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IJIEMR Transactions, online available on 12th Jan 2021. Link :http://www.ijiemr.org/downloads.php?vol=Volume-10&issue=ISSUE-01

DOI: 10.48047/IJIEMR/V10/I01/12

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Volume 10, Issue 01, Pages: 68-73
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A Novel Framework using Deep CNN to detect COVID-19 virus through Chest X-rays

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Abstract: The current pandemic caused due to the COVID-19 virus is the major breath taking problem. Artificial Intelligence is playing a major role in finding solutions related to COVID-19 in various aspects. One of the challenges in this field is to predict the positive cases from the sample images like chest X-ray or CT scan etc. This paper presents a novel architecture to predict virus symptoms from the chest X-ray images. In lieu of this study, the Chest X-rays are pre-processed by applying image processing techniques, trained and tested by Convolutional Neural Networks(CNN). The experimental results show better recognition rate in comparison with other research works.

Keywords: **Convolutional Neural Networks, X-ray Images, COVID-19, Image Processing.**

1. Introduction

In the year 2019, China faced a deadly disease due to an illness caused by corona virus named COVID 19[1]. The symptoms to identify illness are dry cough, fatigue, inhalation problems, aching throat, muscle and body pains, diarrhea, loss of taste or smell, eye infections, headache, membrane rashes, yellowing of fingers or toes. The viruses started it spread in the city of Wuhan in December 2019 [2-5]. The virus made a global travel causing 6,01,51,799 [6] public not only to writhe none the less undergo death rate of 14,15,776 [6]. The illness triggers respiratory region infectivity that affects the nose, throat and sinuses, windpipe & lungs.

The initial testing method for the virus was swab test, however accuracy and promptness is a compromise. [7]. To identify the infections in respiratory tract, imaging techniques such as chest X-ray and CT scan [8] partake a vital role in endorsing the test reports as positive. CT scan is an effective method to test, but not many people can afford it. Hence we focus on the implementation of X-ray imaging for identifying virus. However, the images captured have poor contrast and limit the identification of soft tissues. Hence to improve the quality of X-ray images, identify and provide diagnosis at low price, the X-ray images are processed by implementing various algorithms that include preprocessing, enhancement, segmentation, recognition etc.

Nowadays, techniques using Artificial Intelligence(AI) such as Machine Learning(ML) and Deep Learning(DL) show potential results in analyzing medical images. The purpose of this paper is to propose a framework relating training and testing using deep CNN classifiers to identify the Covid- 19 virus and assist radiologists.

Michael Chung, MD • Adam Bernheim, MD • Xueyan Mei et al., [9] experimented with recognition of virus using CT scan

images. The testing was performed on 21 people to evaluate the presence of the ground glass opacities, the no. of affected lobes due to it, the degree of involvement of lobes, presence of nodules, lung infections etc., The limitations are early stages or mild symptoms cannot be identified.

Lawrence O. Hall, Rahul Paul, Dmitry B. Goldgof et al.,[10] created a dataset with chest x-rays, trained and tested using deep Convolution Neural Networks(CNN). The accuracy obtained is 89% for Covid-19 tests. However, the CNN fails to identify the state of disease, lack of information on outcomes. S. Ravi, M. Suman, P.V.V. Kishore, K. Kumar et al.,[11] created a co-trained CNN with single modal testing with convolutional layers, maximum pooling, feature fusion and flattening with two dense and one softmax layer. R. Sunitha, M. Suman, P.V.V. Kishore et al.,[12] represents training and testing using ANN.

2. System Architecture

In this paper, a novel architecture using deep learning techniques is presented for the asserting virus from the Chest X-ray images. Figure 1 represents the system architecture.

