A Novel Aided Diagnosis Schema for COVID 19 Using Convolution Neural Network

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Abstract. Lately, the COVID-19 pandemic is the first reason of deaths in people. Where the number of patients who have the same symptoms increased; however, the main causative agent separated and analysed. At the first, it called a novel coronavirus (2019-nCoV) then it was renamed as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) that cause a disease called COVID-19. One of the symptoms of the disease is the difficulty breathing caused by lung damage that needs to be detected earlier as much as possible. Chest X-ray images are one of medical images, which can be read by physicians to detect COVID-19. In this paper, the suggested Schema of convolutional neural network (CNN) that can aid the doctors in hospital to improve the diagnosis of the five different classes (COVID-19, MERS SARS, ARDS and Normal). For evaluating testing set, the practical outcomes demonstrates the suggested Schema of CNN classifier with an accuracy of 98%.

1. Introduction

At the end of 2019, a new virus is known as COVID 19 started to appear; where the first case of the infection was recorded in China, specifically in the city of Wuhan [1]. However, this virus continued to spread to cross the city of Wuhan to the rest of the Chinese cities and even worldwide. Where a large number of infections are recorded in more than one hundred and fifty countries according to the statistics of the World Health Organization until the seventh of March 2020[2]. The rapid spread of infection has caused panic in all the countries of the world, which led to a state of alert among all the scientists and researchers to find appropriate solutions that can limit the spread of this disease [3]. Where many studies have cleared that this virus can survive outside the human body such as the smooth surfaces, cooling systems, cardboard, plastic materials and other different environments for different periods as well. Moreover, all studies up to the moment advise the people to move away as much as possible from being in public places to help in the limitation of the very rapid spread of this disease [4]–[6]. Many infections over a short period are recorded in the countries that did not take care and caution in dealing with this disease. In the researching scope, Xray medical images diseases are beneficial for researchers and doctors by explicating medical images will aid them in their plans [7][8][9].

The following charts according to the world health organization show the rapid spread of the disease in many developed countries: the number of affected countries, the number of confirm cases and the number of total deaths in fig. (1), fig. (2) and fig. (3), respectively [2].
These days, owing to the rapid spread of the COVID-19 outbreak, the researchers are paying more interest to the scope of detecting the outbreak.

In [10] suggested two various ways to classifying lung pneumonia and cancer chest images by utilizing AlexNet over only two classes Normal and covid-19 with accuracy 96%. In [11] offered...
deep intelligent learning for classifying X-Ray images over only two classes Normal and covid-19 from 70 cases with accuracy 95%. In [12] intended COVID-Net based CNN for checking chest images over 13,645 sick person cases with accuracy 92%. After obtaining many samples for patients with this disease. It has become a moral obligation for all scientists around the world to present a contribution as much as possible to help in the limitation of this disease, according to the scientific modern papers, it obviously that a sensible accuracy can be acquired when checked over only two classes. The challenge is to have more than 2 classes.

From this standpoint, the contribution of this research suggesting an intelligent system according to designing and testing new CNN architecture to be convenient for five different classes (COVID-19, MERS SARS, ARDS and Normal). Also, diagnose the patient’s condition based on X-ray medical images taken from many countries to accelerate the process of diagnosing the patient’s condition, which takes a long time according to the procedures used today.

2. Convolution Neural Network (CNN)
Designing and implementing intelligent systems has become a crucial factor for the innovation and development of better products of most technologies[13]–[21][22][23], [24]. A convolutional neural network (CNN) in the deep learning is a class of deep neural networks that used in common to visual imagery analyzing. Also can be defined as invariant of shift or invariant of space of artificial neural networks which is depend on the architecture of the shared-weights and characteristics of the translation invariance [25][26]. The convolutional neural network are consist of input layer, multiple hidden layers and the output layer. A series of convolutional layers that perform the process of convolve with a multiplication or other dot product are contained in the hidden layers. RELU layer are mostly used as the activation layer that is almost followed by different layers such as additional convolutional layers, pooling, normalization and the fully connected layers. The activation function and final convolution are used to mask the output of the hidden layers, therefore; these layers called hidden layers. Though the layers are colloquially referred to as convolutions, this is only by convention. Mathematically, it is technically a sliding dot product or cross-correlation. This has significance for the indices in the matrix, in that it affects how weight is determined at a specific index point.

