COVID-19 DETECTION MODEL

A Project Work Synopsis

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Submitted by:

Ujjwal	**20BCS6849**
Ayush Bajaj	**20BCS6843**
Manasij Haldar	**20BCS6838**

Under the Supervision of:

Prabhjot Singh Manocha

CHANDIGARH UNIVERSITY, GHARUAN, MOHALI - 140413,
PUNJAB-

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Annexure-4 **(A typical specimen of table of contents)**

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List Of Symbols

CXR: Chest X-ray

GGO: Ground glass opacities

TSS: Total severity score

WHO: World Health Organization

SARS: Severe acute respiratory syndrome

ARDS: Acute respiratory distress syndrome

CT: Computerized tomography

1. INTRODUCTION

1.1 **Coronavirus disease (COVID-19)** *is an infectious disease caused by the SARS-CoV-2 virus.*

Most people infected with the virus will experience mild to moderate respiratory illness and recover without requiring special treatment. However, some will become seriously ill and require medical attention. Older people and those with underlying medical conditions like cardiovascular disease, diabetes, chronic respiratory disease, or cancer are more likely to develop serious illness. Anyone can get sick with COVID-19 and become seriously ill or die at any age.

The best way to prevent and slow down transmission is to be well informed about the disease and how the virus spreads. Protect yourself and others from infection by staying at least 1 metre apart from others, wearing a properly fitted mask, and washing your hands or using an alcohol-based rub frequently. Get vaccinated when it's your turn and follow local guidance.

The virus can spread from an infected person's mouth or nose in small liquid particles when they cough, sneeze, speak, sing or breathe. These particles range from larger respiratory droplets to smaller aerosols. It is important to practice respiratory etiquette, for example by coughing into a flexed elbow, and to stay home and self-isolate until you recover if you feel unwell.

So while a person infected with Covid 19 can be cured, it is important to understand that the factors that lead to fatality, include underlying illnesses (hypertension, diabetes, cardiac problems, respiratory issues) and individuals who are on immune-suppressing medications. In older individuals, the risk is higher, as the immunity decreases with age and they have a higher disposition for other illnesses.
Another important aspect in understanding Covid 19 is its effect on the body system, especially the lungs.

1.2 Effects of Covid 19 on the human body.

<u>Acute Respiratory Distress Syndrome (ARDS)</u>

There is a direct correlation between Covid 19 and ARDS, severe cases of Covid 19 infection leads to ARDS and pneumonia, which can prove to be fatal for the infected individual. Acute Respiratory Distress Syndrome causes dry cough, heavy breathing, breathing difficulties and increased heart rate. In most healthy individuals, who do not have underlying issues Covid 19 exhibits mild symptoms, which can be treated with medications and eventually the patients recover. In severe cases, where the infected person has an impaired immunity due to underlying health conditions, an infection due to Covid 19 can progress to severe ARDS. Once the patient progresses to ARDS, it eventually leads to pneumonia.

Before understanding the severity of Covid 19 infection, it is important to understand the different stages/categories of Covid 19 infection:

First category: These individuals are infected by the virus, but act as carriers but may not exhibit the symptoms. These individuals are at a higher risk of spreading the virus as they might be oblivious to its presence.

Second category: Individuals with mild fever, cough, headache or possible conjunctivitis. This is due to an infection in the upper respiratory tract.

Third category: Similar to the third category, the symptoms here are more pronounced and might require hospitalization. Immediate treatment can help alleviate the symptoms and prevent a fatality.

Fourth category: Severe cases of Covid 19, might lead to ARDS and pneumonia. At this stage, it is fatal.

<u>Effect of ARDS on lungs</u>

Covid 19 directly impacts the lungs and damages the alveoli (tiny air sacs). The function of the alveolus is to transfer oxygen to the blood vessels. These blood vessels or capillaries carry the oxygen to the RBCs (Red blood cells). It is the RBCs that finally deliver the oxygen to all the internal organs in the body.