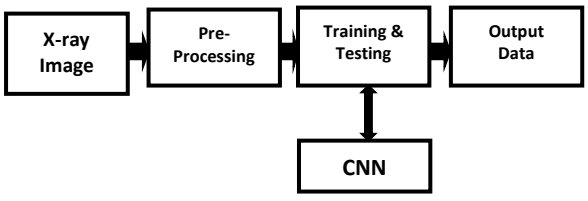

Figure 1: System Design for finding COVID-19 through Chest X-Ray

2.1 X-ray Image Dataset

The most commonly used and lucrative process for observing the chest is X-rays. Analyzing a CT scan image proves easier compared to the X-ray. However, in terms of cost there exists a lot of variation. Aimed for a layman, chest X-ray proves to be economical. Further, research and application implying deep learning techniques proved to be promising over images. The X-ray image dataset chosen in this paper is an open Research data set [13].

2.2 Pre-Processing

The captured X-rays images may vary in size terms of pixels. Therefore, these images are scaled to a size of 224x224 pixels. Further, these X-rays are categorized based on the differences. Deep learning techniques cannot be directly implemented on this dataset. The dataset must be converted to numerical based on categories. Hence, to make this data more meaningful one hot encoding is used in preprocessing.

2.3. Training and Testing

The dataset is split into two parts: 80% for teaching the machine and remaining 20% for analysis. The training dataset is also applied for validation.

2.4.Output Data

The tested data is given to the CNN to identify the images and confirm if the patient is normal or suffering from Covid-19. The performance of the CNN is analyzed.

3. Convolutional Neural Network (CNN)

The pre-processed data is fed to CNN. CNN represents a deep learning algorithm. . The inputs to this are images. It adds weights and biases to several objects that are present in an image and differentiates between them. These networks help to extract features such as edges, point of reference, colour and makes sense of the image. The CNN consists of different convolutional layers. These convolutional layers generate feature maps for the X-ray

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images. The size of the convolutional layers in increased in steps from 32 to 256. The final output features are flattened and are then fed to dense layers 1&2 and one softmax layer. The softmax layer gives the feature vector at its output.

