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Online COVID-19 Infection Diagnoses via Chest X-Ray Images using Alexnet Deep Learning Model

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ABSTRACT

Since the outbreak of Covid19 virus to date, various methods have been introduced in order to diagnose the virus infection. One of the most reliable tests is assessing frontal Chest X-Ray(CXR) images. As the virus causes inflammation in the infected patient's lung, it is possible to diagnose whether one is infected or not using his/her CXR image. in contrast to other tests which mostly are based on the virus genome, this test is not time-consuming and it is reliable against new strains of the virus. However, this test requires a specialist to assess the CXR images. As the datasets of Covid19 patient CXR images are increasing in number, it is possible to use machine learning techniques in order to assess CXR images automatically and even online.

In this study, we used deep learning approaches and we fine-tuned the Alexent in order to automatically classify CXR images and label the whether "Covid" or "Normal". The data we used in this study include about 10,000 chest images, half of which are related to CXR images and the other half are related to patients with Covid19 infection. The model proved to be very reliable with 99.26% accuracy in diagnosis and 95% sensitivity and 99.7% specificity.

*Keywords: **Covid-19, Deep Learning, Alexent Model, Medical Imaging Processing, Pneumonia***

1. Introduction

One of the main solutions to control the Covid-19 epidemic is the early detection of a person infected with the virus[1]. In this respect, the best way to identify a method is to make it easily accessible to the public; A free, web-based method that uses the methods that have been introduced so far to diagnose the virus and it is easily accessible. There are various criteria for evaluating a test. However, researchers in this field have paid attention to the introduction of an accurate testing method with high sensitivity and accessibility and less time-consuming and low cost. Because one of the methods to control this epidemic is the rapid diagnosis of the disease and the timely start of treatment and quarantine of the patient. This research, by using the "Alexent" deep learning model, tries to provide an accurate web-based service to enable accurate and fast diagnosis of patients with the Covid-19 virus.

Various methods have been proposed in order to diagnose this disease. The most prominent of these methods is the PCR test. This test, despite its many upgrades during these two years, still has many challenges. For instance false negative ratio and time-consuming. Also, with the spread of various strains, this test loses its capabilities more than before [2].

Despite many advances in the development of diagnostic methods for the disease, access to a rapid and accurate test has always been a challenge. One of these methods, which was used especially in the very early stages of the disease, was frontal Chest X-Ray(CXR) images. Covid19 virus causes inflammation in the lungs of an infected person called pneumonia [3]. These inflammations can be detected in the chest radiographs, so chest radiographs provide good information for doctors to diagnose the virus.

This method, which is also reliable against all new Covid19 strains, despite its accuracy, reliability and high sensitivity, still has disadvantages, including the harmfulness of imaging due to radiation from radiological devices and the need for a pulmonologist to analyze the photo of the patient's CXR. However, in order to solve the second challenge, an online and intelligent service that can inform people of chest radiographs in few seconds and inform them whether or not they are infected with Covid19 virus is very helpful. In particular, this service should be provided to physicians for free. It should be noted that the purpose of this study is to provide this service online.

The general structure of this article is as follows: In the second part, the research literature is discussed in order to get acquainted with the previous works. Then, in the third section, we are going to introduce the data used in this research. In the fourth section, we will give an overview of deep learning and the technique we have used in this work. In the fifth section, the Alexent model and in the next section, the online service are going to be introduced. Then in the seventh section, the implementation method is discussed and in the final sections, which are the eighth and ninth sections, we deal with the results and compare them with similar works.

2. Literature

The task of pneumonia diagnosis has always been raised in the applications of artificial intelligence in medicine [4]. Marcelo Fesman et al. In 2000, used natural language processing algorithms in order to diagnose acute bacterial

