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A Review of an Effective Deep Learning Network for Estimating COVID-19 severity from chest X-ray Imagery: Co Severity-Net

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Abstract: The COVID-19 pandemic has become an integral part of our existence and shows no signs of abating. In 2020, the World Health Organization declared it a pandemic, and its effects have impacted our lives in myriad ways. To detect COVID-19 from Chest X-Ray images, researchers have developed deep learning techniques. Given the severity of the disease, scoring the level of COVID-19 infection can aid in determining the optimal course of treatment and care for patients, as not all COVID-19 positive patients require specialized medical attention. However, the limited availability of a large-scale dataset has resulted in few studies being conducted to estimate the severity of the disease from Chest X-Ray images. Consequently, we propose CoV Severity-Net, a deep learning-based architecture trained on a public COVID-19 dataset curated by experienced radiologists for severity estimation. Our proposal is based on a review of 18 papers from reputable sources such as Google Scholar, PubMed, and Science Direct.
Keywords: COVID, Deep Learning, ChestX-ray, Cov Severity-Net, CT, Pneumonia

INTRODUCTION

December 2019 saw the discovery of the new Corona Virus Disease in Wuhan, Hubei Province, China. Serious Case of Acute Respiratory Syndrome SARS-CoV-2 is a rare strain of Coronavirus2, a member of the "Coronavirus" (CoV) family of viruses. It was classified as COVID-19 by the World Health Organization in February 2020. The most current numbers show that as of right now, 22.6 million individuals have been affected by this virus, and 792,000 people have died as a result of it. In March 2020, COVID-19 was classified as a pandemic. The USA, Brazil, Europe, and India are the country's most severely impacted by the virus, which has spread to over 210 nations. India requires quicker testing procedures in order to discover viruses in a timely manner due to its dense population. A speedier testing mechanism is urgently needed, nevertheless, as the existing testing methods are sluggish.

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The COVID-19 epidemic has increased the importance of radiology in the detection, management, and care of the illness. Early studies on the virus concentrated on the imaging characteristics discovered in Chinese patients' computed tomography (CT) scans. These realizations have shown to be invaluable in helping medical practitioners with clinical advice. Because of their high cost, the possibility of spreading viruses during patient transfers to and from CT imaging suites, and the lengthy decontamination periods between scans, CT scanners are not readily available in many regions of the world. These drawbacks have limited their application and rendered them less widely available than CXR imaging equipment. Because CXR equipment is less expensive and sanitizes more quickly, it is more widely available globally. Additionally, there is a portable Chest X-Ray (CXR) device that may be used in an isolation room to provide imaging, greatly lowering the possibility of virus transmission. Four strategies are proposed by [1] to stop the transmission of SARS-CoV-2: physical separation, contact tracing, testing, and isolation. The lack of testing kits makes large-scale testing challenging and makes contact tracing more challenging. Rapid and reasonably priced COVID-19 testing is required in areas with high population densities. With differing degrees of success, some researchers have created deep learning-based systems that identify COVID-19 from CXR pictures.

Identification of COVID-19 using Chest CT scans

Utilizing deep learning and image processing methods, researchers are creating frameworks for automatic COVID-19 identification from chest CT scans. CNNs and deep learning in general are being used more and more to tackle challenging problems. CNNs are now used in the medical industry for pattern recognition tasks, having first been used for handwritten digit recognition. As the most successful image classification method, DCNN is the recommended option because it doesn't rely on pre-designed features. Sometimes, especially when there is several pneumonia causes occurring at the same time, chest CT scan results can be misclassified. The most common finding on chest CT scans is ground-glass opacities (GGO). Air bronchograms, interlobular septal thickening, and combining accompanied by or without vascular enlargement are some other a normalizes that may be seen, though [2]. In order to train a light CNN for COVID-19 detection,[3] retrieved low-level characteristics from chest CT scans. Their suggested network had an accuracy of roughly 85.03% and was based on SqueezeNet. For the identification of COVID-19, [4] suggested a DCNN constructed using multi-objective differential evolution (MODE), which takes CT-Scans as an input picture. Their stated accuracy rate is 93%. An artificial intelligence (AI) mobile app was developed by [5] to evaluate input CT scans and analyze smart phone sensor signal data to determine the severity of pneumonia in a person. A learning model that relies on initial migration and can identify COVID-19 was presented by Wang and colleagues in 2021. The proposed model underwent training and testing on an isolated dataset of 453 CT scans. A precision of 73.1% has been attained. AUC was reported as 0.96 by [6].

