

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

Arman Haghanifar

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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 problem, persistent pain in the chest, and/or 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 method, yet not a hundred percent confident, of diagnosis 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 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 feature of pneumonia. Even Ai et al. [7] showed that chest CT images have a high sensitivity for diagnosis of the CoVid-19, and they may be considered as the primary technique for detection in epidemic areas.

Since radiologists are visiting many patients everyday, 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 a 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 being fine-tuned on the dataset and their performance is compared with the previously-build 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.

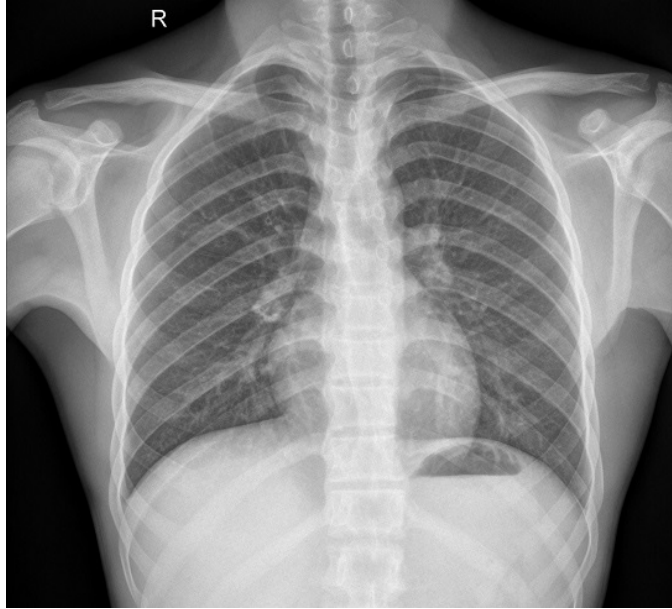


Figure 1: Frontal X-ray of a normal chest from a posteroanterior (PA) view

The number of publicly available X-ray images of patients infected by CoVid-19 is relatively small. There are three major 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 are 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 is no problems with creating other classes with sufficient number of samples. Since the number of samples seems to be insufficient for CNN models with hundreds of thousands of weight values, data augmentation functions are also applied on input data to randomly generate more images.

## 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-prot080887, 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>