The virus works by damaging the wall and the lining of the alveolus and capillaries. The debris from the damage, which is plasma protein, accumulates on the alveolus wall and *thickens the lining. As the walls' thicken, the transfer of oxygen to the red blood cells is impaired. The thicker the wall gets, the more difficult it gets to transfer oxygen to the red blood cells, which causes difficulty in breathing as the body is running short of oxygen. And the lack of oxygen to the internal organs results in a deficit in the body and impairs the functioning of the organs. At this juncture, the body fights to increase oxygen intake.*

And the first response of the body is to destroy the virus and prevent its replication, but if the individual has weaker immunity then the body is unable to stop the virus, and this aggravates the crisis.

Pneumonia

As the air sacs are damaged, there is an influx of liquid which is mostly inflamed cells and protein and this fluid build-up leads to pneumonia. This further impairs the oxygen intake by the lungs and hinders the oxygen exchange. Due to the novelty of the Covid 19 strain, there is no immediate treatment to directly cure pneumonia in Covid 19 patients and are mostly given supportive care.

There are some key indicators that the doctors to judge the onset and severity of ARDS in infected individuals:

1. *Hypoxia – Low oxygen levels in the blood, due to damage to the alveolus*
2. *Breathing difficulties and shortness of breath*
3. *Chest x-rays of the lungs exhibit an opaque and glassy look against the black background*
4. *Worsening symptoms over the course of time, from the day of detection of the virus*

Acute Cardiac Injury:

Studies have shown that patients in China who were diagnosed and hospitalized with COVID-19 had developed some heart problems, including arrhythmias. Researchers from Washington, U.S.A, studied patients who were extremely ill due to COVID-19 and they found that the patients were also diagnosed with high levels of cardiac issues. It's assumed that COVID-19 may cause serious cardiac complications long after a patient has recovered from coronavirus. However, since this virus is novel its implications on the heart are still unknown.

Secondary infection:

As secondary infection occurs when you contract an infection that is unrelated to the first issue you had. In this case, if someone with COVID-19 begins to get infected with another contagion. Reviews and studies that were done on COVID-19 patients, who were hospitalized, have found that secondary infection is quite possible, but it's not common. It can happen when the patient's immunity is quite weak; so, if they are fighting off a virus (or recovering from it) they can contract a bacterial infection. Strep and staph infections are common culprits. If the infections are not treated immediately. They can be serious enough to risk death.

Septic shock:

Sepsis takes place when the body's reaction to an infection goes astray. The chemicals that are released in the blood, to battle the illness, don't trigger the correct response and your organs are affected negatively. If the Sepsis process is not stopped, as soon as possible, then you can go into a septic shock state; especially if your blood pressure drops too much then septic shock can be dangerous.

Acute Kidney injury:

This is a rare complication, but if it does happen then it can be quite serious. If your kidneys stop functioning then the doctors will start treatment to reduce the damage, immediately. You may be put on dialysis (a machine that filters your blood) until your kidneys start working normally. Sometimes, the damage won't heal entirely and people will get chronic kidney disease, which will require long term management.

Blood clots:

Blood clots can be caused due to a condition called disseminated intravascular coagulation (DIC). Due to this condition, the body's blood clotting response will work differently than it should; unusual clots will begin to form around major organs of the body and it will lead to internal bleeding and organ failure, if not treated at the earliest. A study among Chinese COVID-19 patients has shown that DIC was common among the deceased patients.

1.3 Problem Definition:

The reference diagnostic test for COVID-19 pneumonia is real-time reverse transcription-polymerase chain reaction (RT-PCR). The specificity of RT-PCR is approximately 95%, but the sensitivity of RT-PCR at the initial presentation is 60–71% because of kit performance, sampling and transportation limitations. Because of these low sensitivity rates and the need for rapid diagnosis, X-Ray has been frequently used in the current pandemic condition. Also, several cases with initial negative RT-PCR results are reported to have positive chest CT findings or X-rays. So in the direction of finding an accurate way of testing Covid19, X-rays tend to be more trustworthy than any RT-PCR reports, blood reports or various other symptoms. Which led us here for the project of Covid19 Detection analysing X-Ray imagery using Neural Networks.