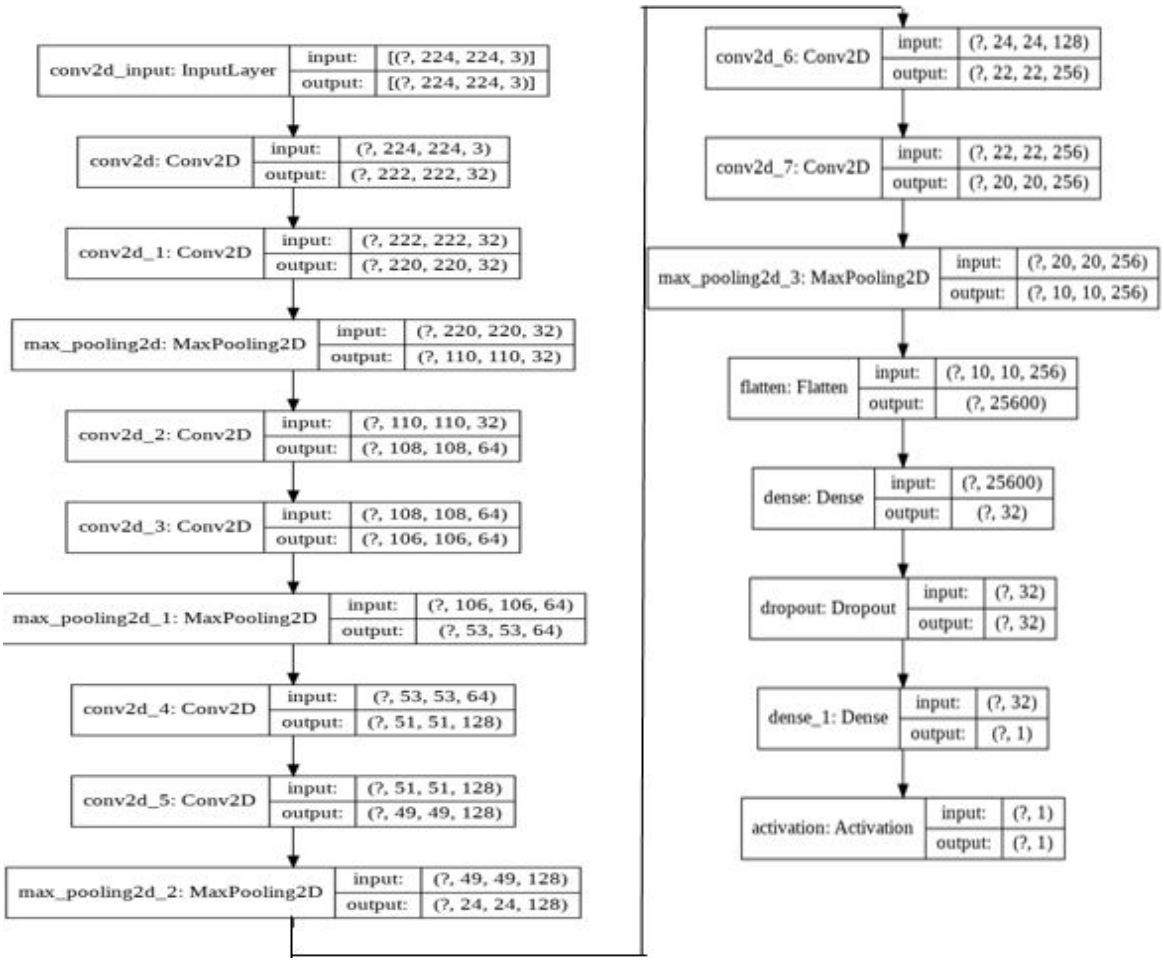


Figure 2: Proposed CNN methodology

4. Dataset and Experimental setup

The X-rays taken for the experimental process are chosen from the National Chest X-ray dataset [14]. The dataset comprises of 5910 Chest X-ray images. Out of these 5286 images are considered for training and validation. The remaining 624 images are for testing purpose. The images of X-ray are in Joint Photographers Expert Group(JPEG) format. Both Normal and Pneumonia X-rays are included. The diagnosis of virus from the captured X-ray images directly poses accuracy problem. Hence, to attain accuracy, the dataset is subjected to preprocessing, trained and tested using deep learning techniques to obtain results of Covid-19.

The CNN is designed with several convolutional layers. These are enhanced after every maximum pooling stage. The layers consists of filters 32, 64, 128 and 256. The size of filters is 3x3. Every set of convolutional layers is followed by Maximum pooling to down size the image. The stride of the pool is chosen as 2. The final convolutional layer output is flattened and is fed to two dense layers and a softmax layer to obtain the result. Figure 2 presents the proposed CNN architecture.

5. Results and Discussions

The proposed model is implemented in Intel i5 processor with Windows 10. This section presents the results of the analyzed Chest X-ray images for positive or

negative results. Accuracy & Loss functions are considered as performance metrics. Figure 3 and Figure 4 provides two-sample chest X-ray images each along with its histograms for both normal and covid-19 cases respectively.

