A DEEP LEARNING APPROACH FED BY CT SCANS FOR DIAGNOSIS OF COVID-19

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Abstract

Since the beginning of 2020 Covid-19 disease has widely spread around the world. To both fight disease and slow the outbreak, early detection of infected individuals is one of the most effective ways. Although the coronavirus has many symptoms, the fatal one is the damage to the lung. One of the methods used to detect this damage is computed tomography (CT). Convolutional Neural Networks (CNNs), which is a highly effective deep learning algorithm on multidimensional data, is used on different types of medical images such as CT scan, MRI, and X-ray. In this study, we aim to develop a deep learning approach and thus detect/diagnose COVID-19 by using chest CT scans. For this purpose, a public resource consisting of 349 CT scans of 216 patients with COVID-19 clinical findings and CT scans of 397 healthy individuals was used. Diagnostic performance was assessed by accuracy, precision, recall, Matthews's coefficient correlation (MCC), and F-measure criteria. The validity of the approach was tested using a 10-fold cross-validation technique. The results showed that CNN achieves an average accuracy of 92.63%, precision 92.95%, recall 93.18%, MCC %85.20, and F1-measure 93.06%. Considering the results obtained with this approach developed within the scope of this study, the mentioned approach may be an alternative or supportive of classical diagnostic approaches in coronavirus outbreak.

Keywords: COVID-19, deep learning, diagnosis, CT-scan, classification

1. Introduction

Coronavirus disease 2019 (COVID-19) is a contagious viral ailment that began in China in late 2019. In addition, a worldwide epidemic was declared by the World Health Organization (WHO) in mid-2020 [1-3]. COVID-19 has affected many people around the world and the spread of this disease has not been fully controlled. Prevalent diagnostic tests are mostly based on reverse transcription-polymerase chain reaction (RT-PCR). throughout the epidemic period, the lack of the test and the long test results are the main problems in controlling the spread of this disease. For these reasons, alternative diagnostic methods such as computed tomography (CT) scans and X-ray images have been used. Because one of the known cases related to this disease is that the disease causes pneumonia.

Many studies show that CT scans are useful and rapid for the diagnosis of COVID-19 patients. Hence, CTs can be used to assess whether a patient is infected with viral pneumonia [4]. Precisely, CTs cannot be used to confirm whether a patient is infected with COVID-19. However, during an irruption, if a patient is confirmed to have viral pneumonia based on CT results, this viral pneumonia is likely to be COVID-19. Therefore, CTs are considered to be useful for the diagnosis of COVID-19.

This study aims to diagnose whether the patient is COVID-19 from CT scans with CNN based on AlexNet architecture. The rest of this paper is organized as follows. Section 2 presents related studies on COVID-19. Section 3 explains experimental results which include the dataset, CNN, experimental setup, and experimental results. Finally, conclusions and discussions in greater detail were presented in Section 4.

2. Related Work

There are many studies to diagnose COVID-19 patients. Yang et al. [5] performed experimental studies to build up diagnosis approaches based on multi-task learning and self-supervised learning using their collected dataset that had chest CT images of 746 subjects; 349 diagnosed as COVID-19 positive and 397 diagnosed as COVID-19 negative. They achieved an accuracy of 89%.

Xu, et. al. [6] aimed to utilize deep learning algorithms for classifying CT scan

images of the corona, viral-pneumonia that originates flu A and healthy individuals for 618 individuals and they achieved 0.86 accuracy.

The study has used profound learning strategies to get rid of graphic features from CT scans which providing pre-diagnosis to the medical doctor before the infective examination [7]. They achieved 89.5% accuracy. When applied to the external dataset, however, the accuracy of their algorithmic rule was 79.3%.

Zheng et al. [8] processed the U-Net model to segment lungs, and after the segmentation, results were taken as the input of the deep learning method CNN to prognosticate the probability of COVID-19. Their dataset had chest CT scans of 540 subjects; 313 with COVID-19 and 229 without COVID-19. Their proposed model achieves a specificity of 91.1%.

Another study proposed a UNet++ segmentation model to locate lesions and used a ResNet50 to classify diagnosis' labels [9]. Their dataset had chest CT images of 1136 subjects; 723 with COVID-19, 413 without COVID-19. Their combined model using UNet++ and ResNet50 achieved a specificity of 92.2%.

3. Experımental Setup

3.1 Dataset

Dataset used was collected by [5] there are 349 CT scans containing clinical findings of COVID-19 from 216 patients. The second dataset consists of 397 CT images of healthy patients. We used the CNN which is ideal for 2D images. Also, the differential diagnosis problem is considered as a supervised classification task where these CT images are fed into a CNN classifier. To find a solution to this problem, The CT images were resized 224x224 pixels and then classified with a deep learning algorithm developed on the AlexNet architecture. In Figure 1, an example is given to the corona patient with COVID-19 positive label. We carried out 10-fold cross validation. The performance of the proposed method was evaluated using the accuracy, precision, recall, MCC, F1-score, specificity and negative predictive value metrics were used. Also, the confusion matrix from the test results was given.
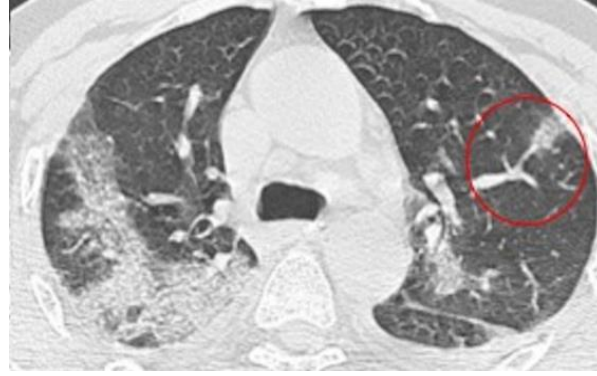
Figure 1. Example CT scan of the corona patient with COVID-19 positive label [5]