2. PROBLEM FORMULATION

For the formulation of this project, we plan to gather and combine as many possible dataset available on the internet regarding X-Ray imagery of Lungs, positive and negative to Covid-19.
We then plan to divide the dataset for training and testing purpose after preprocessing and fit the data into the CNN model that we propose to create.
We plan to get an outcome with appreciable accuracy in classifying out COVID-19 positive input data

3. LITERATURE REVIEW

CXRs are a good monitor of COVID-19 chest manifestations and its scoring system provides an accurate method to predict the disease severity. The study also revealed a positive correlation between the patients' age and total severity score to the final disease outcome providing a good indicator for clinician to identify at an early stage the patients with the highest risk and plan specific treatment strategies for them.

COVID-19 is a highly infectious disease that has been spread widely throughout the world. The disease management strategies primarily depend upon the early disease diagnosis. However, the dramatic dissemination of the disease created a great challenge due to the insufficient laboratory kits . That is why radiology has become a forefront method during the outbreak of COVID-19 .

Current literatures are mostly assessing COVID-19 CT findings, as it offers more sensitive results than chest X-ray (CXR) especially in the initial assessment of the patients.

The increased number of hospitalized patients and the consequent increase in radiological examinations would make the constant use of chest CT scan (from diagnosis to discharge) difficult to sustain over time . The dependence on CT creates a huge burden on radiology departments and this makes the CXRs greatly substitute the CT examinations .

Although chest X-ray (CXR) is considered less sensitive for the detection of pulmonary involvement in early-stage disease, it is useful for monitoring the rapid progression of lung abnormalities in COVID-19, especially in critical patients admitted to intensive care units .

To provide valuable help for the clinicians and improve the stratification of the disease risk, chest X-ray (CXR) scoring system was tailored providing a semi-quantitative tool for assessment of lung abnormalities .

In this study, we analyzed the CXRs findings and severity scores of patients proven to have COVID-19 in different stages of disease. CXRs abnormalities were detected in 268 of 350 patients (77%) at certain points of the disease course.

