Diagnosis of Covid-19 using Optimized Convolutional Neural Network

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Abstract

According to the report of the World Health Organization, corona disease is the most dangerous and contagious disease in the world. Currently, the most common method used to diagnose corona disease is the polymer chain reaction laboratory technique of reverse transcription, but since this method requires time to confirm the presence of the virus in the laboratory and also due to the unavailability of diagnostic kits and its high costs, Suspected corona virus patients cannot be identified and treated in time; This, in turn, can increase the likelihood of spreading the disease.Another diagnostic method is the use of X-ray chest imaging technique as well as chest computed tomography scan. Also, the use of deep learning methods can be very important for faster and more accurate diagnosis of the lung problems of the corona virus.In this study, using optimized deep convolutional networks based on X-ray images, patients with corona virus were diagnosed.In this article, using the optimized convolutional neural network of healthy people and those with corona, with 10-Fold cross-validation, average accuracy of 98.9% and average sensitivity of 96.5% were obtained.According to the obtained results, it can be said that the proposed method has the ability to separate healthy and unhealthy signals with acceptable accuracy.

Keywords: deep learning, optimized convolutional neural network, X-Ray images, Covid 19 disease.

1. Introduction

Rapid diagnosis of virus infection is very important to prevent further spread of the virus, help identify the infected population and treat patients. RT-PCR test or reverse transcriptase polymerase chain reaction is currently the most commonly used method to diagnose Covid-19 [1]. But because this laboratory technique requires time to confirm the presence of the virus in the laboratory, and also because of the unavailability of diagnostic kits and its high costs, patients suspected of having the coronavirus cannot be identified and screened and treated in time. This, in turn, can increase the probability of spreading the disease.[2]

Also, despite its special features, this method has a high rate of false negative results. On the other hand, RT-PCR results using nasopharyngeal and throat swabs can be affected by sampling errors and low viral load in the sample taken from the patient. Therefore, the existence of other diagnostic techniques along with this technique can be very effective and useful in identifying and treating this dangerous disease in time.[3]

Another method to diagnose corona disease is tests to check antigens (IgM and IgG). Antigen tests may also be rapid, but have low sensitivity. Also, these tests only increase slightly after a certain period of time after the symptoms appear, and they may give false negative results in the early stages of

infection. The disease of Covid-19 begins with mild or even no clinical symptoms, but it can progress rapidly and leave patients in a very critical condition with possible fatal consequences due to multi-organ failure.[4]
Therefore, quick and reliable diagnosis of infected people is very important to apply appropriate screening and treatment as well as to prevent the spread of the virus. Although most patients with Covid-19 have some degree of pulmonary infection, no laboratory method can determine the presence or severity of pulmonary involvement. Chest X-ray images (CXR) and chest computed tomography scan (CT-SCAN) are among the most common radiological methods for the diagnosis of lung involvement associated with Covid-19.[5]
Currently, the most common method used to diagnose corona disease is the reverse transcription polymer chain reaction (RT-PCR) laboratory technique. But since this method requires time to confirm the presence of the virus in the laboratory, and also due to the unavailability of diagnostic kits and its high costs, patients suspected of having the corona virus cannot be identified and treated in time, which in turn It can increase the probability of spreading the disease [6]. Another diagnostic method of this disease is antigen tests, which, despite being fast, have poor sensitivity [7]. Therefore, other suitable diagnostic methods are needed.
During the investigations, it has been found that chest X-ray imaging technique as well as chest computed tomography scan (CT-Scan) are more sensitive than RT-PCR in early diagnosis of corona disease. . Also, more recent studies have shown that taking advantage of deep learning and combining it with radiology techniques such as chest radiography and CT scan can be very important in order to diagnose the lung problems of the corona virus more quickly and accurately.[8]
According to the investigations carried out, the CT machine is not available in most of the country's hospitals, the cost of the machine is high, it causes magnetization and requires a long time for diagnosis, but despite this, it has high accuracy, information and resolution.
But the X-Ray machine is more accessible. It is less expensive and time-consuming, and it also has less magnetic waves and damage. However, X-ray images have less information and accuracy than CT images [9]. Recently, the deep learning technique has been developed as a powerful technique for automatic diagnosis of corona disease using X-ray and CT scan images [10]. Therefore, in this study, we are trying to identify patients with corona virus from X-Ray images by using deep convolutional networks and using transfer learning technique among the models trained based on X-Ray and CT images. Let's recognize that we intend to take advantage of the generality of the X-Ray machine in order to take X-Ray images of people, but since X-Ray images have less information than CT images, we want the accuracy of CT images. let's use Therefore, we train the pre-learned network with CT images and test it with X-Ray images, and vice versa, considering that with the availability of the CT device, we have a large information bank for training, we use this feature. With this purpose, we train the pre-learned network with X-Ray images and test it with CT images.

