A Review of Computer Aided Diagnosis Model for the COVID-19 Detection using Chest X-Ray Images

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Abstract
Many CAD systems have been developed by various authors using the machine or deep learning methods. The goal of such systems is to identify the patients with COVID-19 positive. Most of the existing CAD systems are based of standard steps i.e. pre-processing in which the acquired images are enhanced to get the clear images before providing the input to the CAD system. Segmentation is used to detect disease part or the ROI is segmented from the image. There are many methods used for feature extraction like Otsu thresholding that can extract features from image and identify the area to segment. Finally learning Methods are used to classify images into COVID-19 positive or negative category.
Keywords: DNN, COVID, LEARNING, X-RAY, CAD.

1 Introduction

The The COVID-19 is one of the deadliest recognized diseases of the 21st century. The outbreak of coronavirus had impacted the health system, people, and business of many countries. Many people across the globe also died due to COVID-19. Initially this virus was said to have originated from China. It has been reported that the virus is leaked from Wuhan Institute of Virology, where it starts to spread among the community. Later the virus started to spread across the globe and more than 80 thousand cases reported in China only. The WHO issues advisory regarding the virus and later in March 2020 COVID-19 is declared as pandemic by WHO.

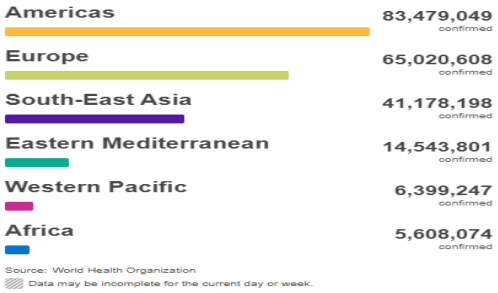

Figure 1: COVID-19 Confirmed Cases on 30 Aug 20, 2021(Source: WHO Data)

The person suffering from COVID-19 can have symptoms like fever, cold, cough, itchy throat, and body pain. In severe cases a person can also feel breathless and the SPO2 level can fall.

2 COVID-19 Detection Methods

1. RT-PCR Testing: It is one of the most sensitive methods to detect COVID-19. It is pronounced as Reverse Transcription-Polymerase Chain reaction. It measures the load of viruses. The accuracy of this test is more than 95%. Reporting time is more than 8 hours.

2. Rapid Antigen Testing: It is a kit variant of testing, in which the sample can be tested within 15-30 minutes. The accuracy of detection is reported to be around 60%. The testing kits are available for home usage too.

3. Computer Aided Diagnosis using Chest X-Ray Images: This is one of the recent methods used by the doctors and the radiologists to detect the COVID-19. The lungs of a person suffering from COVID-19 may appear whitish and air gaps seen in the lungs. While the x-ray of a healthy person appears to be black. So, nowadays many authors have developed and proposed a CAD based method for the detection of COVID-19.

Many countries are reporting the different variants of COVID-19, which makes it difficult to detect for existing methods too. The present stats of COVID-19 as reported by WHO for top ten countries are as shown in Table I below:

Table I: Cumulative cases and Death's data of COVID-19 as per WHO

Name	WHO Region	Cases - cumulative total	Deaths - cumulative total
United States of America	Americas	38524389	631134
India	South-East Asia	32737939	438210
Brazil	Americas	20728605	579010
Russian Federation	Europe	6882827	181637
France	Europe	6728858	114157
The United Kingdom	Europe	6698486	132376
Turkey	Europe	6329549	55958
Argentina	Americas	5171458	111324
Iran (Islamic Republic of)	Eastern Mediterranean	4926964	106482

3 Literature Review

(Nur-a-alam et al., 2021) had proposed a method to detect COVID-19 from chest x-ray images using deep learning. The early detection of COVID-19 can save thousands of lives. In this

paper the author had proposed a detection method-based convolution neural network (CNN) learning, in which a CAD system is trained to detect the COVID-19 from the patient chest images. This method was proved to be quite cheaper than detection through any other method. The proposed method had shown an accuracy of more than 98% which is quite good and acceptable.

(Osman et al., 2021) had proposed a method for the detection of codid-19 using the radiology images. The proposed method was based on a locality weighted learning algorithm integrated with a self organizing map. Based on the existing evident data, there are certain irregularities in the chest x-ray of the patient suffering from covid -19. Based on that data in this paper a publicly available dataset was acquired and used for training the CAD system after the feature extraction from the dataset. The proposed method had shown detection accuracy over 92%. Also the method was able to predict and detect COVID-19 in early stages.

