Covid-19 Detection Using X-Ray Images

Major Project I

Submitted By

Lakshya Khera(9917103014)

Gaurav Parihar(9917103015)

Shubham Tak(9917103031)

Under the Supervision of

Dr. Arti Jain

Department of CSE/IT

Jaypee Institute Of Information Technology University, Noida

December 2020

TABLE OF CONTENTS

DECLARATION

I/We hereby declare that this submission is my/our own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which has been accepted for the award of any other degree or diploma of the university or other institute of higher learning, except where due acknowledgment has been made in the text.

Place: Lucknow
Date: 6th December 2020
Enrollment No: 9917103014

Signature:
Name: Lakshya Khera

Place: Gwalior
Date: 6th December 2020
Enrollment No: 9917103015

Signature:
Name: Gaurav Parihar

Place: Jodhpur
Date: 6th December 2020
Enrollment No: 9917103031

Signature:
Name: Shubham Tak

CERTIFICATE

This is to certify that the work titled "**Covid-19 Detection Using X-Ray Images**" submitted by **Gaurav Parihar, Lakshya Khera and Shubham Tak** in partial fulfillment for the award of degree of Bachelor of Technology of Jaypee Institute of Information Technology, Noida has been carried out under my supervision. This work has not been submitted partially or wholly to any other University or Institute for the award of this or any other degree or diploma.

Signature of Supervisor :
Name of Supervisor : Dr. Arti Jain
Designation : Assistant Professor
Date :

ACKNOWLEDGEMENT

We would highly like to place on record our deep sense of gratitude to Dr. Arti Jain, Assistant Professor at, Jaypee Institute of Information Technology, Noida for his generous guidance and constant supervision as well as for providing necessary information regarding the project and also his support in completing this work. I express my sincere gratitude to faculty, Dept. of Computer Science, and project evaluators for their stimulating guidance, continuous encouragement and supervision throughout the course of present work. I also extend my thanks to my college for providing adequate resources for the project, my group members and seniors for their insightful comments and constructive suggestions to improve the quality of this project work.

Signature(s) of Students
Lakshya Khera (9917103014)
Gaurav Parihar (9917103015)
Shubham Tak (9917103031)

Signature(s) of Supervisor:
Dr. Arti Jain
Assistant Professor
(Department of CSE & IT,JIIT)

LIST OF FIGURES

LIST OF TABLE

LIST OF ACRONYMS

CNN	Convolutional Neural Network
SVM	Support Vector Machines
Covid-19	CoronaVirus Disease 2019

CHAPTER 1: INTRODUCTION

1.1 General Introduction

In this epidemic of COVID-19, people will continue to suffer until people receive the vaccine. A lot of scientific research is being done continuously. So, until people receive vaccines they should be tested at a correct time so that they can be cured and prevent the spread of coronavirus from that person. Test analysis is often performed in automated , high-throughput , medical laboratories by medical laboratory scientists . Test samples can be obtained by various methods, including a nasopharyngeal swab , sputum (coughed up material), throat swabs, deep airway material collected via suction catheter or saliva.The limited availability of test-kits and domain experts in the hospitals and rapid increase in the number of infected patients necessitates an automatic screening system, which can act as a second opinion for expert physicians to quickly identify the infected patients, who require immediate isolation and further clinical confirmation.

After going through many articles the world demands a fast, reliable and secure way of testing. Here comes the role of Computer Vision, Machine Learning and especially Deep Learning as it is described as the state-of-the-art for all analysis of medical imaging and plays an important role. Recent studies and radiologists specify that the physical examination of the body shows the chest radiographs were found abnormal as it infects the respiratory system mainly. Studies also state that chest X-Rays are insensitive in the early stages of the disease. Further if quarantined the patient's X-Rays often reveals changes in the lungs. So, the above findings could be green signal to make advancement in the field of computer vision, machine learning and deep learning as X-Ray images could help to detect the presence of Coronavirus.