2. Related Work

In [11] to help radiologists, data scientists and the research community, they designed a system that can be deployed on mobile phones that includes a simple yet effective CNN model combined with a pre-trained AlexNet test for disease diagnosis. Covid-19 includes chest X-ray and CT images. Although the accuracy of the proposed models is not enough, the diagnosis result can be

compensated by using other symptoms of the disease. The level of symptoms can be clearly identified by reading the sensor data of the built-in smartphone sensors, including the level of fever symptoms through the temperature sensor, or the fatigue symptoms through the inertial sensor, or the cough symptoms through the microphone sensor.

By analyzing X-ray images, Nigam et al [12] used the popular and best-performing deep learning architectures to detect COVID-19 in suspected patients. The architectures used in this paper are VGG16, DenseNet121, Xception, NASNet and EfficientNet.

By analyzing chest x-ray images, these models classify a healthy person and a person infected with the corona virus and other unhealthy people who have non-covid-19 disease. In this work, SoTA deep learning architectures are used to perform chest x-ray imaging of Covid-19. The highest recognition accuracy is obtained from the EfficientNet model, i.e. 93.48%. It has been observed that deep learning models provide better and faster results by analyzing image data to identify the presence of Covid in a person.

Elsewhere, using an automated method for optimal meta-parameter selection, techniques for detecting Covid-19 from chest X-rays (CXR) have been presented, and the problems associated with training deep models with smaller volume datasets and class imbalance as presented in most of the CXR datasets obtained in Covid-19. In this paper, a discrete fine-tuning approach is used, which dynamically assigns different learning rates to each layer of the network. The learning rate is set using the periodic learning rate policy. They have addressed the high computational demand of deep models by implementing their algorithm using precision training, an efficient combination of memory and computation. Despite the availability of small data sets, the model has achieved high performance and generalization. Validation accuracy is 96.83%, sensitivity and specificity are 96.26% and 95.54%, respectively [13].

In [14], he proposed an automatic method for early detection of Covid-19 infection using X-ray images and utilizing Deep Learning methods. In this research, several pre-trained CNN architectures were studied using the concept of TL, considering several important factors. The results showed that the best performance is achieved by the ResNet-34 model with an accuracy of 99.33. Therefore, it can be considered as a potential model for predicting covid-19 infection. This model can be used by radiologists for screening and thus reducing workload. Also, the proposed DL model has been developed to achieve significant performance in binary classification of covid-19 (vs. normal) and a limited number of studies to date have been proposed for multi-class classification of covid (vs. pneumonia). Therefore, in future studies, the effectiveness of the proposed model for the multi-class classification problem will be verified.

Also [15] have proposed an extended set of 9 deep learning models for the diagnosis of COVID-19 based on transfer learning and implementation in a new architecture (SEL-COVIDNET), which includes a global averaging pooling layer, smoothing, and two It is a dense layer that is completely connected. The effectiveness of the model has been evaluated using balanced and unbalanced covid-19 radiographic datasets. After that, the performance of the proposed model has been analyzed using six evaluation criteria: accuracy, sensitivity, specificity, accuracy, F1 score and Matthews correlation coefficient. The experiments showed that the proposed SELCOVIDNET with 121DenseNet, 2InceptionResNetV and 3MobileNetVLarge models for multi-class classification of covid-19. 19 performs better in terms of accuracy

(52%) vs. not found vs. pneumonia. Sensitivity (98.5%), accuracy (98.7%), F1 score (98.7%) and MCC (97.5%).

Finally, the result obtained was that their proposed method for classifying Covid-19 has 99.77% accuracy, 99.85% specificity, 99.85% sensitivity, 99.7% F1 score, and 99.4% MCC. The proposed model provides an accurate approach to identify covid-19 patients, which helps to contain the covid-19 epidemic.

The studies mentioned above show that the convolutional neural network can automatically classify and identify diseases and images. But deep learning methods have high processing time, which are not suitable for real time processing. Here, to overcome this task, the optimized convolutional neural network has been used to reduce the calculation load for the diagnosis of existing diseases.