(Al-shargabi et al., 2021) had introduced an efficient learning scheme for COVID-19 detection. The proposed method is based on transfer learning where certain check x-ray images are acquired, and the large dataset images are generated from the acquired images. In this paper the proposed generative adversarial model generates 84% of the total training images from the acquired images. The network training is done on multiple architectures of transfer learning like Alex-Net, Deep-Net and Res-Net. The proposed model had shown the average accuracy of 98% disease detection for all the architectures.

(Abraham & Nair, 2020) had developed a CAD based system for the diagnosis of COVID-19 using multilayer CNN and Bayes net classifier for chest x-ray images. In this work the author initially extracted the features from the images using CNN. The images are further resized to form the group of homogeneous images. The experiments were performed using the MATLAB-2020a edition. The graphical processing unit (GPU) is required for this research. Once the network is trained the classification is done using Bayes net classifier. The architecture of the proposed method is shown in below figure 3. The proposed method had achieved an accuracy of 91%.

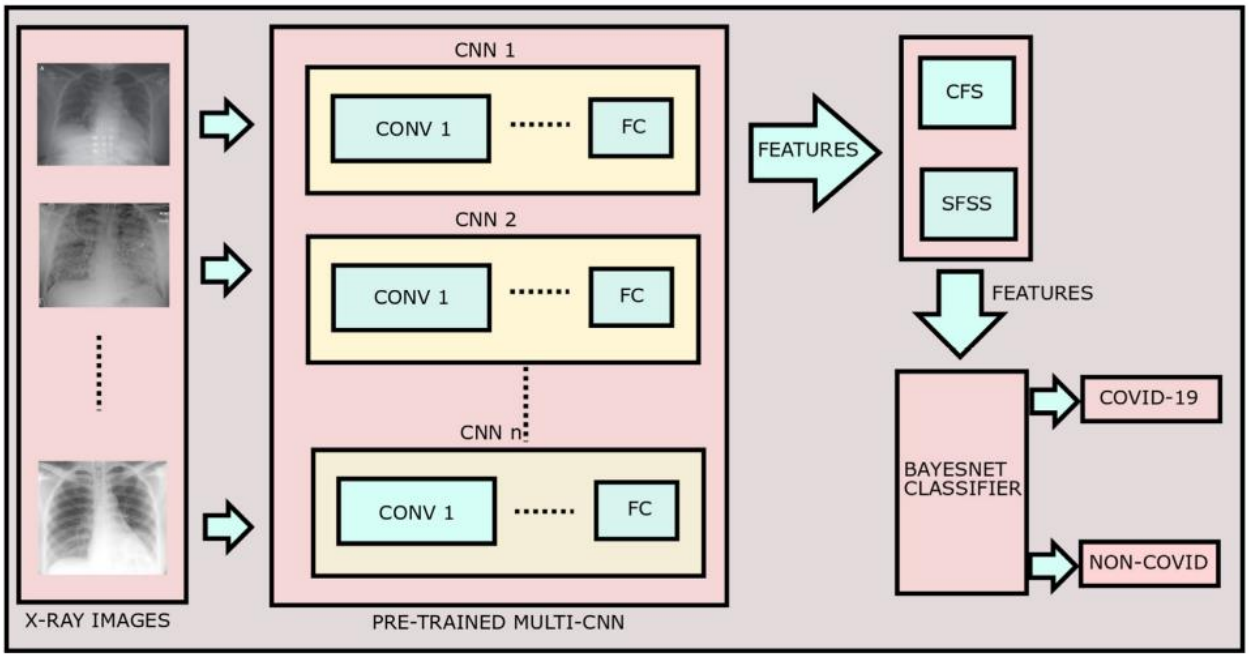

Figure 3: CNN Based CAD Model Developed by (Abraham & Nair, 2020)

(Singh et al., 2020) had classified the chest x-ray images of COVID-19 patients using a multi objective CNN network. The author has developed a method that can classify the x-ray images as positive or negative. The positive signifies that the patient is suffering from COVID-19. Additionally, the proposed method is proved to be cheaper than the rapid and RT-PCR test. Also the report of the patients is available in a very lesser time period than rapid and RT-PCR testing. The method had shown an accuracy of more than 93%.

