Deep Learning Approaches To Detect COVID-19 Using Chest X-Ray Images

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Abstract- *Novel corona virus disease called covid-19 is an infectious disease caused by newly discovered corona virus, which causes the difficulty in breathing, chest pain and loss of movements or speech. Approximately there are 175 million confirmed cases worldwide. As it spreads rapidly among the people, it is difficult to test manually and in most of the cases it takes few days to a week to get the result. Therefore, it is necessary to implement the automatic detection system as an alternative diagnosis option using the chest X-Ray images. In this work an Automatic Detection of Covid-19 Using Chest X-ray Images with Deep Learning Approaches is an automated system, which helps to classify whether the given X-Ray image is tested covid-19 positive or not. In this proposed system four pre-trained deep learning models have been used, such as DenseNet201, VGG16, ResNet152V2 and InceptionV3, each model is trained individually to detect the covid-19 for further treatment. Among all the four models DenseNet201 and VGG16 has reached the highest accuracy of 95%, the system accuracy.*

Keywords- Covid-19, novel corona virus, VGG-16, DenseNet, Inception, ResNet

I. INTRODUCTION

From the recent literature survey it shows, that clinical finding of novel corona virus called COVID-19. It has multiple symptoms like cough, fever, sore throat, difficulty in breathing, lungs problem which can be detected using radiographic images [1,2]. Clinical covid test is accepted as standard diagnosis, but it takes more time with the few false negative diagnoses. Also the covid-19 kits are very limited in the laboratories and hospitals. Therefore, fast and alternate diagnosis method of covid-19 is done using multiple medical imaging techniques such as computed tomography (CT) and X-ray images, these images should be chest radiographic images. This method of diagnosis is the best and fast way to test the covid-19 in early stages [3]. From the recent literature of radiology, it shows that most of the studies are concentrated on chest computed tomography (CT) of covid-19 [4, 5]. It is advised from the recent studies that early stage of detecting covid-19 might be diagnosis using radiographic images [6]. Further, the study of [7] shows that, the covid-19 also be detected easily using chest X-rays. Especially in chest X-rays, it shows various white patches on lungs of covid-19 patients.
From the recent studies it shows that different machine learning techniques and artificial intelligence (AI) with various image processing techniques are used to detect the covid-19 in early stage of disease. Using these techniques, the affected and normal chest X-ray images are differentiated with better accuracy. It is the best way to identify the covid-19 disease and to decrease the spreading rate, especially in the less resource areas where there is no high-end medical facilities for early stage diagnosis [8].

Based on the recent studies, it shows that by uniting the clinical finding test and chest X-ray images might help in finding the early stage of covid-19 [9,10]. In [11], proposed a new approach to diagnosis the covid-19 by using AI with covid and non-covid CT images, in this approach a set of ten convolution neural networks (CNN) are used to classify covid and non-covid. Further, to increase the system performance further they adopted Xception and ResNet models. Squeeze-Net is used to diagnosis the covid-19 X-ray images with Bayesian optimization technique [12]. In [13], proposed a new approach to detect the covid-19 by chest X-ray images by adopting the binary classification with multi classes and used Dark-Net with seventeen convolutional layers. A new approach called COVIDX-Net based deep learning approach in order to diagnosis the automatic covid-19 detection using X-ray images [14], here various well known models are applied, like, VGG, CNN and DenseNet to classify covid and non-covid patients. CNN architecture is adopted to classify covid and non-covid with the transfer learning for X-ray images [15]. In [16], proposed a new method using CNN based models are, pre-trained networks like Inception and ResNet in order to classify covid and non-covid X-ray images.
Rest of the papers is organized as follows, section 2 explain the related works are explained. The methodology to detect and classify the covid-19 is briefly explained in section 3. Experimental results and discussions with dataset description are explained in section 4. Finally the work is concluded in section 5.

II. LITERATURE REVIEW

i. VGG-16

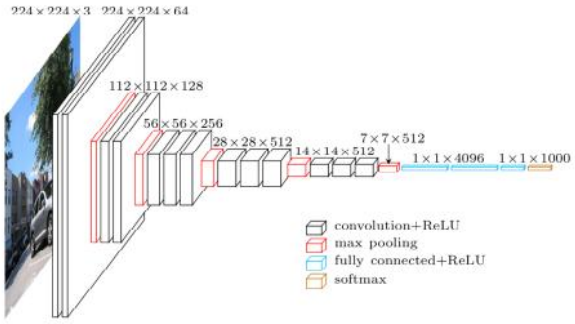

Fig.1: VGG architecture

In this work, the architectures of VGG-16 consist of three convolutional filters and sixteen convolutional layers in order to extract the features. Each layer follows a ReLU and further it has a maximum pooling layers for sampling. It consist of three layers out of that two layers are hidden layers, and the third layer is for classification [17]. The structure simulates the higher filter, by keeping the benefits of smaller ones. VggNet has provides better system performance by fine tuning different parameters [17]. The VGG architecture is as shows in fig.1.

ii. ResNet-152V2

Generally, the ResNet was designed in 2015 [18], it has been ranked top in the Image-Net competition, with 3.6% of error rate [18]. The residual mapping of the ResNet model is as sown in the fig.2. Compare to other architectures the distinguish features of the blocks are which are feed to the next layers are added to model. The feature values are added to each two layers between ReLU and linear activations, and changes the system values.