3. Materials and Methods

Database

In this research, to test the performance of the proposed algorithm and model, experiments have been conducted on the public dataset called Radiography DataSet COVID19.

Radiography DataSet COVID19 contains 1000 Covid-19 images from 466 positive patients and 800 normal images from 604 negative patients.

In this research, 60% training set, 20% validation set and 20% test set have been used.In this article, 1800 x-ray images (800 healthy and 1000 corona) have been used for training and testing.

Optimized convolutional neural network

Convolution neural networks are similar to artificial neural networks to a great extent. These types of networks consist of neurons with a large number and with learnable weights and biases.

Convolutional neural networks have different architectures that have been used in different researches, and AlexNet is the most common architecture that has been used. In this article, the optimized architecture based on AlexNet is used. In this architecture, the layers of the convolutional neural network have been merged together and the layers have been reduced from 25 to 8 layers [16].

At the end of the architecture, the classifier is placed. Figure 1 shows the structure of the optimized convolutional neural network based on AlexNet.

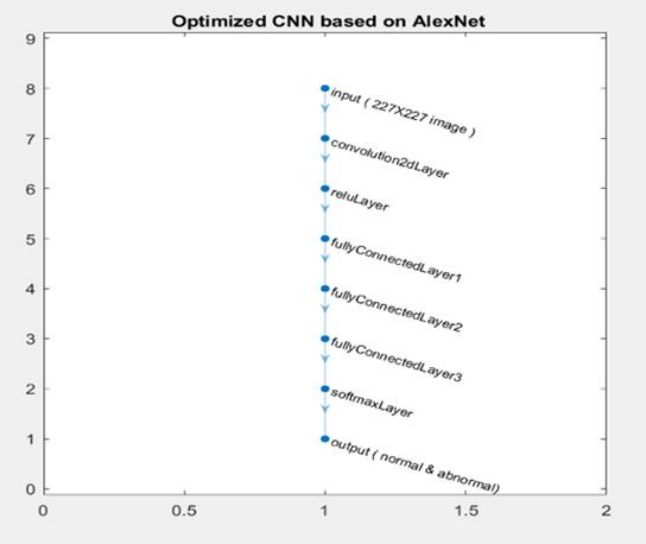

Fig.1. The structure of optimized convolutional neural network based on AlexNet

In this paper, sensitivity (Sen), specificity (Spe), precision (Pre) and accuracy (ACC) are four criteria to evaluate the classification performance of MS-CNN. Based on the values of true positive (TP), true negative (TN), false positive (FP) and false negative (FN), the definition of these four criteria can be expressed as follows:

$$Sen = \frac{TP}{TP + FN} \quad (1)$$

$$Spe = TN/(TN+FP) \quad (2)$$

$$Pre = TP/(TP+FP) \quad (3)$$

$$Acc = (TP+TN)/(TP+TN+FP+FN) \quad (4)$$

That the results based on the above equations were calculated and reported as an average with 10 times validation.

4. Results

In this article, 1800 X-Ray images have been used for review, and you can see an example of them in Figure 2 and Figure 3.

Fig. 2. Four examples of X-ray images of people with covid disease

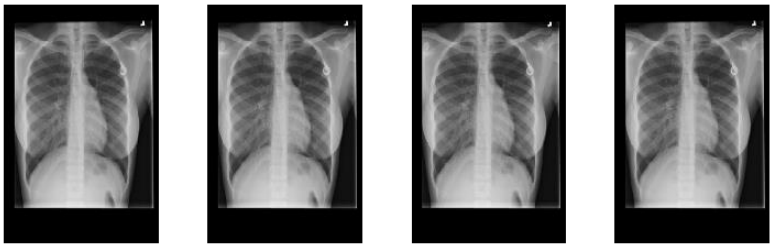

Fig.3. Four examples of X-ray images of healthy people

The images were resized to the standard size of 227x227 and entered into the convolutional neural network.

The optimized convolutional neural network extracts deep features and the last layer is embedded with two neurons, so that it can separate two groups and there is no need for separate classification.

In Tables 1, you can see the accuracy, precision, sensitivity, and specificity of the average classifier

Table 1 Classifier results

SPE	PRE	SPE	ACC
98	**97.9**	**98.1**	**98**

In Figure 4, you can see the confusion matrix.