(Nur-a-alam et al., 2021) had done COVID-19 detection from x-ray images using an integrated feature extraction and learning method. In this paper the author had used a histogram-oriented method for contrast enhancement of the original images. The VGG-Net is used for network training and classification. The anisotropic filtering is used to reduce the noise and better edge detection. The testing of the method is done using 5 cross fold verification methods. The proposed method had shown an accuracy of more than 93%. The method is also validated on higher accuracy using the k-fold generalization.

(Ismael & Abdulkadir, 2020) had trained a pre-trained network architecture based on CNN model. The author had worked on the chest x-ray images to detect the occurrence of COVID-19 to conclude that a patient is COVID-19 positive or negative. The author had used the 200 chest x-ray images of healthy patients and 180 images of COVID-19 patients. The training of a pre-trained network saves a lot of computational resources. The features were extracted from the image using the Res-Net architecture and SVM classifier is used for the classification of the images. The method had achieved an overall accuracy of 94.7% which is further tuned using Res-Net architecture and the then achieved accuracy is 96.40%. The results had shown that the method proved to be quite significant in detection of COVID-19.

(Singh et al., 2020)had proposed a screening model for the COVID-19 detection using the chest x-ray images. The author had used a DNN architecture, but DNN mostly suffers from

overfitting and hyperparameter advancement issues. To address this issue the author had used a metaheuristic based Alex-net architecture. The architecture is used for classification and detection. The proposed network is also tested on tuberculosis. The model had attained a high f-score of 1.23%. The overall computational efficiency of the model is also low.

Table II Performance Evaluation of Various Existing CAD Models

Author	Method	Learning and Dataset	Performance
(Ahmed et al., 2020)	Data augmentation and normalization for pre-processing and ResNet-50 learning architecture is used	CNN (ResNet-50) Dataset: COVIDx	Accuracy:96% F Score:100
(Hemdan et al., 2020)	The method rescale the images after pre-processing to enhance the image quality.	VGG-19, Dense-Net Dataset: Cohens	Accuracy:91% F Score: 91%
(Wu et al., 2020)	The author performs pre-processing followed by hybrid segmentation. The rescaling is done to reform the image with same pixels.	The ResNet-50 Learning model is used. Dataset: Clinical	Accuracy: 76% Sensitivity: 91
(Pereira et al., 2020)	Multistage fusion is used with a resampling algorithm. The classification architecture is less complex.	Inception-V3 Dataset:RYDL-20	Accuracy 91% F Score: 83%
(Khalifa et al., 2020)	GAN based network architecture with contrast adaptive histogram equalization to reduce the image blur areas and for edge preservation	ResNet-18 Architecture used. Dataset: Pneumonia Images Dataset	Accuracy: 99% F Score:98%
(Özkaya et al., 2020)	Otsu thresholding for feature extraction and transfer learning models are used to verify the accuracy percentage of different models.	VGG-16, Res-Net, Google-Net Dataset: SIRM	Accuracy: 98.86% Sensitivity: 98.93% FR Score: 98.28%
(Bhattacharya & Bhattacharya, 2021)	The GAN used for image pre-processing and resizing is done to enhance the image clarity for better detection. The cropping of	Transfer Learning Based Method Dataset:UCSD and	Accuracy: 87.60% F Score: 87.1%

	image is also performed to uniform the dataset and image quality	Clinical	
(Ramadhan et al., 2020)	Contrast limited adaptive histogram enhancement with wiener filtering. The image resize is done dynamically.	Transfer Learning (COVID-NET) Dataset: Multiple	1. Accuracy: 98.4% Sensitivity:100%
(Shoeibi et al., 2020)	Hybrid Method of combining filtering with segmentation. The thresholding is done for feature extraction. The k-mean method is used for pixel enhancement	Multimode CNN Dataset: Kaggle	Accuracy: 93%

Conclusion

1. The classification of COVID-19 x-ray images is still not proven to be an effective method of classification due to very limited datasets and study.

2. Most of the existing CAD based methods suffered from the lack of computational resources due to which the process of training degrades.

3. The learning method to use while training a CAD system is still a question of concern. As accuracy is one of the most desired factors with minimum resource usage.

4. Training a CNN network from scratch is a tedious task and involves a heavy development cost.

5. The chest x-ray images suffered from noise induction which degraded the image quality and sometimes hardware with low resolution may depict false details. Also sometime there are other multiple reasons for whiteness in lungs, but it can be categorized as positive.

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