Proceedings of the 2nd International Conference on Computing Innovation and Applied Physics (CONF-CIAP 2023)
DOI: 10.54254/2753-8818/5/20230388

Detection for COVID-19 Chest X-ray Based on Convolutional Neural Network

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Abstract. COVID-19 has been the most serious public health problem of the past decade. To date, the pandemic has taken a huge toll on the globe in terms of human lives lost, economic impact and increased poverty. However, due to its viral characteristics, determining whether a patient carries COVID-19 is not easy. RT-PCR methods are the gold standard for detecting COVID-19, but their time cost, as well as the need for specific equipment and instrumentation, limit their ubiquity in some medically underdeveloped areas. Chest X-rays, a test with high ubiquity and rapid results, require a certain number of professionals to read and determine whether a patient is likely to have COVID-19. Therefore, it is important to have a system to assist in the determination in areas where professionals are lacking. In this experiment, a convolutional neural network-based machine learning technique was used to create a model for recognizing COVID-19. Although there is no clinical evidence to prove its effectiveness, the model can assist professionals in judgment to a certain extent.

Keywords: Machine Learning, Computer Vision, COVID-19, Convolutional Neural Networks.

1. Introduction

COVID-19 was the most serious public health issue in the past decade. To date, the pandemic has cost the globe dearly in terms of human lives lost, economic impact, and increased poverty. The world has been affected and changed a lot. For example, during the pandemic, more than 94% of students worldwide were educationally impacted by the closure of their learning spaces. Some schools even shut down face-to-face instruction and switched courses to online instruction to ease the restrictions on venues [1].

COVID-19 symptoms, according to Ciotti et al., a large number of patients have symptoms such as fever and cough although most patients are asymptomatic infections [2]. On chest X-ray, usually showing multiple spots and ground-glass opacities [3]. COVID-19 has a high rate of misdiagnosis. And misdiagnosis has very expensive costs [4]. Thus, reducing the misdiagnosis rate has become a major research direction. The most popular method for detecting COVID-19 is RT-PCR, although the test can take up to two days to complete [5]. However, it is not readily available in many areas around the world due to cost and operational requirements. Due to this limitation, doctors widely use radiology-based methods for initial screening of suspected cases. Guan et al. introduced that COVID-19-positive cases shows imaging abnormalities such as ground-glass opacities, bilateral abnormalities, and interstitial abnormalities on chest X-ray and CT images [6]. Thereinto, chest X-ray image analysis may have better sensitivity than RT-PCR-based diagnosis [7]. Additionally, although RT-PCR testing is known as the most effective standard for detecting COVID-19, the ubiquitous availability of chest X-rays makes them an appealing choice for rapid and extensive screening compared to the equipment needed for RT-PCR testing [8]. Thus, it is worth noting that most of the current methods on chest X-ray with COVID-19 are not intended to replace RT-PCR, but rather in attention in serving as an adjunctive diagnostic measure to RT-PCR to help doctors can quickly screen patients for disease [7]. However, the drawback of chest X-rays is obvious: only trained and experienced professionals can read the X-rays. Most underdeveloped medical regions do not have enough of these professionals. If artificial intelligence and software can assist local doctors in image identification and symptom determination of X-rays, it will improve the level of medical care in these areas. Therefore, it is advantageous to use software and artificial intelligence to assist physicians in image judgment and diagnosis.

A COVID-19 recognition network built on a convolutional neural network is presented in this paper. It is characterized by being designed for detecting COVID-19 cases from chest X-ray images, which can quickly identify chest X-ray films and determine whether the patient is likely to have COVID-19, thus assisting physicians in making diagnostic judgments. In addition, since most of the data are derived from open-source datasets, the stability of the source and clinical reliability cannot be explored. Therefore, this study used data augmentation in this network to increase the accuracy and robustness of the model.

2. Methods

2.1. Dataset description and preprocessing

The dataset used in this experiment is from two publicly available datasets [6, 7]. In addition to chest X-ray photos of patients with COVID-19 infection, the original dataset also includes images of bacterial infections, common pneumonia, and other viral diseases including SARS. Therefore, in order to perform the classification task of COVID-19, the original dataset has been organized and merged the data from both datasets into two types of data, COVID and Non-COVID, to facilitate the subsequent model training. Two examples belong to these two groupings, as shown in Figure 1. As shown in the figure, the characteristic of chest radiographs is that they are gray images, so compared with RGB images which have 3 dimensions, gray images have only 1 dimension represented, 255 is all white and 0 is all black. Therefore, the amount of data parameters is much smaller compared to RGB images, which is very convenient for training. To unify the image size, the standard image size of 180×180 is used to scale the size of the dataset images in this experiment.

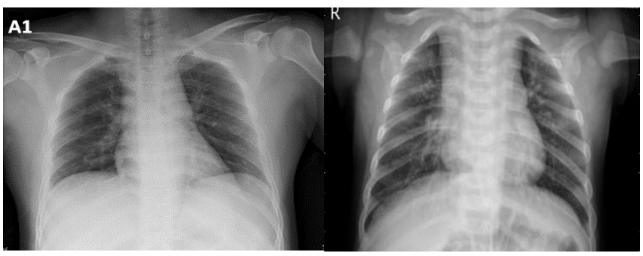

Figure 1. Example of chest X-ray image of COVID-19 (left) and SARS (right) [8].