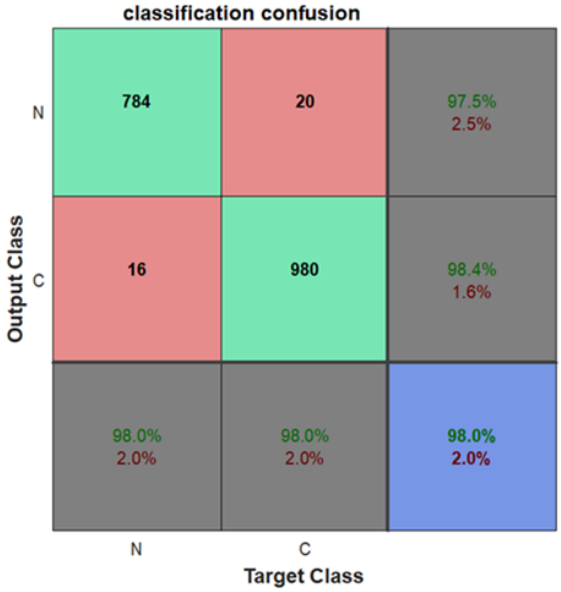

Fig.4.example of confusion matrix (1000 covid and 800 healthy)

In the reviewed articles and other articles, the reliable and freely available data bank of corona disease has been used, and we have also used this data bank.

Higher accuracy and reliability is another advantage of the proposed method. Also, the use of optimized architecture reduces the calculation load to a great extent.

For a better understanding of the results, the ROC diagram is shown in Figure 5.

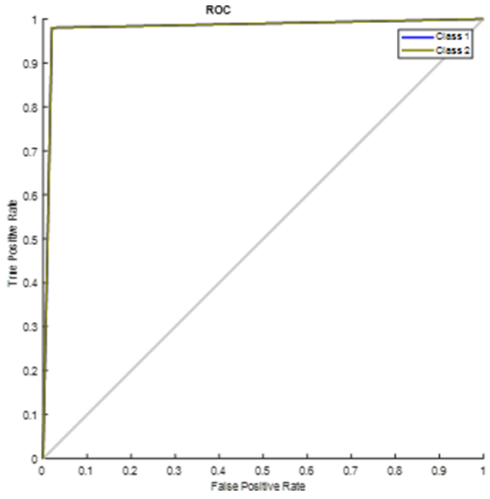

Fig.5.ROC diagram of the proposed method

In this article, the valid and publicly available Radiography DataSet COVID19 database is used to evaluate the proposed algorithm. that the obtained results are considered completely specialized in the field of covid-19 disease and indicate a better performance than the algorithms of previous studies in the field of deep and transfer learning according to table no. 2.

Table 2-Comparison of the proposed method with similar methods

According to Table 2, it can be said that the proposed method has high accuracy compared to similar methods. In Table 3, you can see the standard deviation of the accuracy of the classifier, and in Figure 6, you can see the accuracy graph, the standard deviation line, and the average of the data

Table 2-Comparison of the proposed method with similar methods

Ref	ACC	Pre
[57]	96.3	93.2
[58]	96.7	91.6
[59]	94.9	91.5
[60]	97.7	92.1
[61]	91	90.8
[62]	85	82.3
Proposed Method	98	98

Table 3 standard deviation of the accuracy of the classifier

Mean	Min	Max	Standard Deviation
98.9	96.9	99.8	1.27

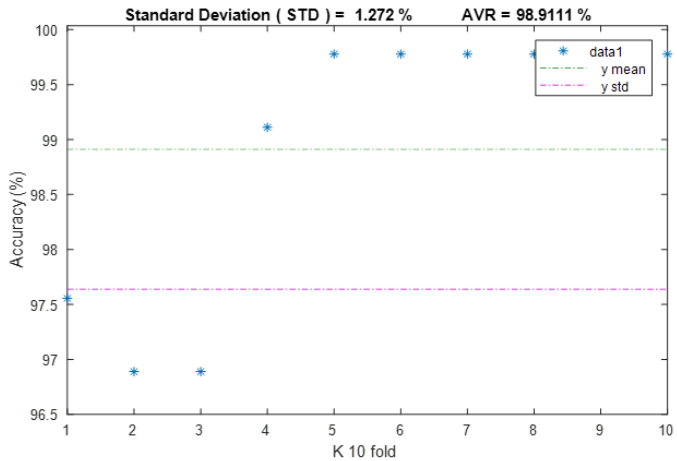

Fig.6. Standard and average deviation and accuracy of the classifier

According to Table 2, it can be said that the proposed method has high accuracy compared to similar methods.

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