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pneumonia and achieved a 94% accuracy [5]. The subject of image processing in medical science goes back decades before. In 2000, Bruce Hillman published an article entitled "Medical Image Processing in the last 25 years" in which he examined the advances in the seventies to the nineties. It was important because, at that time, the radiological data had been increased. However, researchers have become much more serious about pneumonia since 2020, when the World Health Organization announced the Covid19 as a global pandemic. As the Covid19 virus infects the respiratory system and causes severe pneumonia, it has killed more than 6 million people in two years [7]. In January 2020, Hang Si et al. Published an article on the symptoms of Covid19 virus in which acute lung pneumonia was one of the leading causes of Covid19 death [8]. Zo et al. In an article, the main way to diagnose covid is to examine chest radiographs [9]. From the beginning, researchers began research to provide accurate technologies for the diagnosis of Covid19 patients from chest photographs. Abbas Asma et al. trained a DeTraCResNet18-based binary model with 196 images to identify Covid19 (Covid 105 images, Normal 80 and SARS 11 images). The obtained model was able to achieve 95.12% accuracy, 97.91% sensitivity, 91.87% specificity, and 93.36% correct prediction [10]. Maguolo and Nani collected and applied 339 and 271 images (74 Covid19, 339127 pneumonia) and implemented the Alexnet algorithm to detect Covid on them, achieving 99.97% accuracy [11] but the dataset was imbalanced and Covid19 images were too small in number. Hall et al. Taught Resent 50 on a total of 455 photographs of the chest (135 cases of Covid and 320 cases of viral and bacterial pneumonia). They achieved 95% accuracy [12]. In the appendix article [13], the authors collected 3905 X-ray images (450 covid and 3455 non-covid) and categorized them using the pre-trained Mobile-Net version 2 model to achieve 99.18% accuracy. alam et al. Trained 5090 images (1979 Covid photos, 3111 normal photos) using (CNN + HOG) + VGG19 pre-trained model and achieved 99.49% accuracy [14]. In the article [15], the authors collected 6926 images (2589 Covid images, 4337 normal images) and used a convolutional neural network to classify the images and achieved 94.43% accuracy. In the article [16], the authors of 610 images (305 covid and 305 normal photos) were accurately obtained to teach a Cannolic model using a 97.4 % accuracy of learning transfer techniques. The authors collected 900 images (500 Covid-19 images, 400 normal images) and proposed a small auxiliary model that achieved 99.1% accuracy. Abdullah Omar Ibrahim et al. [18] In late 2020, during a study of 5,000 chest photographs of patients with non-covid and covid inflammation, acceptable results were obtained. In this study, several categories including a combination of normal conditions, viral inflammation other than covid, viral inflammation with covid 19 and bacterial inflammation have been investigated. The important point of this research is the use of Alexent model. In this article, the authors show how the Alexnet model has a good advantage over other deep learning models.

3. Dataset

In this study we trained Alexnet - a deep convolutional neural network – using publicly available CXR images related to patients diagnosed infected by Covid19 virus as well as CXR images related to individuals without Covid19 infection in order to classify new CXR images into two categories (Positive for Covid19 and Negative for normal CXR images). In order to achieve state-of-the-art results, we used 8,840 CXR images from 9 public available datasets. Half of our images are labeled as COVID and the other half as NORMAL. The resources of our datasets are shown in Table 1.

Due to the limitation in the number of Covid19 images, the number of normal photos is considered to be the number of Covid19 images. So, the model has the same amount of input for training in two categories. This data has been already used in the research of Ms. Badavi et al. [19], with the difference that about 580 Covid images have been added using the data-augmentation technique.

4. Deep Learning & Transfer Learning

Deep learning is a branch of machine learning, a subset of artificial intelligence inspired by the structure of the human brain. Deep learning is called a sub-branch of machine learning that tries to simulate the learning method of the human brain using a tool called deep artificial neural network.

Many medical tasks, such as cancer diagnosis (brain tumor and breast cancer), are performed using computer-aided diagnostics based on artificial intelligence models. Deep learning models can detect hidden features in images that are not obvious or cannot be detected by medical professionals.

Convolutional neural networks are a leading tool in deep learning that is widely used. The reason for the popularity of this tool is its high ability to extract features in medical photos. These models have a high ability to categorize photos in the medical field (for example, categorizing photos of cancerous and non-cancerous masses).

Transfer learning provides an easier approach to rapidly retraining neural networks on high-precision selected datasets. In this method, convolutional neural networks are pre-trained for various purposes and can apply their previous knowledge to new related issues.

