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Classification of COVID-19 InfectedX-Ray Image using deep Learning Techniques

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ABSTRACT

In 2019,Coronavirus disease emerged as a pandemic all over world thus named as COVID-19. It has a greater impact on the global scenario in recent times. Its effect started in the year of 2019 from Wuhan,China. This ongoing pandemic situation has attracted the attention of medical professionals, technocrats, and researchers to work together aiming towards the reduction of spreading and death. Though enough evidence is not found, still the imaging technique has occupied an important role to diagnose the disease. Due to the limited availability of images, it becomes a challenge for researchers. In this piece of work, authors have tried to detect infected personnel using theconvolutional neural network (CNN) based classification model. Out of many variants of CNN classifiers, SqueezeNet and GoogleNet have been utilized for the classification of human chest X-ray images. A total of 1811 X-ray samples are used as training and testing input to the model. It is found that GoogleNet results better and tuned a well classifier in comparison to that of the SqueezeNet model. The performancemeasure like accuracy, sensitivity, specificity, and jaccard are evaluated and are shown in the result section.

Keywords
Corona Virus, COVID19, CNN, GoogleNet, SqueezeNet

Introduction

The world is passing through a very difficult situation due to the spread of the coronavirus. People in every country all over the world are losing their life due to the COVID-19 pandemic. This disease has brought an exceptional impact on the people in both explicitly or implicitly manner. Infection and death rate due to coronavirus is increasing day- by- day [1]. The world economy is also falling due to this epidemic situation. The medical infrastructure is not enough to accommodate the COVID infected people. Still, it is a challenging task to find out the vaccine for this disease and most of the countries are also working on it. Different strategies are adopted by the countries to take a break on the spread of this virus. It is an important factor to detect a corona virus-infected person at an early stage. Physicians can advise patients for the COVID test if they have any symptoms in their bodies [2]. Various advanced technologies and strategies are adopted for accelerating the patient detection and diagnosis process. Research on developingnovel techniques for COVID patient detection is also going on rapidly. It is one of the crucial tasks to create an atmosphere where the patients can avail quick treatment. At the current stage, the need for a rapid diagnostic method is highly essential[3]. The application of machine learning based various techniques seems to be highlyhelpful for the diagnosis of this disease. It can accelerate the diagnosis and detection process with minimum human involvement.

Deep learning is one of the most used machine learning models in various applications for the last few years. The popularity of this method is increasing day-by-day due to its performance with the huge amount of data. In conventional Machine learning algorithms, most of the relevant features need to be extracted by an domain expert for reducing the data complexity and making patterns more accurate. The major plus point of a Deep Learning algorithm is that, it try to automatically learn the high-level features from the input data in an incremental approach. This characteristic eradicates the requirement hardcore feature extraction step. From

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the literature, it can be found that various deep learning models were used by the researchers in numerous domains [4].