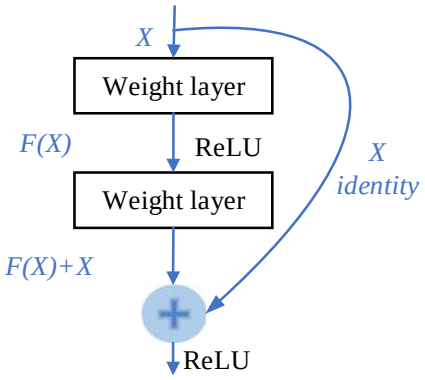

Fig.2: Residual mapping structure of ResNet

Basically, it is a pre-trained model which has initial weights, which helps to increase the system performance than compare to general CNN model. The architecture consist of ResNet-152V2 model followed by reshape, flatten, dense layers with neurons, dropout with finally Softmax layer in order to classify covid-19 or non-covid.

iii. DenseNet 201

DenseNet has condensed network, which is easy to train the dataset and it is efficient parametrical model, due to it has feature re-use possibility with multiple layers, which intern increases the variation of succeeding layer inputs and also improves the system performance [19]. DensNet-201 has provided best performance for different datasets like CIFAR-100 and Image-net. In order to improve the system performance, the dense-net-201 provided the direct connections from the previous layers to later layers [20] [21]; the layered densenet-201 architecture is as shown in fig.3

iv. Inception V3

In [22], proposed a new solution in order to estimates the complexities of preceding models with convolution of 1x1. The basic idea behind inception is to provide a best sparse structure in a convolutional network that can cover dense components [23].

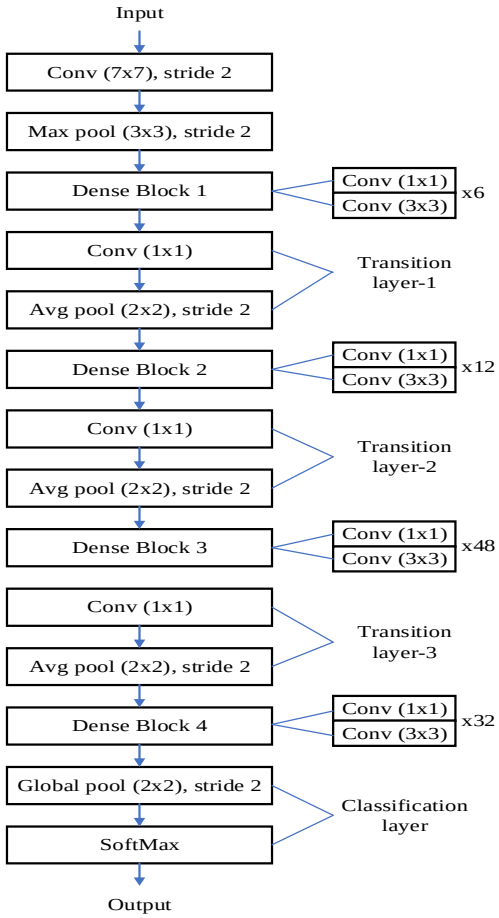

Fig.3 Architecture of layered densenet-201

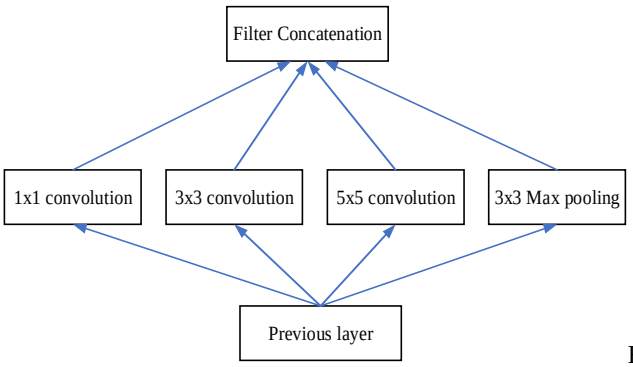

Fig.4 Inception module

Further, the key point of 1x1 convolutions is to condense the number of channels in an image, which intern reduction in the number of parameters required. Though the given input matrix is multichannel, then the channel matrix of output will be 1x1 convolutions, which is basically equal to the applied filter 1x1 convolutions. From the studies, inception-v1 is also called as Google Net, later which has different versions like inception –v2, inception-v3 [24], and inception-v4. It is shows that the inception-v3 has two parts, one for feature extraction process another one is for classification. Further, shows that the feature extraction process consists of CNN and fully connected and Softmax layer is used for classification. The inception module is as shown in fig.4.