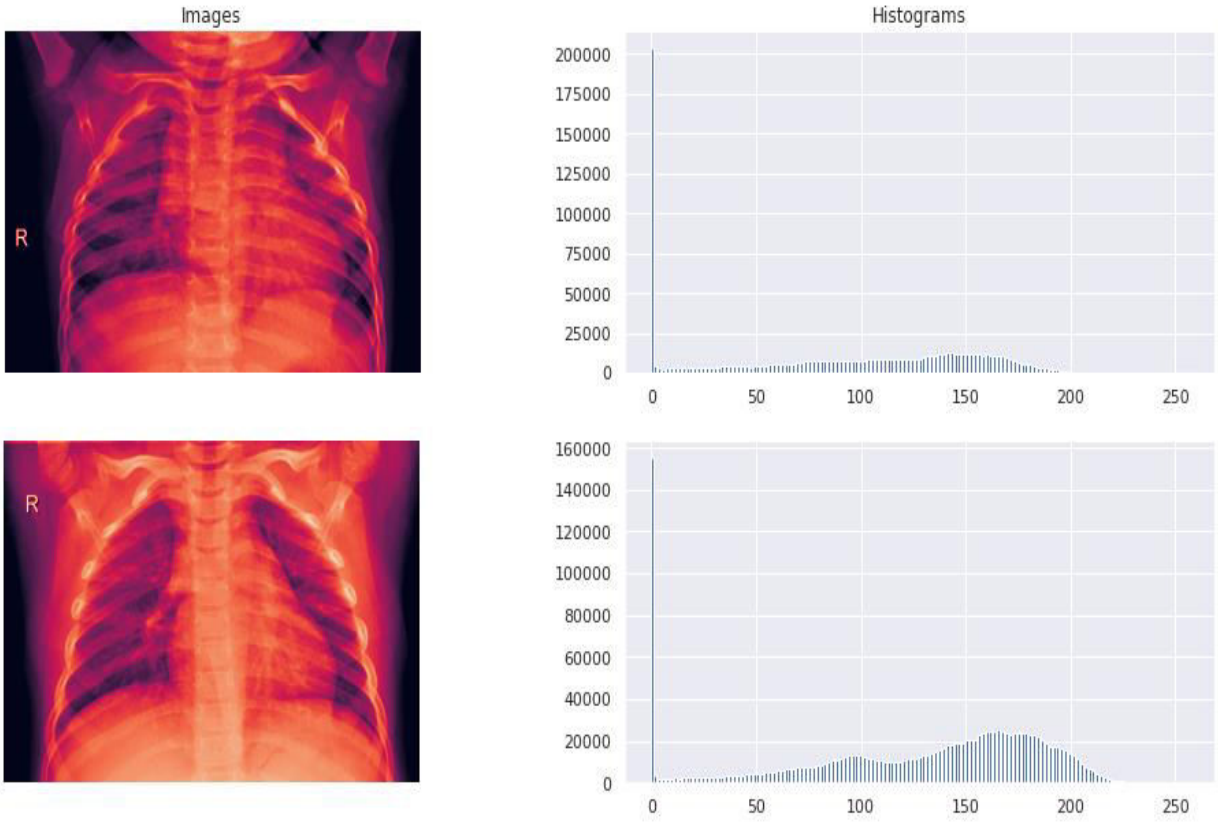


Figure 3: Sample images and corresponding Histogram for Normal Chest X-ray images.