5. Alexnet Model

The model used in this research is a deep convolutional neural network architecture called Alexent. This model was introduced in 2012 by Alex Krizowski and won ImageNet

Table 1. Resources

Resource	*Label*	*Amount*
chestX-ray8	Normal	4420
BIMCV-COVID19 dataset	COVID19	2473
COVID-19 Image Data Collection	COVID19	208
Figure1-COVID-19 Chest X-ray Dataset	COVID19	55
ActualMed COVID-19 Chest X-ray Dataset	COVID19	238
SIRM database	COVID19	68
Twitter data	COVID19	37
COVID-19 Repository	COVID19	243
COVID-CXNet	COVID19	877
MOMA-Dataset	COVID19	221

competition. This model has been trained on a database of 1.4 million images containing 1000 different categories[20]. Due to the high accuracy and proficiency, this model has limited the data within the network to zero values or above by using a function called ReLu, whereby the volume of processing required for training is considerably reduced. The general architecture of this model is shown in Figure 1.

The input of this architecture is a 227*227*3 image. This architecture has eight parts, the first 5 parts are convolutional neural network and the last three layers are complete neural network. The ReLu function runs on all layers except the last part. This model is generally designed and trained to categorize thousand of different photo titles. However, in this research, the model has been fine-tuned to categorize two different groups of photos. To do this, only the last layer, which is a 1000 SoftMax, is converted to a 2 SoftMax. The architectural details of the Alexent model are shown in Figure 2. Earlier in Table 2 these details are given along with the parameters of each layer.

6. The Online Services Introduction

Since one of the main objectives of this study is to provide an online service for diagnosing coronavirus from a chest photograph, after completing the learning process, a copy of the trained program is located at www.alihdr.ir/covid. Visitors to the site have been given the opportunity to simply upload a CXR image, and the system will immediately notify them of a Covid19 virus infection status via email. This service is made available to the public free of charge and its main purpose is to provide services to specialists and physicians in order to help to control the Covid19 epidemic.

7. Methodology

MATLAB program has been used in order to train the model on the desired database. The model is trained on a virtual server with the specifications in Table 3.

About the data; 80% of the data is for training and 20% for evaluation. This selection was made by the system and randomly, which means that an equal number of healthy and Covid images were selected.

The main hyper-parameters used in the training are Epoch = 20 and BatchSize = 10. These parameters have been selected according to the available hardware capabilities.

After 150 hours of processing, the model completed its work with 99.26% accuracy. The training process is illustrated in Figure 3.

8. Result

The evaluation of the performance of a learning program or an artificial neural network is usually being considered by three main criteria: sensitivity, specificity and accuracy. To introduce these three criteria, we need to make several definitions in advance:

True positive (TP): Cases in which the test result is positive and the person is infected with the virus.

True negative (TN): Cases where the test result is negative and the person has not been infected with Covid virus 19.

False Negative (FN): Cases of a patient being misdiagnosed as healthy when in fact they are actually infected with the Covid19 virus.

