Detection of COVID-19 Using Chest X-ray Images by Convolutional Neural Networks

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The recent outbreak of a transmissible disease known as COVID-19 has caused a global alarm due to its infectious nature. It has been observed that the symptoms of COVID-19 can be very mellow; some people may not show any symptoms at all but can infect other people. It is not as carcinogenic as SARS and MERS.

COVID-19 is normally detected in the upper and lower respiratory specimens of the individuals with the help of RT-PCR (real-time transcription-polymerase chain reaction) test. Since the origin of the outbreak, the availability and quantity of the testing kits have been low. The stability and reproducibility if the detection kits are being questioned. These factors play a determinant role in the accuracy of test results. In several areas, the accuracy of the kits has found to be only 80% and has to be hence repeated several times before the cases can be confirmed. There are questions being raised about quality of the detection kits.

X-ray images of the chest can be used to diagnose COVID-19 with technological advancements made in the field of machine learning. One of the most vital methods of machine learning is deep learning. Deep learning focuses on extracting features and classifies images which are applied in detecting objects or in medical cases, classification of tasks. Machine learning and deep learning have become established disciplines in applying artificial intelligence to mine, analyze, and recognize patterns from data.

In the study, a prediction of the COVID-19 detector will be modelled using Convolutional Neural Network (CNN) based on Chest x-rays images. CNN helps in the extraction of the features by enhancing low-light images with the help of training data. In the early stages of COVID-19, bilateral distribution of patchy shadows and ground-glass opacity has been observed which are similar to the viral pneumonia symptoms with slight differences [3]. With the aid of the CNN model, unique features can be identified which are difficult for visual recognition. After the model is trained on the dataset, performance of this classification model is evaluated on the validation dataset using a Confusion Matrix.

The dataset contains a total of 412 chest x-ray images. The dataset is balanced in nature with 50% normal chest x-rays and 50% COVID-19 chest x-rays. The dataset is further divided into train and validation having 80:20 proportion. A CNN model is to be built having two classes in order to distinguish between the Chest X-rays of patients infected with COVID-19 and Normal Chest X-rays.

The CNN model consists of two types of layers: Convolutional layers and Fully Connected Layers. A nine layered CNN model is created, consisting of three sets of stacked convolutional and pooling layers followed by two fully connected layers for classifying COVID-19 and normal x-ray images. There are four convolutional layers with filter sizes of 3 x 3 but having increasing filter numbers (32, 64,64,128) over the layers.

The initial layers are small in the beginning because the lower layers detect features in small parts of the images and can find small patterns in the image as we go deeper into the layers, the receptive field of the CNN layer increases. The kernel size is 3 x 3, which is a standard choice. Activation of Relu layer is used in the convolutional layers for non-linearity. Since this is the first layer, we specify the input size as 224 x 224 x 3. There are three pooling layers with filter size 2 x 2 each which is the default size, by using Max Pooling, the receptive field of the layer increases.

On evaluating the model, it is observed that the validation accuracy is 97%. Although it is a good accuracy score, there may be some cons to deploy this model since there could be some major consequences. For example, with a 97% accuracy, the model would be able to detect 97 patients out of 100 rightly but would wrongly guess three patients. There can be a scenario where a patient can be misclassified, that is, a patient can be COVID-19 negative, but the model states that he is COVID-19 positive. Hence, he will be made to quarantined with patients who are COVID-19 positive, leading to him getting affected. On the other hand, it may also happen that a patient can be COVID-19 positive, but the model states that he is COVID-19 negative. The patient could be dangerous as he could spread the virus to other people in his surroundings. Thus, when it comes to medical imaging, one must be super cautious and must have a good accuracy score as it is a question of human life.

Chest X-ray images play a vital role in the detection of COVID-19. In this study, a CNN Model was used to detect COVID-19 using Chest X-ray images obtained from COVID-19 patients and Normal patients. CNN enables learning highly representative and hierarchical local image features directly from data. The model performance is 97% which is a high accuracy score with the recent origins of the virus. Although this paper is only for educational and research purposes, not for medical purposes, it will aid doctors to make better decisions in clinical practice due to the higher performance of the model.

Nonetheless, the present work contributes to the possibility of a low-cost, rapid, and automatic diagnosis of COVID-19. Also, even though the appropriate treatment is not determined solely from an X-ray image, an initial screening of the cases would be useful, not in the type of treatment, but in the timely application of quarantine measures in the positive samples, until a complete examination and specific treatment or follow-up procedure are followed. An additional advantage of automatic detection of COVID-19 from medical imaging lies in the reduction of exposure of nursing and medical staff to the outbreak.