3.2 Convolutional Neural Network

Unlike conventional neural networks, CNN, which is used in many computer vision fields, especially in classification, contains convolution, pooling and fully connected layers [10, 11]. It is a specific type of multilayer neural networks designed to understand patterns as well as extending from pixels with minimal pre-processing.

The convolution starts at the top left and takes a small filter window of a certain width and height and performs an operation on it, the process is usually the matrix multiplication, which is decided by the gradient descent to achieve the best result. This process continues until it is completely completed throughout the image and creates a new image.

One problem of the feature map output of the convolutional layers is the filing of each function in the input. A common method to deal with this difficulty is called down sampling, which can be accomplished with the Pooling Layer. Pooling can be processed according to the maximum, minimum or average principles.

After some convolution and pooling, the final output is passed through a conventional feed forward neural network, which is a fully bonded layer to achieve a result.

3.3 Implementation Details

In this study, we built CNN based AlexNet architecture [12], is one of the most popular neural network architectures to date, for classification of COVID-19 CT images to normal and COVID-19. The AlexNet architecture is comprised of eight layers in total, out of which the first five are convolutional layers and the last two layers before the softmax layer are fully-connected. The first two convolutional layers are linked to overlapping max-pooling (MXP) layers to extract a maximum wide variety of Features

by using Local Response Normalization (LRN). The third, fourth, and fifth convolutional layers are at once related to the fully-connected (FC) layers. All the outputs of the convolutional and fully-connected layers are related to ReLU non-linear activation function. The ultimate output layer is linked to a softmax activation layer, which produces a distribution of labels. ReLU nonlinearity is utilized after all the convolution and entirely associated layers. The ReLU nonlinearity of the first and second convolution layers is followed by the usage of a nearby normalization step before doing Pooling. Figure 2 demonstrates the AlexNet CNN architecture that has been used.
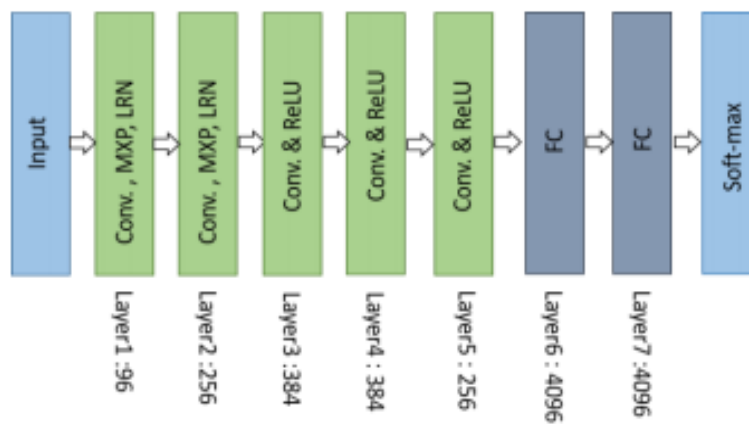

Figure 2. Architecture of AlexNet: Convolution, max-pooling, LRN and fully connected (FC) layer [12]

During the training process of CNN, Adam Optimizer was used. Epochs were set as 50. The mini-batch size was set as 32 and the learning rate was set as 0.001. The training data was shuffled before each epoch.

4. Results

To detect COVID-19, the system is designed to predict positive or not labels regardless of participants. Table 1 shows the mean results obtained with performance metrics derived from estimates obtained with 10 fold cross-validation. The confusion matrix of proposed method is shown in Table 2.

Table 1. Performance metrics of CNN on COVID-19 dataset

Accuracy	92.63
Precision	92.95
Recall	93.18
F1-measure	93.06
MCC	85.20
Specificity	92.00
NPV	92.26

Table 2. Confusion matrix of COVID-19 and Healthy

True Class		Healthy	COVID-19
	Healthy	369	28
	COVID-19	27	322
		Healthy	COVID-19
		Predicted Class	

5. Conclusions

Early diagnosis of COVID-19 patients is important in preventing the spread of disease. In this study, we used a publicly available COVID-19 CT scan dataset, to facilitate the training of the CNN model using CT to screen and test COVID-19 patients. The classification model identified whether the patient is COVID-19 positive or not and the dataset contains 216 positive COVID-19 CT scans. The study obtained 92.63% accuracy, 93.06% F1-measure, 85.20% MCC, and 92.95% precision on the test set of COVID-CT dataset. Comparing to the baseline study accuracy of 89%, our model achieved an improvement. In future studies, by using relatively more CT-scan images to be obtained from the literature, it will be tried to obtain precise and accurate results for the related problem with different models.

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