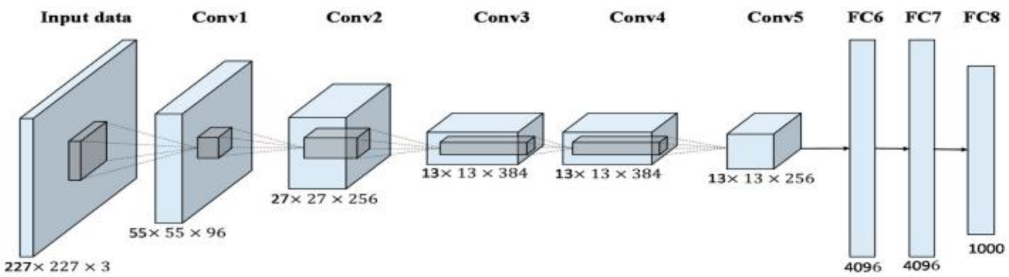

Figure. 1. Alexnet Architecture

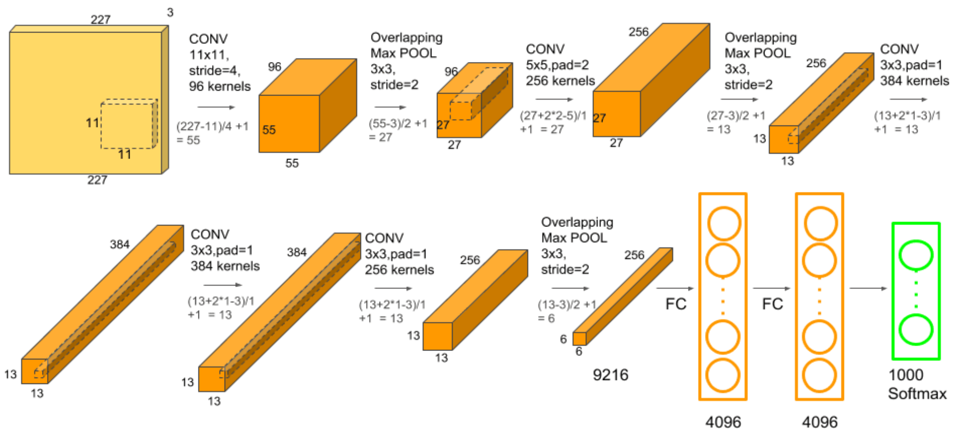

Figure. 2. Layers Details

Table 2. Layers Details

No.	Layer Name	Layer Title	Description
1	data	Image Input	227×227×3 images with 'zerocenter' normalization
2	conv1	Convolution	96 11×11×3 convolutions with stride [4 4] and padding zero
3	relu1	ReLU	ReLU Function
4	norm1	Cross Channel Normalization	Cross Channel Normalization with 5 channels per element
5	Pool1	Max Pooling	3×3 max pooling with stride [2 2] and padding [0 0 0 0]
6	conv 2	Grouped Convolution	2 groups of 128, 5×5×48 convolutions with stride [1 1] and padding [2 2 2 2]
7	relu2	ReLU	ReLU Function
8	norm2	Cross Channel Normalization	Cross Channel Normalization with 5 channels per element
9	Pool2	Max Pooling	3×3 max pooling with stride [2 2] and padding [0 0 0 0]
10	conv3	Convolution	384, 3×3×256 convolutions with stride [1 1] and padding [1 1 1 1]
11	relu3	ReLU	ReLU Function
12	conv4	Grouped Convolution	2 groups of 192 3×3×192 convolutions with stride [1 1] and padding [1 1 1 1]
13	relu4	ReLU	ReLU Function
14	conv5	Grouped Convolution	2 groups of 128 3×3×192 convolutions with stride [1 1] and padding[1 1 1 1]
15	relu5	ReLU	ReLU Function
16	Pool5	Max Pooling	3×3 max pooling with stride [2 2] and padding[0 0 0 0]
17	fc6	fully connected	4096 fully connected layer
18	relu6	ReLU	ReLU Function
19	drop6	Dropout	50% dropout
20	fc7	fully connected	4096 fully connected layer
21	relu7	ReLU	ReLU Function
22	drop7	Dropout	50% dropout
23	fc7	fully connected	1000 fully connected layer
24	prob	Softmax	-
25	output	Classification Output	crossentropyex with 'tench' and 999 other classes

False positive (FP): Cases in which a person has been misdiagnosed with Covid19 virus but has not actually been infected.

8.1 Sensitivity

This criterion is the same as the RECALL criterion, which is called sensitivity in dual or binary classification modes. The ability of a program to detect positive cases is called the sensitivity of that program. To calculate the sensitivity of a program, the ratio of true positives to the sum of true positives and false negatives must be calculated. In other words, sensitivity is the ratio of true positives to the sum of true positives and undetected positives. Mathematically, this ratio can be expressed as Eq.(1).

