19 along with the normal images (negative) (data A) [23]. Second, collected by a researcher from different sources and research papers and combined them to create one comprehensive dataset (data B) [24].

(Data A) used in the model training which consists of 3616 COVID-19 and 10192 normal images, and (data B) used in the testing of the model which consists of 536 COVID-19 and 668 normal images. All images are resized with 224×224 pixels, as illustrated in Figure 1 and Table 1. The training data were augmented by rescaling to (1/255), sharing with a range of (0.20), zooming with a range of (0.20), and horizontal flipping. While the testing data were rescaled to (1/255). These augmentation tools enhance the data and make the model more accurate and robust.

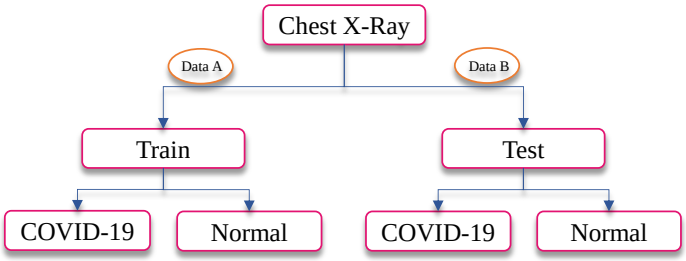

Figure 1. Categories of datasets

Table 1. Division of training and testing data-sets

	COVID-19	Normal
Training	3616	10192
Testing	536	668

3.2. Proposed CNN model

The DL model based on a CNN is proposed in the present study for binary classification of COVID-19 depending on CXR images as input datasets. The suggested model consisted of various layer types (which are pooling layer, convolutional layer, flatten, and fully connected layer) as presented in Figure 2. Our proposed model consists of (3 layers of convolutional followed by 1 pooling layer connected with 2 convolutional and 1 pooling layer connected with 2 convolutional and 1 pooling layer followed by 1 flatten and 2 fully connected layers) connected together for introducing a well-defined CNN architecture. All convolutional layers with filter (Kernel) size (3×3) and each layer followed by Relu as activation function. The pooling layer type is max pooling with size (2×2). The input images were reshaped to (64×64) pixels. The suggested model is built with tuned parameters as illustrated in Table 2. All of the proposed model's experimental processes have been carried out with the use of Google Colaboratory [25].

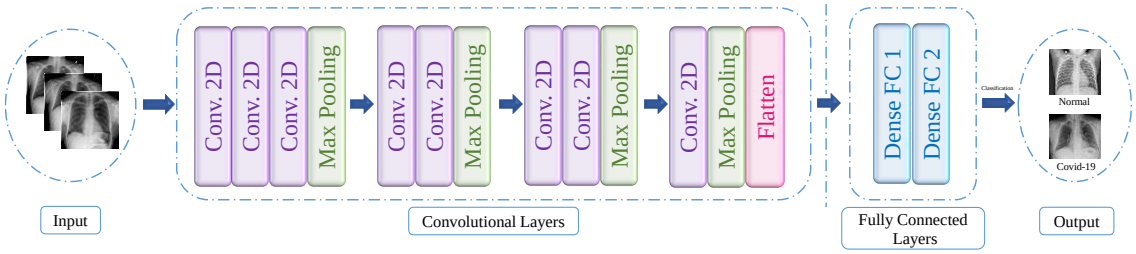

Figure 2. The proposed CNN model architecture

Table 2. Tuned parameters of the proposed model

Parameters	Values
Batch size (BS)	30
Learning rate (LR)	1e-5
Classification type	Binary
Optimizer	Adam

4. RESULTS AND DISCUSSION

In the present study, the suggested model has been implemented using python 3 and Keras framework and was run on Google Colab free version using graphical processing unit (GPU). For training and validating the model, an optimizer "Adam" was used with 1e-5 learning rate and a batch size of 30. The obtained accuracy of proposed model's training was 92.29% and 96.57% for the testing and training datasets, respectively. It should be mentioned that, the trained model had accomplished good results compared to Alwawi and Abood [22] model. As presented in Table 3 and Figure 3. Show training and validation accuracy based on every epoch.

Table 3. The result and enhancement

	Oleiwi and Abood (%)	Proposed approach (%)	Enhancement (%)
Training Accuracy	93.8	96.57	2.868
Testing Accuracy	92.1	92.29	0.2

The accuracy is calculated as (1):

$$Accuracy = \frac{Number\ of\ correct\ classified\ samples}{Total\ number\ of\ samples} * 100\% \quad (1)$$

From Table 3 and Figure 3, show that the enhancement in our model accuracy was 2.868% for training and 0.2% for testing. This enhancement is covered by using less batch size and learning rate with more data

compared with [22] Furthermore, the different classification types between the two models are demonstrated in Table 4.

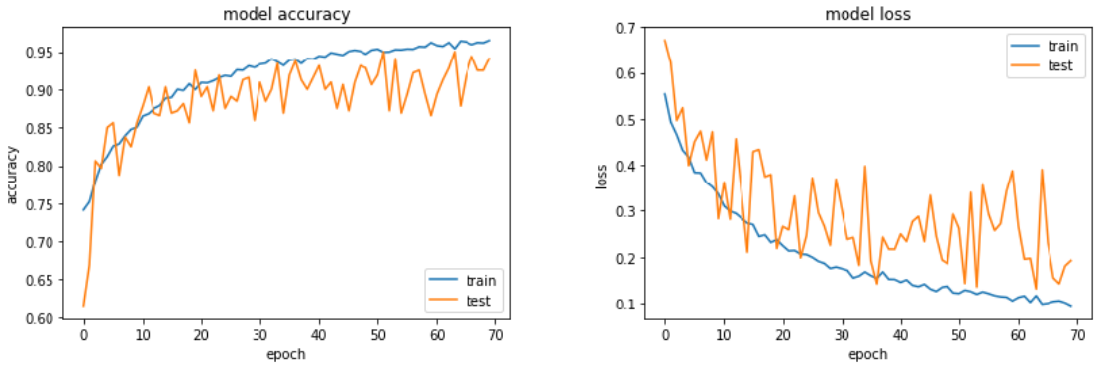

Figure 3. Accuracy of training and validation based on each one of the epochs

Table 4. The difference between the suggested model and Abood and Alwawi

	Proposed model	Abood and Alwawi
Batch size (BS)	30	32
Learning rate (LR)	1e-5	1e-4
Classification type	Binary	Categorical
No. of images	15012	5865

5. CONCLUSION

In conclusion, the present study validated the DL approach's feasibility to help doctors in detection of patients who have COVID-19 and automatically identifying the potential lesions from CXR images. The proposed model for binary classification based on CNN technique performs with an accuracy of 96.57% for the training model and 92.29% for validating data-set and reached a targeted point with a minimal learning rate for training this model and getting good results. For future work, the suggested model may be developed and tested for other types of datasets (CT-scan) and largest amount of data for higher accuracy. Moreover, it can be developed for multi-classification.

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