In our study, each lung was given a score of 0–4 depending on the extent of lung involvement (score 0 = no involvement; 1 ≤ 25%; 2 = 25–50%; 3 = 50–75%; 4 ≥ 75% lung *affection). A total severity score was calculated by summing both lung scores (total severity scores ranged from 0 to 8). Borghesi et al. made another CXR scoring system for COVID-19 pneumonia (Brixia score) by dividing the lungs to six zones on frontal projection (upper, middle, and lower zones); then, a score (from 0 to 3) is assigned to each zone based on the lung abnormalities detected on frontal chest projection as follows: score 0, no lung abnormalities; score 1, interstitial infiltrates; score 2, interstitial and alveolar infiltrates (interstitial predominance); and score 3, interstitial and alveolar infiltrates (alveolar predominance). The scores of the six lung zones are then added to obtain an overall "CXR SCORE" ranging from 0 to 18 . In our study, most of the patients showed bilateral lung affection (181 patients, 67.5%) with lower zonal predominance (196, 73.1%) and peripheral distribution (156 patients, 58.2%) . The most common CXRs features detected in COVID-19 cases were consolidation seen in 218 patients (81.3%), followed by reticular interstitial thickening seen in 107 patients (39.9%) and GGO seen in 87 patients (32.5%). Few cases showed pulmonary nodules seen in 25 patients (9.3%) and pleural effusion seen in 20 patients (7.5%). This agreed with Wong et al. who did a study on 64 COVID-19 patients, they found that Consolidation was the most common finding (47%), followed by GGO (33%). Also, peripheral predominance was seen in 41% of CXR abnormalities with lower zone distribution (50%) with bilateral lung involvement (50%). Pleural effusion was uncommon, only seen in 3% . Also, Lomoro et al. performed a study on thirty-two patients of COVID-19 disease; they found that consolidation is the most common finding (46.9%) with bilateral lung affection in (78.1%) and lower zone involvement (52%). No pleural effusion was identified . Jacobi et al. stated that standard CXR can easily identify reticular opacities accompanying regions of ground glass attenuation. They state that air space consolidation opacities with peripheral and lower zone distribution are unique for COVID-19 disease . Chen et al. reported bilateral pneumonia as the most common finding on chest radiographs . While, Ng et al. reported that CXR lacks sensitivity in the early stages of lung disease . In most studies, pleural effusions, pneumothorax, and lung cavitation are rare in COVID-19 infected patients . Pneumothorax was detected in 2 cases in our study and it was iatrogenic due to mechanical ventilation in intubated patients. We classified patients according to the stage of illness into four stages (1–4 days, 5–9 days, 10–15 days, and > 15 days). The degree of disease severity was assessed using* *semi-quantitative CXRs severity score that reflects the severity of different stages of this disease. The total severity score was lowest at stage 1 compared to other stages, with significant difference among other stages, indicating that the disease changed rapidly within 10–15 days after the onset of the initial symptoms. We estimated the total severity score in the baseline and follow-up CXR, and it ranged from 0 to 8. In most cases (230 patients, 65.7%), TSS was mild, ranging between 0 and 2. While, in 82 patients (23.4%), there was moderate severity score ranging between 3 and 5. Severe cases with severity score of ranged between 6 and 8 was found in 38 patients (10.9%) with more disseminated lung involvement. Wong et al. found in their study that 41% had mild findings with total severity score of 1–2, while moderate and severe cases with more extensive lung involvement was seen in 20% and 8% patients, who had severity scores of 3–4 and 5–6, respectively. There was no patient who had a severity score of > 6 on their baseline CXR with the severity of CXR findings peaked at 10–15 days from the date of symptom onset . In our study, the maximum total severity score was reached in 113 patients (42.2%) in the initial baseline CXR with mean total severity score 1.49 ± 1.53 followed by 92 patients (34.3%) who reached the maximum TSS at 1st follow-up CXR done (done 1–4 days) with mean total severity score 2.08 ± 1.83. The highest total severity score of the CXR findings was found in the 4th follow-up CXR 15 days after the onset of the symptoms with its mean 4.51 ± 1.61. Our study correlated the disease outcome to the patients' age with a significant difference between the age of the patients and COVID-19 disease outcome (P value = 0.008). The mean age for the recovered patients was 41.09 ± 14.14 while, the mean age for the dead patients was 51.04 ± 10.17. Lowest mortality rate was observed in 20–40 years, while patients aging 40–59 and ≥ 60 years showed significantly higher mortality rate. In our study, there were 261 males (74.6%) and 89 females (25.4%) with male patients showing significantly higher mortality rate compared to the female patients (P value 0.025). This agreed with Borghesi et al., who did a study on 783 Italian patients. They found that most patients (67.9%) were males and only 15.2% were younger than 50 years. They stated that in older age groups between 50 and 79 years, there was more significant pulmonary affection with highest severity score seen in males ≥ 50 years or female ≥ 80 especially that underlying comorbidities (such as hypertension, diabetes, cardiovascular disease, and oncologic history) are risk factors of fatal outcome in adult patients with* *confirmed SARS-CoV-2 infection . In our study, the disease outcome showed a positive correlation with the maximum severity score (6.87 ± 0.71 for the dead patients and 2.06 ± 1.84 for the survived patients) with high statistical significance (P value < 0.001). In patients with TSS 2, there was a statistical significance between the TSS and the outcome of COVID disease for the survived patients (P value 0.032), while, in patients with TSS 7 and 8, there was a highly statistical significance for the outcome for the dead patients (P value < 0.001). This agreed with Toussie et al. that showed that the severity of lung involvement on the initial chest radiograph was associated with more need for patients' hospitalization as well as the increased risk of intubation and have proposed the use of initial CXR severity scores as a prognostic indicator of COVID-19 patients' outcome. The major strength of this study is the large sample size, which comprised of 350 COVID-19 patients. Our study had some limitations. First, it is a retrospective analysis. Second, the lack of correlation between CXR severity score and patient comorbidities (such as hypertension, diabetes, cardiovascular disease, and oncologic history). Third, not all the patients could be followed till the final outcome as the course of the disease was truncated in these patients. Fourth, CXR serial follow-up studies were not performed in a uniform pattern as it was dedicated by the clinician as regards the clinical condition. Fifth, for severe cases in the intensive care unit, the portable AP CXR was suboptimal with only few cases performed CT, so we could not judge the sensitivity of CXR.*