1.2 Problem Statement

The novel coronavirus (COVID-19), known as SARS-CoV-2 previously known as 2019-nCoV causes an illness which affects the respiratory system mainly. It has caused a huge impact on the lives of human lives, health and global economy. A lot of scientific research is being done continuously. So, until people receive vaccines they should be tested at a correct time so that they can be cured and prevent the spread of coronavirus from that person. Test analysis is often performed in automated, high-throughput, medical laboratories by medical laboratory scientists . Test samples can be obtained by various methods, including a nasopharyngeal swab , sputum (coughed up material), throat swabs, deep airway material collected via suction catheter or saliva. So, to solve the above problem many models and research are being done everyday. When talking in terms of deep learning models, there are many models which build till now but, they all had flaws of not having a large size of dataset and more false positive rate.

1.3 Significance/Novelty of the problem

The standard diagnostic technique is the reverse transcription-polymerase chain reaction (RT-PCR) method where The samples are collected by inserting a swab into the nostril and gently moving it into the nasopharynx to collect secretions. Although RT-PCR can identify the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) strain that causes COVID-19, in some cases, it produced negative test results. Also in less developed countries due to the limited number of radiologists, the CT and X Ray imaging procedure is very expensive and slow.

By bringing up solutions, which can automate detection can pace up diagnostic procedures to a greater extent without bringing too much overhead costs.

1.4 Empirical Study

A study suggested a network called “Auto Diagnostic Medical Analysis” trying to find infectious areas to help the doctor better identify the diseased part, if any. Both X-ray and CT images were used in the study. It has been recommended DenseNet network to remove and mark infected areas of the lung.In the study of Chen et al, they proposed Residual Attention U-Net for automated multi class segmentation technique to prepare the ground for the quantitative diagnosis of lung infection on COVID-19 related pneumonia using CT images.Khan et al. classified the chest X-ray images from normal, bacterial and viral pneumonia cases using the Xception architecture to detect COVID-19 infection.

1.5 Brief Description of the Solution Approach

In our approach, we’re using deep learning algorithms to detect Covid-19 using X-ray images and feeding using augmented dataset to bring fast and accurate results, in our approach, we’re using multiple layers of algorithms to provide accurate results, so it takes the best from all rather than be biased towards one approach.

Moreover, we have built a simple UI interface for end users to quickly interact with our model at no cost.

1.6 Comparison of existing approaches to the problem framed

In the manual testing, test samples can be obtained by various methods, including a nasopharyngeal swab, sputum (coughed up material), throat swabs, deep airway material collected via suction catheter or saliva, but there were many cases of false results, some patients showed negative results while their chest imaging shows positive covid results.

In case of existing Xray and CT scans imaging, manual diagnostics is slow and expensive due to the limited number of radiologists, and even using existing machine learning algorithms due to less number of dataset the results were not accurate at all.

CHAPTER 2: LITERATURE SURVEY

Title: Improving the performance of CNN to predict the likelihood of COVID-19 using chest X-ray images with preprocessing algorithms[24]

Author: Morteza Heidari, Seyedeh Nafiseh Mirniaharikandehei, Abolfazl Zargari Zargari, Gopichand Danala, Yuchen Qiu and Bin Zheng

Identification :-

This paper discusses and aims to develop and test a computer-aided diagnosis (CAD) scheme of chest x-ray images to detect covid-19. The model presented uses data preprocessing to generate input of a CNN model.

Steps involved:-

- Original Image
- Diaphragm Removed
- Image Applied Histogram Equalization
- Bilateral Filtering Applied.

These above images are fed into 3 channels of the CNN model to stimulate RGB image. The model used transfer learning techniques. VGG-16 which was pre-trained on the Imagenet Large Scale Visual Recognition Challenge using a large dataset with 14 million images.

- The overall accuracy achieved is 94.5%.
- Removing irrelevant region, normalizing image contrast-to-noise ratio.

Title: COVID-Net: a tailored deep convolutional neural network design for detection of COVID-19 cases from chest X-ray images[21]

Author: Linda Wang, Zhong Qui Lin, Alexander Wong

Identification :-

A deep learning Convolutional Neural Network based model named as COVID-Net which is one of the first open source network designs for COVID-19 detection from CXR images. The implementation has also generated an open access benchmark dataset consisting of 13,975 CXR images, which they call a large number of publicly available COVID-19 dataset. COVID-Net network architecture features are-

- COVID-19 sensitivity>=80%
- COVID-19 positive predictive value(PPV)>=80%

The model COVID-Net described above has the accuracy of 93.3%. Their future work is based on improving sensitivity and PPV to COVID-19 and propose a model to detect risk status and survival analysis.

