# Deep Convolutional Neural Networks to Diagnose the Novel Coronavirus (CoVid-19) in Frontal Chest X-ray Images

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## 1 Introduction

Being declared as a pandemic, the novel coronavirus is now the major emergency worldwide. The virus is transmitted person-to-person by respiratory droplets produced while coughing. It also may infect a person by touching contaminated surfaces and then touching the face [1].

The main symptoms are fever, cough, and breath shortage, which may appear 2-14 days after exposure. Warning signs may include severe breathing problems, persistent pain in the chest, and bluish lips or face [2]. Loss of smell and taste is also a recent rare symptom [3]. As mentioned above, the symptoms hugely overlap with those of the flu or severe cold. The standard diagnosis method, yet not a hundred percent confident, is by reverse transcription polymerase chain reaction (rRT-PCR) [4]. This method has shortcomings, such as time-consumption; it may take up to two days to have the result. Hopefully, the infection can also be diagnosed from a combination of symptoms, risk factors, and a chest CT scan or chest X-ray image showing features of pneumonia [5].

## 2 Problem Explanation

The rRT-PCR test, which is approved by the World Health Organization (WHO) as the standard method of diagnosis, has some certain drawbacks; it needs special test-kits, and the results are generally available within hours to days [6]. A diagnostic guideline made available by Zhongnan Hospital of Wuhan [5] suggests that the disease could be assessed by detecting clinical features as well as imaging features of pneumonia. Even Ai et al. [7] showed that chest CT images have a high sensitivity for the diagnosis of CoVid-19, and they may be considered as the primary technique for detection in epidemic areas.

Since radiologists are visiting many patients every day, especially in epidemic areas like Italy or Iran, and the detection takes significant time, the detection error rate may increase, ending up having false negative classifications which cost a lot to the patient and the medical staff. In this research, we investigate the possibility of using deep learning-based automatic image classification system to detect CoVid-19 in chest x-ray images. Although CT scans have proven to be more efficient revealing detailed features of the chest, there are less widely available and affordable than the X-ray. Besides, the patient's clinical situation often does not allow a CT scan. Thus, there are currently more chest X-ray samples of positive CoVid-19 cases available than the CT scans.

# 3 Proposed Method

A deep learning-based solution is selected to overcome the classification complexity problem. Deep Convolutional Neural Networks (CNNs) have been successfully applied to diagnose diseases from chest X-ray images, such as the CheXNet [8], which outperformed radiologist performance on pneumonia detection. On the next step, pretrained models, such as VGG19, are fine-tuned on the dataset and their performance is compared with the previously-built individual CNN. The Confusion matrix, the Learning curve, and the Receiver Operating Characteristic (ROC) curve are the comparison metrics.

# 4 Materials

In order to make the dataset, frontal X-ray images of the chest are considered as the input to the system. A typical sample is shown in Fig 1. X-ray imaging produces gray-scale images, where the color of body tissues is related to their absorption amount of X wave radiation.