4. OBJECTIVES

This study shows how image pre-processing and the proposed object detection model can be used to detect COVID-19 in chest X-ray pictures. The suggested integrated dataset with pneumonia images enables for the development of a more robust model that can differentiate between COVID-19. We can generate a normalised dataset using the histogram equalisation technique, which helps us model the training step. It also enhances normal picture detection while lowering the probability of false positives. We will accomplish COVID-19 detection sensibility and specificity using our proposed approach.

The proposed work is aimed to carry out work leading to the development of an approach for detection of COVID-19 analysing of X-Ray Imageries of Lungs.

5. METHODOLOGY

We propose using a deep convolutional neural network trained on COVID-19 and pneumonia images, as well as a fresh dataset comprising COVID-19 and pneumonia images. Both are open to the public via GitHub and Kaggle, to name a few. X-rays or CT scans of the chest COVID-19 cases are represented in the GitHub repository. It was made by putting together medical photos from publicly accessible websites and publications. COVID-19 X-ray pictures are included in this dataset.

The Kaggle dataset, on the other hand, was produced for a pneumonia case.

By combining COVID-19 and pneumonia images, we propose a new dataset that is both larger and more diversified. Because normal pneumonia and COVID-19 have comparable appearances in chest X-ray images, including pneumonia images in the training dataset implies an extra advantage. This dataset merger enables the creation of a more robust model capable of distinguishing between those diseases. Another benefit of this merge is that it expands the train dataset, which is important because COVID-19 photos are scarce at the time of authoring this research.

Because of the similarities between pneumonia and COVID-19, this merge does not increase the size of the COVID-19 picture collection, but it does improve detection quality. Train with pneumonia images to offer the model a leg up on the competition. Train using pneumonia images provides more knowledge to the model, allowing it to distinguish COVID-19 from pneumonia, making disease identification more successful and stable.

To avoid biased findings, we split the photos into train and test sets, dividing all the data in a balanced way, meaning that all samples of each class in the training sets are well-balanced. We create a dataset of adequate images for this purpose, despite the fact that we have a huge number of pneumonia and normal photographs. Now, using our deep Convolutional Network model, we will predict whether the X-ray is covid positive or negative.

6. TENTATIVE CHAPTER PLAN FOR THE PROPOSED WORK

CHAPTER 1: INTRODUCTION

This chapter will cover the overview of the targeted disease and approaches used to detect it.

CHAPTER 2: BACKGROUND OF PROPOSED METHOD

This chapter will provide an introduction to the concepts which are necessary to understand the proposed system and the implementation of Deep Learning for detection of COVID-19.

CHAPTER 4: METHODOLOGY

This chapter will cover the technical details of the proposed approach.

CHAPTER 5: EXPERIMENTAL SETUP

This chapter will provide information about the subject system and tools used for evaluation of proposed methods.

CHAPTER 6: RESULTS AND DISCUSSION

The result of the proposed technique will be discussed in this chapter.

CHAPTER 7: CONCLUSION AND FUTURE SCOPE

The major finding of the work will be presented in this chapter. Also directions for extending the current study will be discussed.

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