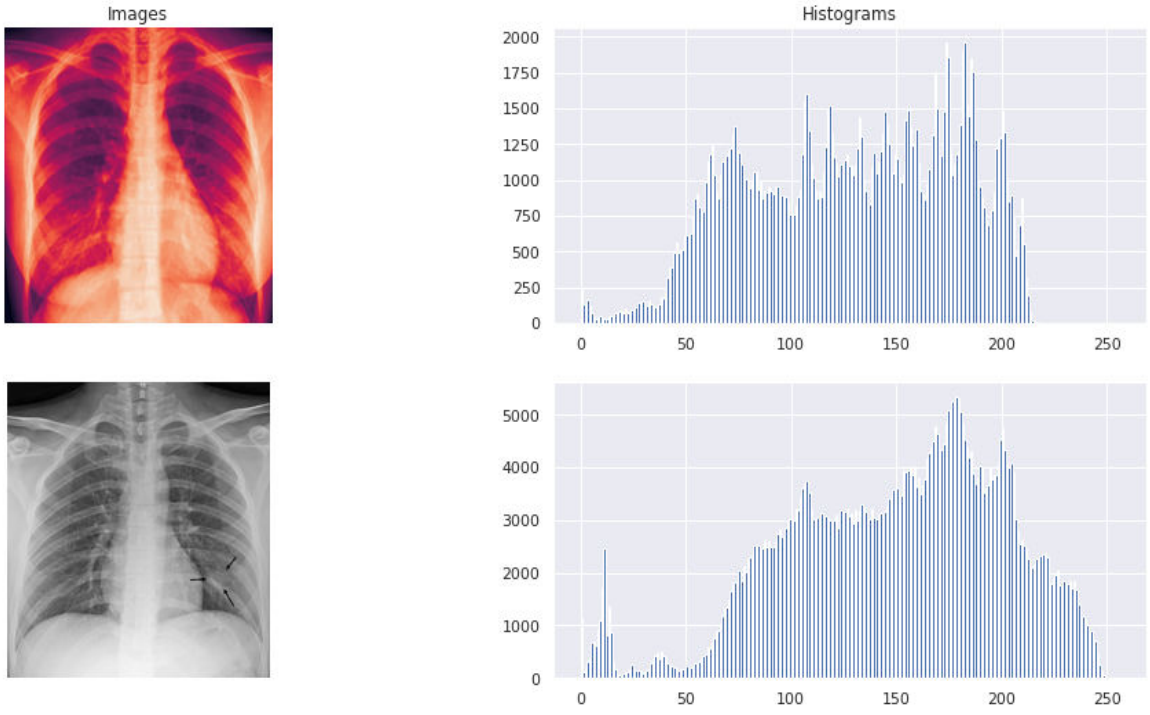
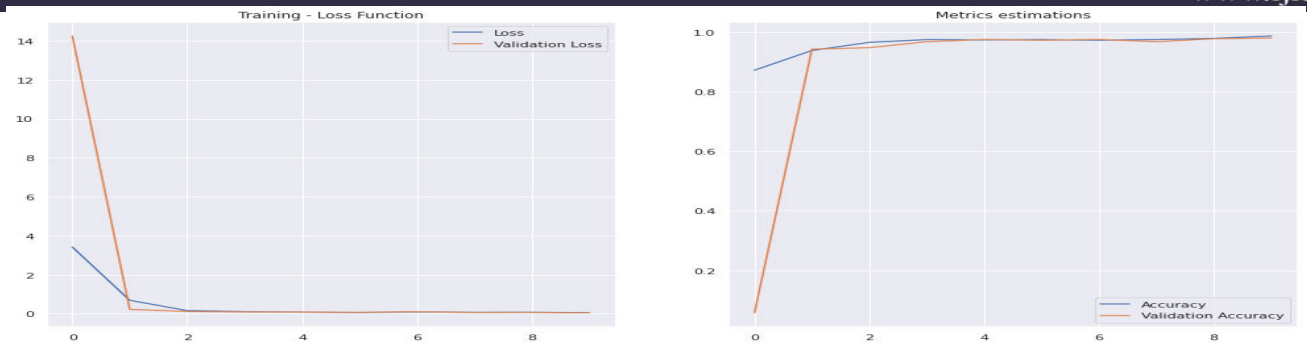


Figure 4: Samples of images and corresponding Histograms for Covid-19 images.



(a) *(b)*

Figure 5: Loss Function and Accuracies of Training set and validation set

The loss function for both learning and validation datasets are represented in graph in Figure 5(a). Here the loss values for learning and validation datasets are obtained as 0.051 and 0.044 respectively. The prediction rate of the CNN classifier is 98.68% for the train set and 98% for the validation set. Whereas the Figure 5(b) presents the training and validation datasets accuracies in which number of epochs are considered in X-axis and percentage of accuracy is represented on Y-axis.

VII. Conclusion:

In this paper, Convolution Neural Network model on Covid-19 Chest X-ray dataset is learned and implemented. The proposed model yields up to 98.68% of accuracy and 0.51% of loss. It is observed that the model is good when compared to other models proposed in the study. The effect of different filtering functions can be tested on the same data as a future work.

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