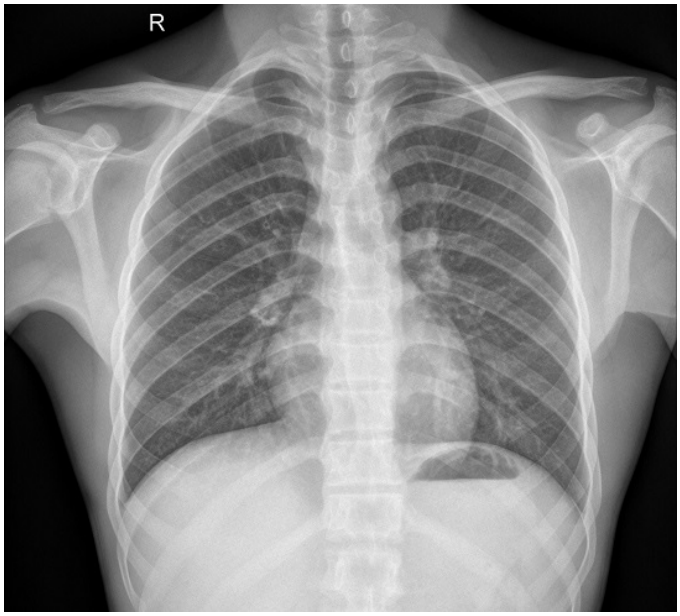


Figure 1: Frontal X-ray of a normal chest from a posteroanterior (PA) view

The number of publicly available X-ray images of patients infected by CoVid-19 is relatively small. There are three main sources of chest X-ray images being regularly updated day by day; a GitHub repository by Dr. Cohen [9], the website of the Italian Society of Medical and Interventional Radiology (SIRM), and the Radiopaedia open-edit radiology resource. Collecting images from the aforementioned sources and other small datasets, there is a total number of 121 frontal chest x-ray images of confirmed cases of the CoVid-19. Other images from different classes, like normal or other types of pneumonia, are available in numerous quantities so that there are no problems with creating other classes with the sufficient number of samples. Since the number of samples seems to be inadequate for CNN models with hundreds of thousands of weight values, data augmentation functions are also applied to input data to randomly generate more images.

# 5 Expected Results

CoVid-19 is an infectious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) [10]. Hence, it attacks the respiratory system and is responsible for pneumonia, which is mostly observed as pulmonary consolidation and Ground-Glass Opacification (GGO) in chest images. Pneumonia is also caused by other germs, such as different viruses or bacteria [11].

To date, there have been some works towards the classification of CoVid-19 based on the chest CT or X-ray images. In [12], the author fine-tuned a pretrained VGG19 model to detect CoVid-19 pneumonia from normal lungs in chest X-ray images, which acquired 90% accuracy on 50 images. Wang and Wong [13] trained the COVID-Net model to classify chest X-ray images between CoVid-19 pneumonia, normal, viral pneumonia, or bacterial pneumonia. The COVID-Net is trained on a dataset of 5941 images, out of which there are only 68 samples of CoVid-19 pneumonia, and perceived the 83.5% accuracy. Other efforts are also made to detect CoVid-19 pneumonia from other types in chest X-ray images [14] or CT scans [15]. Worth to mention that all the research studies mentioned above have collected their dataset of CoVid-19 samples only from [9].

The first milestone is to reach an accuracy of over 90% on detection between CoVid-19 pneumonia and normal chest images, such as Fig. 2. It seems to be easily achievable as the pretrained models on the ImageNet dataset have illustrated an acceptable outcome.

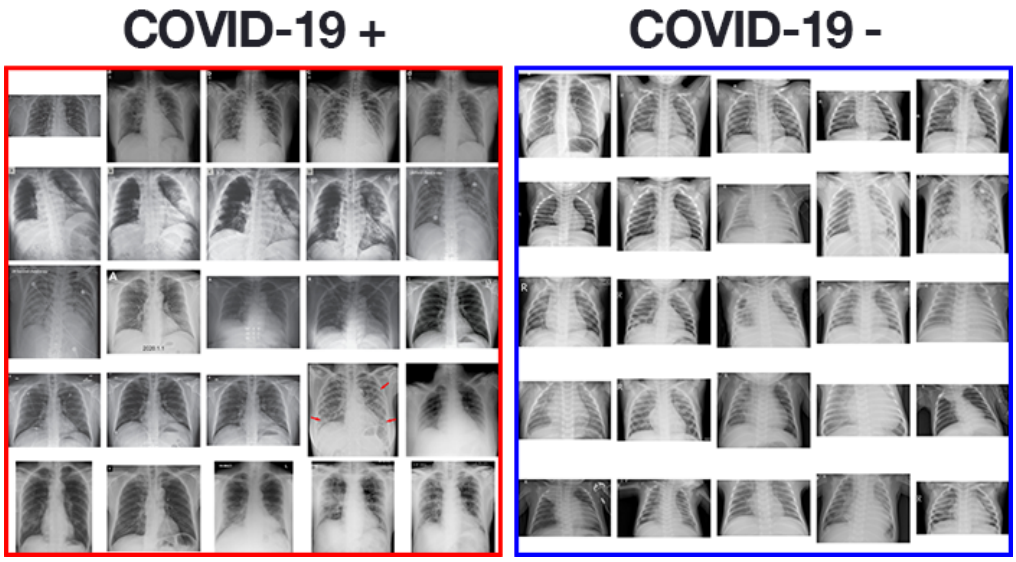


Figure 2: CoVid-19 pneumonia vs normal chest X-ray images. Results obtained by [12].