III. PROPOSED METHODOLOGY

Block diagram of the proposed Covid-19 detection system using multiple deep learning models is as shown in the fig.5. The proposed system mainly consists of three stages, Pre-processing, feature extraction using multiple deep learning models and classification stage. In this work, chest X-rays images are used as input to the model and output is the classification of Covid or non-covid.

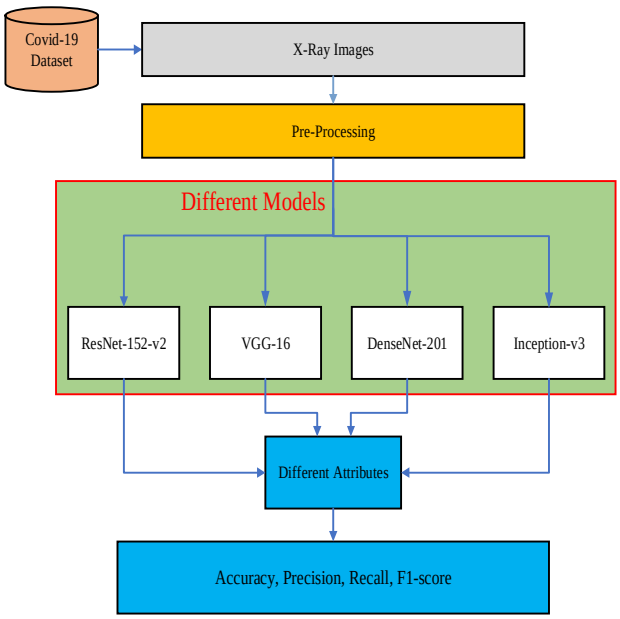

Fig.5: Overall block diagram of the proposed Covid-19 detection system using multiple deep learning models

First stage of the proposed system deals with the pre-processing of the chest X-rays, such as: image resizing, augmentation of an image and splitting the database into training and testing subsets randomly with 80% and 20% respectively. Further data normalization is done after converting the chest X-ray images in to an array of image pixels in order to rescale the pixel values between [0 1] interval. Feature extraction process and classification of covid or non-covid is done in second and third stages respectively by using multiple types of deep learning models like VGG-16, ResNet-15v2, DenseNet-201 and Inception-v3. The input images used in the first stage of the proposed system is chest X-ray images obtained from the covid and non-covid patients. These chest X-ray images are further resized into 224x224x3. Further, in order to increase the system performance, image data augmentation is adopted. Some of the augmentation

techniques adopted in this work are, rotate, flip and skewing. In the final stage of the proposed system, classification is done with the different attributes like accuracy, precision, recall and F1-score are calculated. The work flow of the proposed Covid-19 detection system is as shown in fig.6.

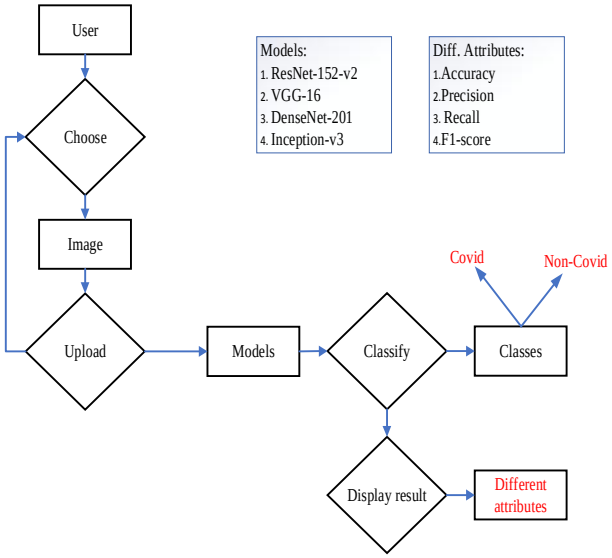

Fig.6: Work flow of the proposed Covid-19 detection system

IV. EXPERIMENTAL RESULTS AND DISCUSSION

The detailed description of the database used in the in this work and experimental results obtained for the proposed system are explained in this section.

i. Database description

The chest X-rays used in this work are taken from [25] and the detailed description of the database used in this work is tabulated in table 1.