3. COVID-19 Dataset
The COVID-19 Dataset is composed of X-ray images of COVID-19, MERS SARS, ARDS illnesses and normal for 1184 Patients with age (12 to 87 years) from different countries. COVID-19 Dataset is taken from https://github.com/ieee8023/covid-chestxray-dataset which is collected by Joseph Paul Cohen, University of Montreal, 2020 related to the COVID-19 investigation. Sample images of COVID-19 Dataset are shown in Figure (4).

4. Suggested schema
A particular suggested Schema of C.NN is created for classifying COVID-19 pandemic as shown in Figure (5). The suggested Schema merges extraction of features and classification procedure in a sole trainable structure are characterized as follows:
A. Extraction of Features: Extraction of features is composed of linked four layers of Convolutional and Max_pooling, the total volume of input image is 128×128×1 and the total volume of output feature map is 8×8×256 for classification.

B. Classification Procedure: Classification Procedure: Classification procedure is composed of 4096 neurons as fully_connected layers. Finally, these layers with Dropout function utilizes as input to Soft_Max activation_function which is appoint a likelihood for each label of COVID-19 pandemic.

Figure 5. Suggested Schema.

Due to make the suggested scheme of CNN usable for five various classes of COVID-19 cases (COVID-19, MERS SARS, ARDS and Normal), the volume of Xray image must be 128x128x1 as accordingly, it is obvious in Figure 5. The deepness of suggested schema is four Convolutional layers: the first two layer is 32 and 64 convolution filter respectively with identical window of volume 3 × 3, followed by 128 and 256 convolution filter respectively with identical window volume of 3×3, for the second two layers utilized, The 2x2 Max Pooling layers that are exist after each four convolution layers and, one fully connected hidden layers, and one fully connected output layer, as it shown in Table (1) which is demonstrates the layers of suggested schema. In accordance with various epochs, the trainable structure of suggested schema will be fit for distinguishing any test of COVID-19 cases.

| Layers                     | Input Volume | Output Volume | Stride@Kernel |
|----------------------------|--------------|---------------|---------------|
| Convolution 1 + Re LU      | 128×128×1×1  | 128×128×32×2  | 1@3×3         |
| Max_pooling                | 128×128×32×2 | 64×64×32×2    | 2@2×2         |
| Convolution 2 + Re LU      | 64×64×32×2   | 64×64×32×2    | 1@3×3         |
| Max_pooling                | 64×64×32×2   | 32×32×32×2    | 2@2×2         |
| Convolution 3 + Re LU      | 32×32×32×2   | 32×32×128×2   | 1@3×3         |
| Max_pooling                | 32×32×128×2  | 16×16×128×2   | 2@2×2         |
| Convolution 4 + Re LU      | 16×16×128×2  | 16×16×256×2   | 1@3×3         |
| Max_pooling + Dropout (0.5) | 16×16×256×2 | 8×8×256×2     | 2@2×2         |
| Fully_connected + ReLU + Dropout (0.5) | 16384 | 4096 | None |
| Fully_connected + Soft_Max | 4096 | No. of classes | None |

The design of CNN's suggested schema will boost the generalization for different Xray. Furthermore, it will result in the problem of overfitting. Using the following techniques to handle this issue:
The 1st technique: Dropout has been utilized with a 50 percent chance, in which the suggested schema randomly eliminates certain transformation units throughout the training phase to inspire the classifier to learn more about robust features.

The 2st technique: the max polling subsampling have been utilized to minimize overfitting with a view to increasing generalization. Furthermore, the SoftMax activation function has been utilized due to enhance the convergence ratio by minimizing the challenge of vanishing gradient in the design of CNN's suggested schema.