On the next step, we classify Covid-19 pneumonia from other types of pneumonia, especially other viral pneumonia samples. An accuracy of over 80% is expected to be achieved. Finally, if the previous results are satisfying, we try to detect CoVid-19 from chest X-ray images of the patients in their early stages (initial X-ray imaging after clinical admission) from normal chests. As the number of these samples are quite a few, the accuracy and the probability of overfitting is questionable. It is possible to feed the network with images and the patient symptoms at the time of the X-ray imaging, to see if it could help.

# References


[1] WHO. (2020) Coronavirus disease 2019 (covid-19): situation report, 51. [Online]. Available: https://apps.who.int/iris/bitstream/handle/10665/331475/nCoVsitrep11Mar2020-eng.pdf

[2] W. J. Guan *et al.*, "Clinical characteristics of coronavirus disease 2019 in china," *New England Journal of Medicine*, 2020.

[3] Y. C. Li, W.-Z. Bai, and T. Hashikawa, "The neuroinvasive potential of sars-cov2 may be at least partially responsible for the respiratory failure of covid-19 patients," *Journal of Medical Virology*, 2020.

[4] D. C. Rio, "Reverse transcription-polymerase chain reaction," *Cold Spring Harbor Protocols*, vol. 2014, no. 11, pp. pdb–prot080 887, 2014.

[5] Y. H. Jin *et al.*, "A rapid advice guideline for the diagnosis and treatment of 2019 novel coronavirus (2019-ncov) infected pneumonia (standard version)," *Military Medical Research*, vol. 7, no. 1, p. 4, 2020.

[6] H. Brueck. (2020) There is only one way to know if you have the coronavirus, and it involves machines full of spit and mucus. [Online]. Available: https://www.businessinsider.com/how-to-know-if-you-have-the-coronavirus-pcr-test-2020-1

[7] T. Ai *et al.*, "Correlation of chest ct and rt-pcr testing in coronavirus disease 2019 (covid-19) in china: a report of 1014 cases," *Radiology*, p. 200642, 2020.

[8] P. Rajpurkar *et al.*, "Chexnet: Radiologist-level pneumonia detection on chest x-rays with deep learning," *arXiv preprint arXiv:1711.05225*, 2017.

[9] J. P. Cohen. (2020) Covid-19 image data collection. [Online]. Available: https://github.com/ieee8023/covid-chestxray-dataset

[10] WHO. (2020) Naming the coronavirus disease (covid-19) and the virus that causes it. [Online]. Available: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance/naming-the-coronavirus-disease-(covid-2019)-and-the-virus-that-causes-it

[11] M. L. B. Costagliola, "Community-acquired pneumonia," in *Pediatric Respiratory Diseases*. Springer, 2020, pp. 299–307.

[12] A. Rosebrock. (2020) Detecting covid-19 in x-ray images with keras, tensorflow, and deep learning.

[13] L. Wang and A. Wong, "Covid-net: A tailored deep convolutional neural network design for detection of covid-19 cases from chest radiography images," *arXiv*, 2020.

[14] A. Y. Xu. (2020) Detecting covid-19 induced pneumonia from chest x-rays with transfer learning: An implementation in tensorflow and keras. [Online]. Available: https://towardsdatascience.com/detecting-covid-19-induced-pneumonia-from-chest-x-rays-with-transfer-learning-an-implementation-311484e6afc1

[15] L. Li, L. Qin, Z. Xu, Y. Yin, X. Wang, B. Kong, J. Bai, Y. Lu, Z. Fang, Q. Song *et al.*, "Artificial intelligence distinguishes covid-19 from community acquired pneumonia on chest ct," *Radiology*, p. 200905, 2020.