In biomedical data processing, deep learning is one of most useful technique in recent years. Research on deep learning-based medical image processing is becoming more popular. Biomedical images like X-ray, magnetic resonance imaging (MRI), mammography, ultrasound,computed tomography (CT) scans, and positron emission tomography (PET) can be considered as the input to various deep learning models.Numerous works were also done by applying deep learning techniques in these medical images.For addressing the issue of intra-class variation and similarity, a synergic deep learning model was proposed in [4]. Multiple deep CNN (DCNN) models were used at a time for improving the performance. The structure of DCNN was fully connected and predicts whether the class of the input belong to same or not. One DCNN makes classification and if a mistake done by another DCNN, it leads to a synergic error for updating the model. Authors in [5] have proposed a deep learning model that is formed with a coding network in combination with multilayer Perceptron (MLP). In the first stage they have trained the CNN as a coding network with supervised learning. After that the traditional background information features were extracted that represents the important information of various medical images. Chest CT scan images are the major diagnosis toll for the diagnosis of COVID patients. It provides rich pathological information about the disease. Manual analysis of CT scans will make a delay in the diagnosis system. A convolutional neural network-based automatic chest CT scan image segmentation approach was introduced by the researchers in [6]. They have segmented the infected regions in the image. Around 250 images were used for training of the neural network and validation is done with 300 images. For classifying the patients, authors have used deep learning approach in [7]. A modified AI method for presenting chest image classification model was proposed by them. 2D and 3D deep learning approaches were used in their work. Different viral pneumonia was visualized in the abdominal CT scans. For extracting the relevant features from the images five types of techniques were considered by the authors. Grey Level Co-occurrence Matrix (GLCM) based features are developed along with Local Directional Pattern (LDP). Again, Grey Level Run Length based Matrix (GLRLM), Grey-Level Size Zone based Matrix (GLSZM), as well as Discrete Wavelet Transform (DWT) feature extraction methods have been utilized for feature generation. Support vector machine (SVM) with different cross-validation approach was used for classification. From their obtained result it has been observed that they have obtained the best performance with 10-fold cross-validation with GLSZM features. By combining Bayesian and convolutional neural network authors in [8] have designed a machine learning-based patient detection system. Their proposed model was predicting the infections by analyzing the X-ray images of the lungs. Three different types of convolutional neural networks were used for virus-infected people [9]. They have classified normal and infected X-rays by applying deep transfer learning techniques. Seven different types of convolutional neural networks were used for classification [10]. The classification performance was measured and compared with other neural networks in their work. Before classification authors have conducted a preprocessing step where they have encoded the original images for accurate symptoms indication. Some other studies were also used deep learning approaches for classifying the X-ray as well as the CT scan images of the patients [11-14] and it was observed that most of the authors have used the standard deep learning models in their works.

The proposed work uses the effectiveness of GoogLeNet with minor modifications using transfer learning mechanism in classifying COVID19 patients and normal patients from chest X-ray images obtained from different sources. A total of 1811 images were used out of which 1268 belongs to patients affected by COVID 19 and remaining 543 belongs to normal

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patients. The same set of images was classified using SqueezeNet and the performance of both the methods was compared with respect to different evaluation metrics like accuracy, sensitivity, specificity etc.

The rest part of this paper is ordered as follows. The 2nd section describes the proposed methodology; the 3rd section provides the details of results obtained by the methods adopted in this workin a comparison way of data representation; the 4th section concludes the work with future aspects.

Proposed Work

The proposed COVID X-ray image classification approach is the combination of multiple-stage as presented in Figure 1.The collected chest X-ray images are pre-processedin initial step to avoid the misclassification issues. Two different deep learning-based classifiers were considered for separating the normal and infected X-ray images. Detail description about the classification model is presented in the next sub-section.