5. Results and Discussion
The suggested schema is implementing on 1184 cases of patients with chest X-ray images in COVID-19 Dataset for classifying five classes by utilizing Python_language and Keras_TensorFlow_Google Tools. The COVID-19 dataset is suffered from imbalance class distribution rate that lead to an essential effect on the classifier of the suggested scheme. thus, utilizing augmentation methodology to balance the volume of per class in training procedure that is done by implementing translations of H and V within the range (-0.25, 0.25 ) and rotations of 3 o, 6 o, 9 o, 12 o, and 15o. Table 2 shows COVID-19 Dataset with data augmentation.

Table 2. COVID-19 Dataset with data augmentation

| Class       | No of cases | Training cases | Augmented Training cases | Test cases |
|-------------|-------------|----------------|--------------------------|------------|
| Normal      | 392         | 250            | 1750                     | 142        |
| MERS        | 185         | 119            | 1785                     | 66         |
| SARS        | 141         | 90             | 1890                     | 51         |
| ARDS        | 130         | 83             | 1743                     | 47         |
| COVID-19    | 336         | 215            | 1729                     | 121        |

For evaluating the suggested schema, set of critical metrics have been utilizing as follows:

A. Confusion matrix: it is a matric that is utilized to depict the performance of a suggested schema on a set of test data of COVID-19 Dataset as shown in Table (3). Noticing that acquired outputs of the suggested schema is promising and there is no issues with the outputs of predicating five classes of COVID-19 Dataset.

Table 3. Confusion matrix utilizing suggested schema.

| Actual Class | Predicate Class |
|--------------|----------------|
|              | Normal | MERS | SARS | ARDS | COVID-19 |
| Normal       | 138    | 1    | 2    | 1    | 0        |
| MERS         | 0      | 66   | 0    | 0    | 0        |
| SARS         | 1      | 0    | 49   | 0    | 1        |
| ARDS         | 0      | 0    | 0    | 46   | 1        |
| COVID-19     | 1      | 0    | 0    | 0    | 120      |

B. Accuracy metric: It is right classification ratio which the proportion of cases which have been rightly classified (0.98%) as shown in Figure (6).
Figure 6. Model Accuracy for Suggested Schema.

C. Loss metric: it is opposite of accuracy metric, refer to the proportion of cases which have been not rightly classified (0.02%) as shown in Figure (7).

Figure 7. Model Loss for Suggested Schema.

D. Precision metric: It is the proportion of cases rightly predicted true noticing to the full predicted true noticing, the value of this metric is 0.99% for suggested Schema.

E. Recall metric: It is the proportion of cases rightly predicted true noticing to the full noticing in actual class, the value of this metric is 0.98% for suggested Schema.

F. F1-score metric: It is the regular rate of Recall and Precision, the value of this metric is 0.98% for suggested Schema.

on the other hand, several scientific researchers were offered that deep learning neural network models have a significant ability of classifying COVID-19 with reasonable outputs. The implementation of the suggested Schema of CNN compared with other previous scientific articles as shown in Table (4).
Table 4. Comparison with previous scientific articles

|          | Accuracy | No of classes                        |
|----------|----------|--------------------------------------|
| [8]      | 0.97%    | Normal and COVID-19                  |
| [9]      | 0.95%    | Normal and COVID-19                  |
| [10]     | 0.92%    | Normal and COVID-19                  |
| Suggested Schema | 0.98%    | (COVID-19, MERS SARS, ARDS and Normal) |

It is obvious that a sensible accuracy can be acquired when checked over only two classes. However, the Suggested Schema is can be sensible for more two classes.

6. Conclusions

For improving the diagnosis of the COVID-19 disease, the suggested Schema of CNN is created for classifying chest X-ray images of COVID-19 dataset for five different classes (COVID-19, MERS SARS, ARDS and Normal), for evaluating the testing set, the practical outcomes demonstrate the suggested Schema of the CNN classifier with an accuracy of 98%. The Suggested Schema is very fast due to the full time required for classifying one case is about 300 millisecond. For future works, the suggested Schema of CNN utilizing a mammoth dataset and/or utilizing another feature fusion technique.

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