Table 3. Hardware Details

Hardware	Detail
CPU	64 Core Intel
RAM	128 GB
HARD	1 TB

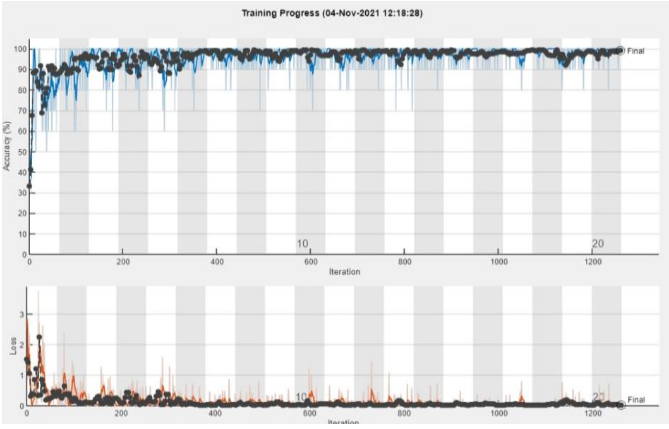

Figure. 3. Training Process

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

8.2 Accuracy

The ability of a test to correctly distinguish normal and infected cases from each other is called accuracy. To calculate this criterion, the ratio of the sum of correct positive and negative cases to the ratio of total cases must be calculated. This criterion is mathematically as Eq.(2).

$$Accuracy = \frac{TP + TN}{Number\ of\ Cases} \quad (2)$$

8.3 Specificity

This criterion determines the program's ability to correctly diagnose healthy cases. To calculate this criterion, obtain the ratio of true negatives to the sum of true negatives and false positives. This criterion is the opposite of the criterion of sensitivity. In fact, this criterion is the ratio of true negatives to the sum of true negatives and negatives that have been misidentified as positive. This criterion is mathematically as Eq.(3).

$$Specificity = \frac{TN}{TN + FP} \quad (3)$$

Now, after the introduction of evaluation criteria, we can refer to the results. The results were obtained using the confusion matrix and in the evaluation phase, we used external images which means they were not included in the training phase and are new data for the model. These results are given in Table 4.

9. Compare With State-Of-The-Art

In the article by Abeer Badawi and Khalid Elgazzar [19], similar work has been done on three well-known convolution models (DenseNet201, VGG16, VGG19). Since the data set used in their research is the same as part of the data set used in this research, the results can be compared with the Alexent model, especially since all models are convolutional.

In this article, several types of categories have been done, However, here only binary categories will be considered. The category that the model tries to distinguish between normal photos and Kuwaiti photos. The results are as follows.

As it is clear in Table 5, the accuracy criterion of the Alexent model used in this research outnumbered the two convolution models DenseNet and VGG19, and only the VGG16 model has a higher accuracy criterion. Alexent model has a very good performance in terms of Specificity criterion compared to other models and has recorded the number 99.70%. In terms of sensitivity, the Alexent model is slightly weaker than the two VGG16 and VGG19 models. The reason for the superiority of the Alexent model over other models is not only in terms of Specificity.

10. Conclusion

With the proliferation of data available on the Internet, as well as the growing number of web-based services available, there is a need to use web-based solutions to control the global Covid 19 epidemic. Because these solutions bring many benefits, including ease of access and reduced time and increase accuracy in diagnosing patients with the disease. The study sought to achieve this by presenting a web-based intelligent service that utilizes deep learning techniques to provide an accurate and fast test. Through this, users can get their test results with 99.26% accuracy by uploading a chest X-Ray image in a fraction of a second. Also, this web-based solution has a 95% sensitivity and a 99.70% specificity in their responses. It is important to mention in this study we improve the dataset's quantity by 10 percent and the results stay the same and it can strengthen our results as well.

11. Discussion

Due to the daily increasing data on Covid 19 virus, this work can be challenged again because the more data available for training, the better and more reliable the results will be. It is also suggested that more work be done on multiple categories, which of course requires a dataset related to Non-covid CXR patients.

Table 4. Results of the Model

	Number %
Accuracy	99.26
Sensitivity	95
Specificity	99.70

Table 5. Results Comparision

	Accuracy	*Sensitivity*	*Specificity*
DenseNet	91.75	89.34	78
VGG16	99.62	99.64	99.67
VGG19	99	98.94	98.66
Alexnet	99.26	95	99.70

Declarations

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Authors' contributions

AH: Study design, acquisition of data, interpretation of the results, modeling, analysis, drafting the manuscript; HE: Supervision, revision of the manuscript;

Conflict of interest

The authors declare that there is no conflict of interest.

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