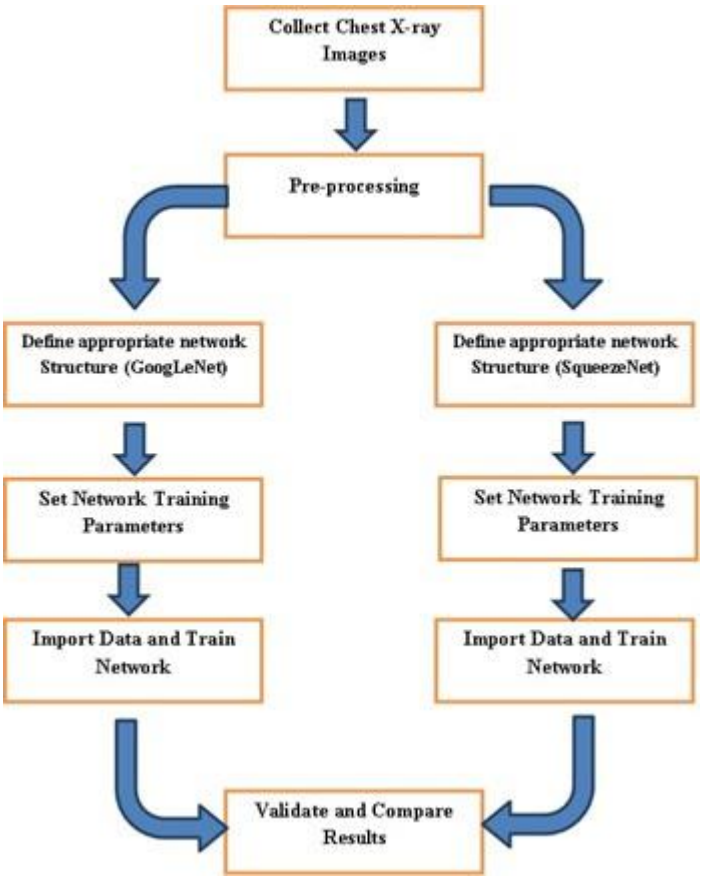

Figure 1. Proposed classification approach

Classification Model

Classification of COVID infected chest and normal chest X-ray images is done by using two different types of CNN model such as GoogleNet and SqueezeNet. GoogleNet is a type of convolutional network where multiple filters are used with the variation in size. The objective behind adopting this type of network is to avoid the overfitting problem occurred due to the use of more number of deep layers. By adopting this strategy the network will become wider instead of deeper. A structure of the GoogleNet is shown in Figure 2. The convolution step is performed on inputs with three various filter sizes. A max-pooling step is also done with the convolutions and is then sent into the next inception module. The proposed

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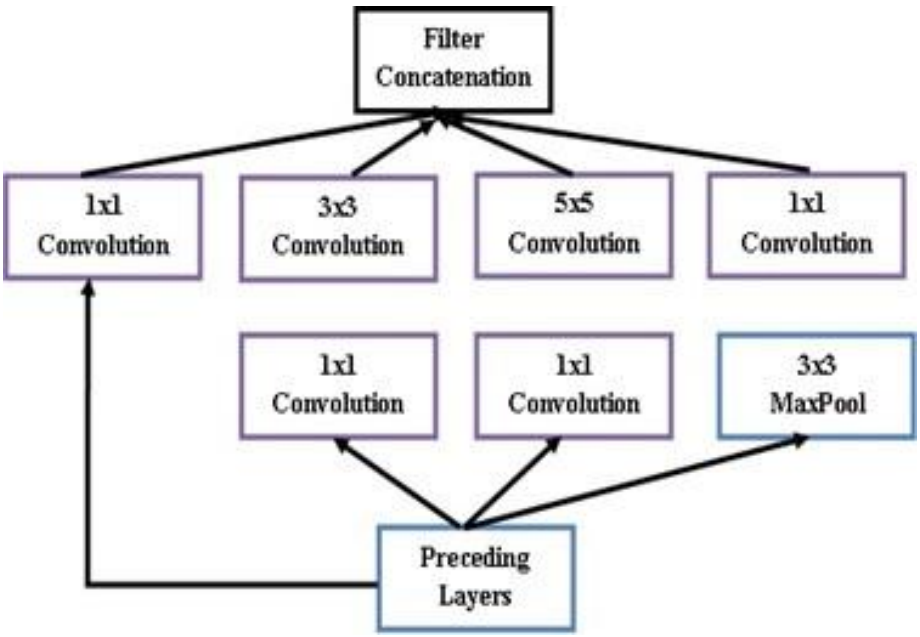

Figure 2. Structure of the GoogleNet

SqueezeNet is a type of deep convolutional neural network with compressed architecture. This model contains a small number of parameters. The basic building structure of this network is of two layers such as squeeze layer and an expanded layer. Here the network is designed with maximum fire modules and minimum pooling layers. The structure of the proposed SqueezeNet is shown in Figure 3. The training parameters of the proposed two types of CNN are shown in Table 1.

Table 1.Training parameters of the CNN classifiers.