2.2. CNN model

Machine learning (ML) has recently increased in popularity in research and has been integrated into a wide range of applications. For instance, image classification, object detection, and email spam detection. Convolutional neural network (CNN) is one of the most well-liked and frequently utilized deep learning networks [9]. The main advantage of CNN over previous machine learning algorithms is that it can automatically detect important features without any human supervision. And the ability of CNN for feature extraction makes it one of the top choices for detection and differentiation algorithms and makes it one of the most commonly used deep learning algorithms today. Thus, this research mainly focused on using CNN to construct the model to solve the problem.

In this experiment, the features of the photos are extracted using a 3 layer convolutional neural network. In order to keep the gradient from disappearing and to make the model more nonlinear, the ReLU function is selected as the activation function. A Max-pooling layer is placed after each convolutional layer. This procedure expands the perceptual field properly and increases the model's invariance. One important thing is to increase the expression of significant features while filtering some of the weak features. After that, the dropout rule is used to increase the robustness of the model [10]. Finally, a fully connected layer with 128 units and 2 units is connected to parse the features extracted from the convolutional layer and classify the images to determine whether they match the COVID-19 features.

2.3. Implementation details

TensorFlow toolkit was originally implemented by Google researchers. It is one of the most well-liked deep learning development libraries. In this research, the TensorFlow library was used to construct the CNN model. In the training process, the default learning rate of this experiment is 0.0001, and the optimizer is chosen as the adam algorithm. A total of 10 epochs. As for loss function, the Crossentropy function is chosen, and accuracy is used as the evaluation metrics.

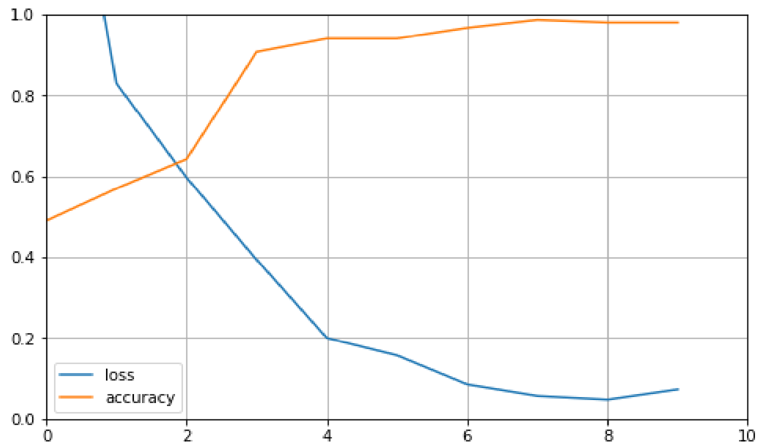

Figure 2. The training accuracy and loss experienced during training process.

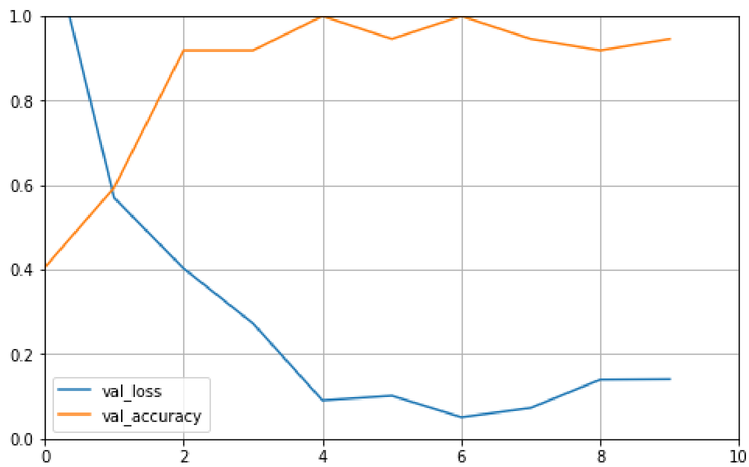

Figure 3. The validation accuracy and loss during the training process.

3. Experimental Results

After training the model, the results of the training can be shown in Figure 2 and Figure 3. It can be observed that with each iteration of the epoch, the accuracy rate almost always increases, accompanied by a decrease in the loss. Meanwhile the accuracy of the last epoch has reached about 98%. This shows that the model has already had a good learning effect for this dataset.

Test loss, test accuracy, validation loss, validation accuracy can be seen in Table 1.

Table 1. Formatting sections, subsections and subsubsections.

	Loss	Accuracy
Test	0.0733	0.9801
Validation	0.1412	0.9459

4. Discussion

The results show that the CNN model has good recognition effect for this COVID-19 dataset. The algorithm is intended to be developed as a GUI application that can be run directly on computers and mobile devices, which will greatly facilitate doctors and patients to quickly understand the symptoms to a certain extent. Although the model has already been able to identify some basic COVID-19 infected radiographs, but more complex and tricky case situations may be encountered in real clinical cases. There is still a long way to go before it can be used in clinical practice. This method still needs some improvement such as the need to increase the amount of training data. Thus, further optimization of the robustness of the model may be needed in the future to improve the ability to solve complex clinical situations. For example, using more regularization algorithms, etc.

5. Conclusion

By learning from chest radiographs of COVID-19 patients, this project builds a machine learning method that can recognize some signs of COVID-19 infection. The technique, which is based on a 2D convolutional neural network, exhibits above 90% accuracy in the experiment. However, due to the limitation of the dataset, there is still some degree of room for improving the generalizability and robustness of the model. In the future, more real clinical data will be collected as training dataset by cooperating with professional medical institutions, which may solve this problem well.

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