COVID-19 identification using CXR pictures

The proposal of several deep learning-based models for the classification of chest X-ray pictures.[7] presented COVID-Net, [8] suggested COVIDX-net, while [9] recommended ResNet50. An ensemble model based on several DCNN designs was proposed by [10]., while a model based on the Xception network was proposed by Asif et al. That being said, 50% of individuals infected with COVID-19 may have a normal CT scan during the incubation period. CT scans expose patients to much higher radiation doses than X-ray imaging, which is a serious health risk. Given that they are more vulnerable to the negative effects of radiation, children and pregnant women should be particularly concerned about this [11]. They decided to use CXR pictures for their investigation because of these hazards.

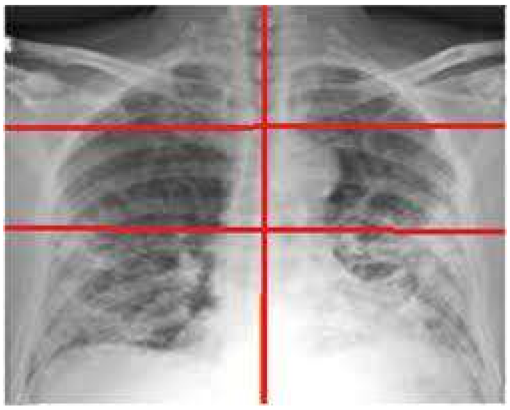

Figure1: A sample CXR image is divided into three sections, one for each lung: the superior, middle, and inferior zones.

Estimating severity

With COVID-19 cases on the rise, automatic severity assessment systems using deep learning to identify infected patients requiring significant clinical treatment are crucial. However, research is limited due to small datasets. [12] Achieved an 87.5% accuracy in binary classification using 176 CT images. [13] Achieved 98.5% accuracy in multi-task multi-instance learning with 666 CT images. [14] Classified severity into four levels from 131 CXR images of 84 patients using transfer learning. [2] Used deep learning to estimate severity from 531 CT images. In 2021, Wong and his colleagues created the regression model Covid-NetS.

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Through analysis of the patient's Chest X-Ray (CXR) pictures, this model is utilized to predict the severity rating of a patient who was tested positive for COVID-19. The degree of opacity and the geographic extent are the two parameters used to compute the severity score. The enlargement of the lung picture determines the geographic extent, and the computation of the opacity extent yields the image's degree of opacity.

Measuring health metrics based on CNN

Research on the death risk factor associated with COVID-19 has been proposed in [15,16] and is based on realistic data and statistical techniques (statistical tests and logistic regression). In this work, they propose a straightforward method to give medical practitioners an estimator for assessing a patient's likelihood of surviving COVID-19 while taking into account risk factors, such as age, comorbidities, and the prevalence of infection indicator (Figure. 2). They assign a score, or penalty, to each risk factor (a large value diminishes the possibility of a patient avoiding mortality). A crucial threshold T divided by the sum of the scores is the proposed measure F. There is no possibility of recovery past T. Formally, F may be written like this:

$$F=(S1+S2+S3)/T$$

Whereas S1 gauges the risk resulting from the patient's age, S2 gauges the danger resulting from the CNN-derived infection rate assessed from the patient's X-ray chest image, and S3 gauges the risk resulting from the patient's co morbidities that may cause problems. To be more specific, allow us to provide an example that shows how to calculate the measure F. First, they make clear that health practitioners must modify the grading system going forward to reflect reality.

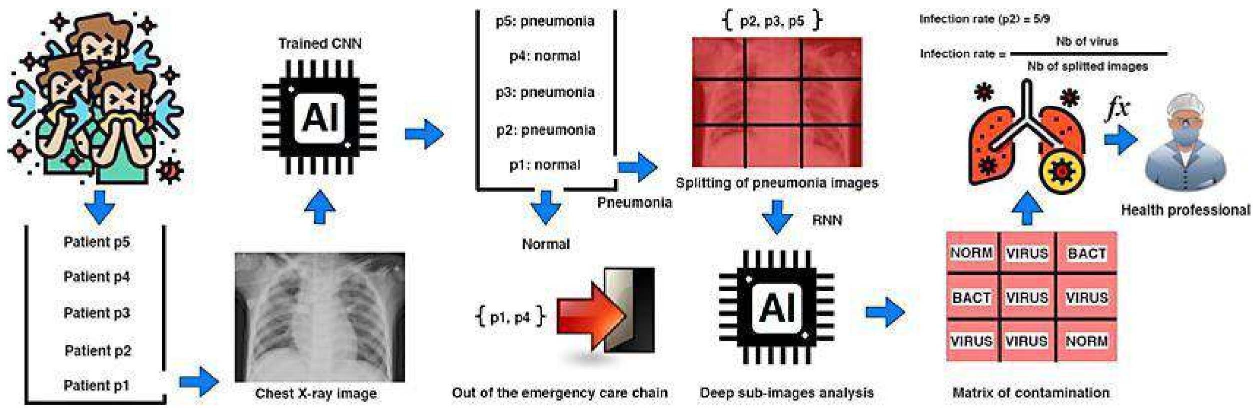


Figure2: Deep learning-based global work flow for CNN-based infection rate indicator automatic estimate from chest X-ray images [16]