Training Options	**Values**
Solver	Stochastic Gradient Descent with Momentum
Preliminary Learniong Rate	0.01
Validation rate	50
Max epoch	30
Minimum Batch size	128
Simulationbackground	CPU
L2-Regularization	0.0001
Gradient Threshold Scheme	I2norm
Gradient Threshold	Inf
Validation Patience	Inf
Shuffle	Every-epoch
Learning rate Schedule	None
Learning rate Drop Factor	0.1
Learning rate Drop Period	10
Reset Input Normalization	Ok
Momentum	0.9

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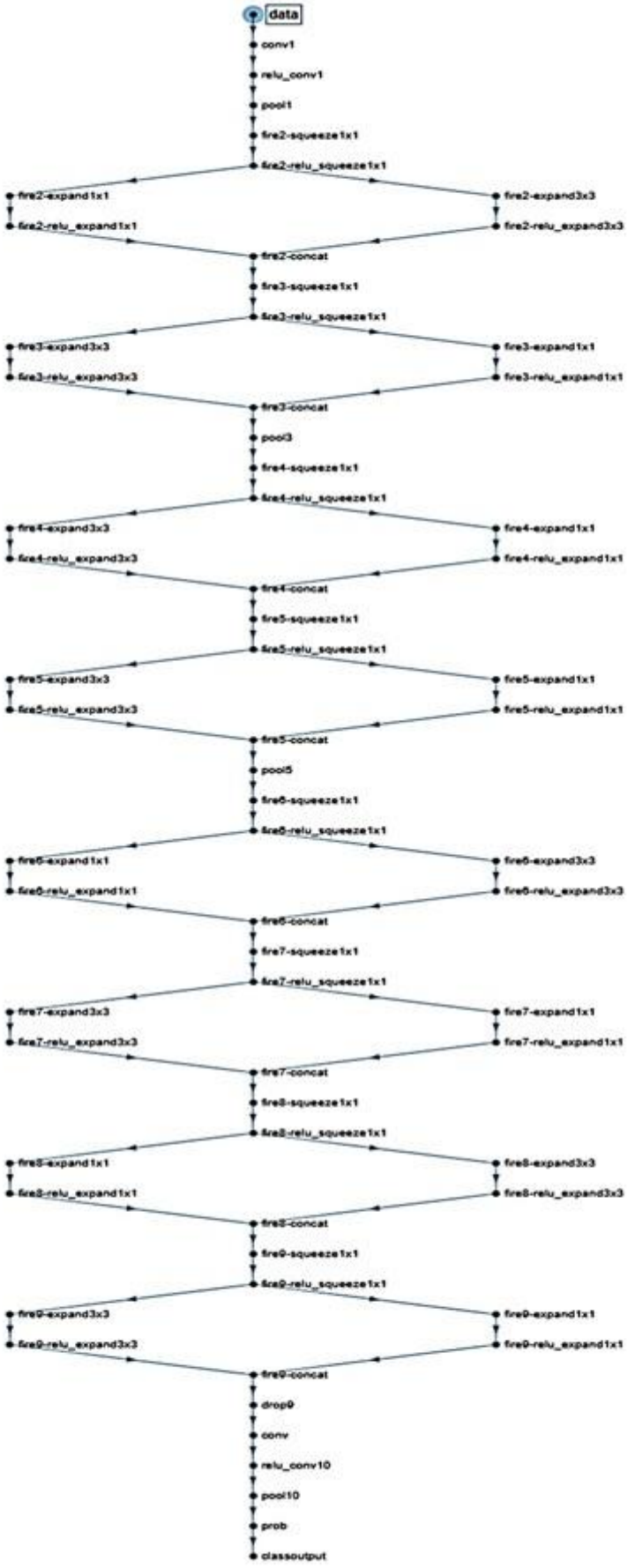

Figure 3. Proposed SqueezNet structure

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Result and Discussion

To train proposed two different types of CNN, chest X-ray dataset of normal and COVID-19 infected persons is collected from the internet source provided by Joseph Paul Cohen *et. al.*[15]. A total of 1811 images were used out of which 1268 belongs to patients affected by COVID 19 and remaining 543 belongs to normal patients. The images are labeled with their class i.e. either 'normal' or 'COVID' which as shown in Figure 4. The network is trained with 70 % data (1868 samples) and remaining 30 % data is considered for testing purpose.