Table 1: detailed description of database

# Subsets	# No. of X-rays images	#Training	#Testing
Covid	415	332	83
Non-Covid	505	404	101
Total	920	736	184

The database consists of two subsets (two classes) mainly, covid and non-covid sets, theses subsets comprises of chest X-ray images, which were used as a input to the proposed system. The total chest X-ray images used in this work is 920 images; out of this 80% of the images (736 X-ray images) are used for training, rest 20% (184 –ray images) of the images are used to test the proposed system.Covid-19 and non-covid chest X-ray images obtained from the covid patient and non-covid patients are as shown in fig. 7 and fig.8 respectively.

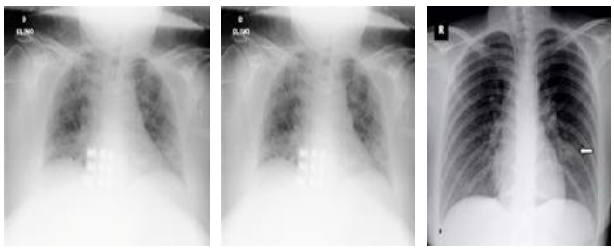

Fig. 7: Covid-19 X-Ray images

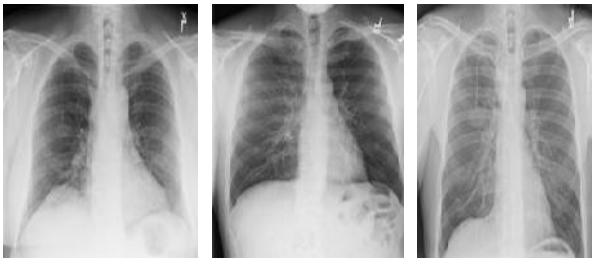

Fig. 8: Non-Covid X-Ray images

ii. Experimental Results

The experimental results obtained from the proposed covid-19 detection system are explained in this section. The different metric used to calculate the system performance is: accuracy, precision, recall and F1-score.Firstly, accuracy is defined as the number of correctly predicted covid or non-covid images from the total number of chest X-ray images present in the given database, the equation is as follows:

$$Accuracy = \frac{Tp+Tn}{Tp+Tn+Fp+Fn} \quad (1)$$

Whereas, TP is true positive rate, TN is true negative, FP is false positive and FN is false negative rate. Secondly, recall also called as sensitivity, is defined as the number of actual images and predicted images as positive from the given total images actually positive, which is also called as true positive. The equation of recall or sensitivity is as follows:

$$Sensitivity = \frac{Tp}{Tp+Fn} \quad (2)$$

Positive predictive value is also called as precision, it represents the number of images are actual and predicted as positive from the given total number images predicted as correctly, it is defined as equation follows:

$$Preciston = \frac{Tp}{Tp+Fp} \quad (3)$$

The harmonic mean obtained from the recall and precision is called as F1-score, the equation of F1-score is as follows:

$$F1\_score = \frac{2*Tp}{2*Tp+Fp+Fn} \quad (4)$$

The different attributes like precision, recall and F1-score of the proposed covid-19 detection system using different deep learning approaches are tabulated in table 2. Whereas, 0 indicates Covid and 1 indicates non-covid in the table 2.

Table 2: different attributes used in the proposed system

Models used in the proposed work	Precision		Recall		F1-score	
	0	1	0	1	0	1
VGG-16	0.92	0.98	0.98	0.93	0.95	0.95
DenseNet-201	0.90	1.00	1.00	0.91	0.95	0.95
ResNet-15v2	0.92	0.94	0.93	0.93	0.92	0.94
Inception-v3	0.83	0.96	0.95	0.84	0.89	0.89

Table 3: Comparison of the models with other exiting models

Different Existing Models	Accuracy (in %)
COVID-Net: Tailored model [26]	92.40
COVIDx-Net [27]	90.00
Dark Covid-Net [28]	90.8

Table 4: Comparison of different models used in the proposed work with accuracy

Models used in the Proposed work	Accuracy (in %)
Inception V3	89
ResNet152V2	93
DenseNet201	95
Vgg16	95

The system accuracy of the proposed covid-19 detection system using chest X-rays with different deep learning approaches are tabulated in the table 3. Form table 4, it shows that the models used in the proposed system are provides better accuracy compare to the other existing state-of-the-art models. Out of four models used in the proposed system, DenseNet-201 and VGG-16 models provides best accuracy as 95% of system accuracy.

V. CONCLUSION

In this proposed work, Covid-19 detection system using chest x-ray images with multiple deep learning approaches. It helps in the early prediction of COVID-19 virus, which is necessary to prevent the rapid spread of infection among the people. In this work we have adopted deep learning approaches for automatic classification of Covid-19 and Non-covid-19 patients using chest X-ray images obtained from the patients. The experimental result proves that DenseNet201 and VGG16 models have reached highest accuracy of 95%. The future scope of this work is to predict different stages of Covid-19 using multiple deep learning approaches and along with covid-19 the system can detect the different diseases like pneumonia and other bacterial diseases.

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