Results based on Chest X-ray

Within the [17] work, Figure 3 provides a comprehensive representation of the Chest X-ray results, accompanied by a clear differentiation between normal and abnormal images. The visual display of the images, coupled with the [17] classification system of normal and abnormal results, serves to facilitate a greater understanding of the data presented.

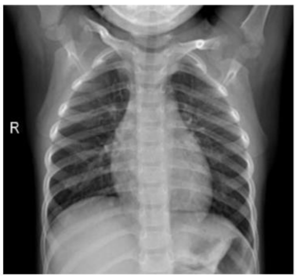
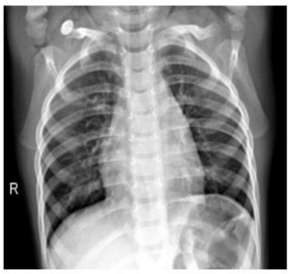
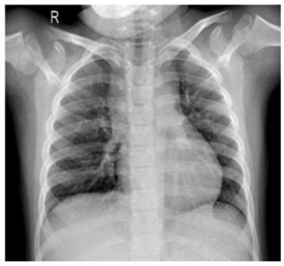
Category	X-rays		
COVID-19			
Normal			

Figure 3: Chest X-ray images normal and abnormal pictures[17]

DISCUSSION

Upon further examining the literature, we discovered that a number of scientists have published or suggested several deep learning algorithm-based models for COVID19 detection from CXR pictures. Unfortunately, very little research has been done on using CXR pictures to estimate the severity of the disease; this may be due to the absence of a sizable dataset. [18] Created the Covid-NetS regression model, which uses a patient's chest X-ray (CXR) pictures to predict the severity score of a COVID-19- positive patient. The spatial and opacity extents determine the severity score. The lung image's consolidation determines the geographic extent, while the degree of opacity is determined by the opacity extent. [18] Propose a classification model called CoV Severity-Net, which divides the input CXR pictures into three severity categories. The following are the benefits of CoV Severity-Net over Covid-Net S:

- While Covid-NetS require human intervention to remove the artifacts and patient metadata from the CXRs, CoVSeverity-Net is a fully automated solution.
- While Covid-NetS are trained utilizing 396 images, CoVSeverity-Net is trained on nearly 3000 CXR images. Furthermore, seven distinct sources provide the dataset that was used to train the suggested CoVSeverity-Net. In contrast, a single source provides the dataset that Covid-NetS were trained on. In light of this, they can conclude that their approach is more robust [18].
- While the top-performing Covid-NetS achieved an R2 score of 0.739 and 0.741 for geographic and opacity extent, respectively, CoVSeverity-Net reported a classification accuracy of 85.71%.

CONCLUSION

There has been a lot of research conducted to detect COVID-19 from various image modalities such as CXR images or CT scans, but very few algorithms have been proposed for severity estimation. It is not necessary for all COVID-19 positive patients to require intensive care or hospitalization. Therefore, severity estimation, if developed appropriately, can help patients determine their future course of action. We have reviewed CoVSeverity-Net, a deep learning-based severity estimator for this purpose. CXR images are selected for this model as X-ray machines are available at almost every primary hospital, and an X-Ray can be done at a very low cost. The large COVID-19 positive CXR from Kaggle is selected, as it contains images from seven different sources. Later, a large dataset of almost 3500 images was curated independently by two expert groups. The images that were of low quality and had discrepancies were removed from the dataset, with proper explanations included in the manuscript. CoVSeverity-Net uses two pre-trained DCNN structures, namely VGG-19 and MobileNet for feature extraction. The final features extracted were classified into three levels of severity, namely Mild, Moderate, and Severe. The model achieved an accuracy of 85.71%. A 5-fold cross-validation accuracy of 87.82 ± 6.25 was reported, and conducting 10-fold cross-validation, we obtained an accuracy of 91.26 ± 3.42. We strongly believe that this study has a high chance of reducing the workload of overworked frontline radiologists, speeding up patient diagnosis and treatment, and easing pandemic control. Future work would be to review a novel deep learning-based architecture on a larger dataset for severity estimation and also to collect images from local hospitals to test our model.

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