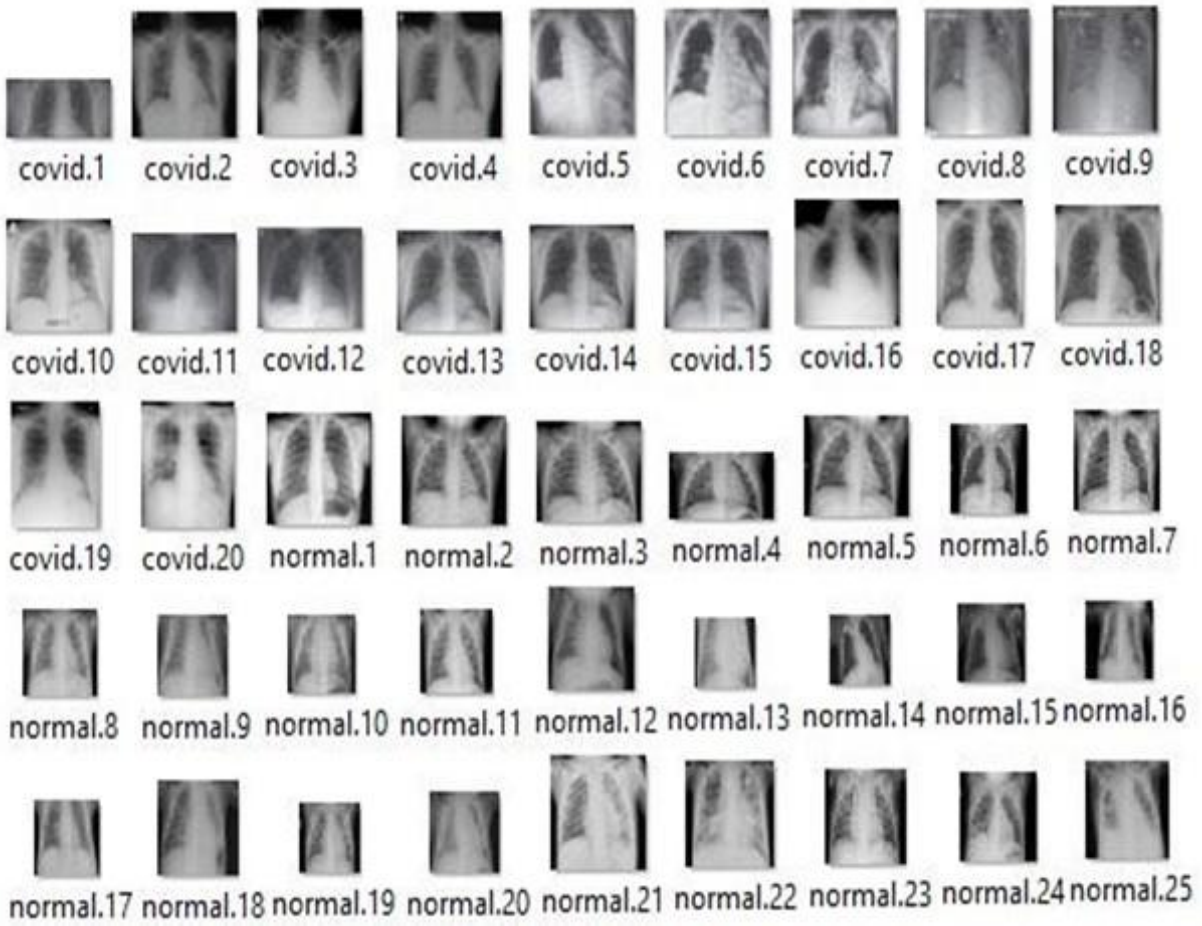

Figure 4. Dataset collected from online sources

Standard measures of sensitivity, specificity, and accuracy are considered for calculating the performance of the classifier. The formulas for calculating these parameters from the confusion matrix is as follows,

$$Accuracy = \frac{TP + TN}{N} \tag{4}$$

$$Sensitivity = \frac{TP}{TP + FN} \tag{5}$$

$$Specificity = \frac{TN}{TN + FP} \tag{6}$$

The confusion matrix obtained from two different types of CNN classifier is shown in table 2 and 3. The validation performance of the two types of the classifier is presented in table 4.Figure 5 shows the comparison accuracy of both classifiers.

Table 2. Confusion Matrix GoogleNet

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	COVID	NORMAL	TOTAL
COVID	359	2	361
NORMAL	5	177	182
TOTAL	364	179	543

Table 3. Confusion Matrix SqueezeNet

	COVID	NORMAL	TOTAL
COVID	355	6	361
NORMAL	8	174	182
TOTAL	363	180	543

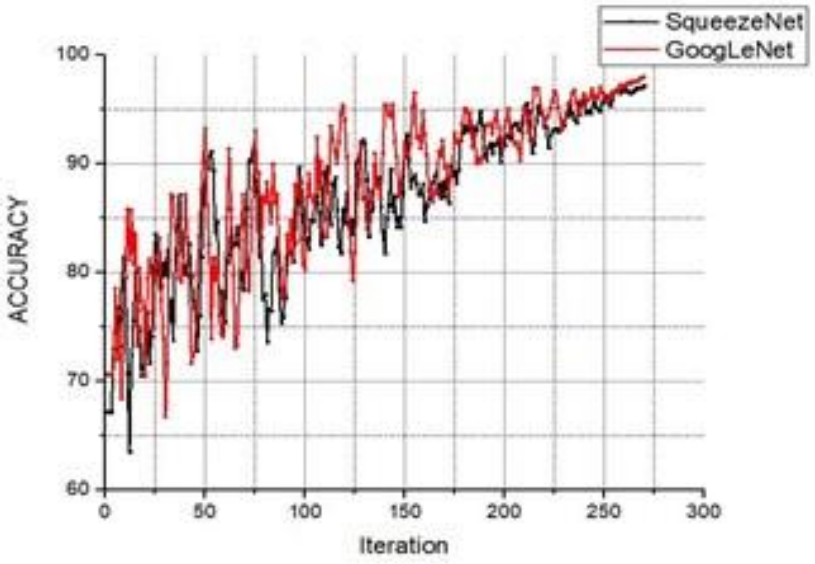

Figure 5. Accuracy plots

Table 4. Performance of the CNN classifiers

Parameter	SqueezeNet	GoogleNet
Accuracy	97.422	98.711
Sensitivity	97.422	99.446
Specificity	96.521	97.253
Jaccard	94.982	97.925

From the obtained result it can be observed that the performance of the GoogleNet is better than SqueezeNet for classifying the COVID chest X-ray images.

Conclusion

In present scenario,COVID-19 creates the pandemic condition and is one of the major health crises. Though the research to develop the relevant vaccine is under process, it is important to adopt different strategies for controlling the infection and spreading rate. Various technologies are also adopted by many countries to avoid the people from infection. Machine learning can be considered as a vital asset for the analysis and diagnosis of COVID-19. In recent decades, it is observed that the deep learning is utilized as a powerful technique for a large amount of data classification of biomedical images. For, better tuning, faster processing, two different types of CNN asSqueezeNet and GoogleNet are used in the proposed work for

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classifying Covid infected and normal chest X-ray image data. From the result section it is found that the model GoogleNet is providing better results as compare to that of the SqueezeNet. This system can be used for any instantaneous application to control the spread of the virus by detecting the infected persons. In future, different machine learning methods can be developed that will process other features like age, sex, symptoms, location, and other diseases of patients as featuresto detect Covid-19 infection.

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