Title: CoroDet: A deep learning based classification for COVID-19 detection using chest X-ray images[23]
Author: Emtiaz Hussain, Mahmudul Hasan, Md Anisur Rahman, Ickjai Lee, Tasmi Tamanna, Mohammad Zavid Parveza.

<u>Identification :-</u>

This study basically focuses on the latest data mining and machine learning techniques to overcome the shortage of testing kits. The current technique RT-PCR has a low sensitivity of 60%–70%, and it is also a time-consuming method The model CoroDet is applied on X-Ray and CT-Scan images of lungs for automated detection of COVID-19. Features of CoroDet are-

- The model consists of 22 layers of CNN.
- CoroDet is developed to find accurate results for 2 class classification (COVID and Normal), 3 class classification(COVID, Normal and pneumonia) and 4 class classification(COVID, Normal, viral pneumonia, and bacterial pneumonia).
- The classification accuracy of the above different class models are 99.1%, 94.2%, and 91.2%.

The accuracy of the proposed CoroDet method is higher than the state-of-the-art method for COVID detection.

Title: Viral Pneumonia Screening on Chest X-rays Using Confidence-Aware Anomaly Detection[2]
Author: Jianpeng Zhang, Yutong Xie, Guansong Pang, Zhibin Liao, Johan Verjans, Wenxing Li, Zongji Sun, Jian He, Yi Li, Chunhua Shen, and Yong Xia

<u>Identification :-</u>

The formulation of differentiating viral pneumonia from non-viral pneumonia and healthy controls. Moreover, when this model was directly tested on the X-Covid dataset that contains 106 COVID-19 cases and 107 normal cases and without fine-tuning this model achieves an AUC of 83.61% and sensitivity of 71.70%. The proposed CAAD model is composed of an anomaly detection network and a confidence prediction network. Both networks share a feature extractor. Given an input, the anomaly detection network aims to learn an anomaly scoring function ($\boldsymbol{\mathcal{V}} = \boldsymbol{Q}$(X;θ,ɒ)), where, ɒ is the trainable parameter of the anomaly detection module.

To evaluate the effectiveness of confidence prediction, we compared the anomaly detection network with the CAAD model, in which the confidence threshold Tconf ranges from 0.5 to 0.95.
The gradient-weighted class activation mapping is used to see which region plays an important role during inference.
Drawback of having false positive rate and high false negative rate.

Title: Deep Learning in Medical Image Analysis[1]
Author: Dinggang Shen,Guorong Wu,Heung-Il Suk

Identification:-
The computer based analysis for better interpreting images have been in the medical imaging field. In the view of the image interpretation, recent advancement in the field of machine learning and especially deep learning has a support hand to identify and classify patterns in medical images. The hierarchical feature representations from the info , rather than handcrafted features mostly designed supported domain-specific knowledge, lies at the core of the advances.
Deep Learning has proved to be the state-of-the-art in the field of image analysis in the terms of advancement of medical advancement. The decade has witnessed the importance of medical imaging e.g. computed tomography (CT), resonance (MR), positron emission tomography (PET), mammography, ultrasound, X-ray, and so on, for the first detection, diagnosis, and treatment of diseases. In real life the analysis of the medical images are done by the experts specially radiologists and physicians.
This paper has given overview of various deep learning techniques by giving explanation of DEEP MODELS like:

- Feed-forward neural networks, Deep Models.
- Unsupervised feature representation learning-Stacked Auto-Encoder, Deep Belief Network, Deep Boltzmann Machine.
- Fine-tuning deep models for target tasks.
- Convolutional neural networks.
- Reducing overfitting.

The explanation gives a great overview how deep learning has advantage. It attracts researchers to work on this field of improving medical imaging to investigate CT, MRI, PET, and X-Ray, etc. The introduction about how deep learning can help in medical imaging for localization, cell structures detection, tissue segmentation, computer aided detection and diagnosis/prognosis.

- Completely explains the impact that computational modeling has on clinical applications and scientific research.

- After explaining the deep learning techniques to work on gives a great idea behind the state-of-the-art in the field of image analysis.
- It does not explain the working of all the techniques or models to interpret the model intuitively.

Title: Finding COVID-19 from Chest X-rays using Deep Learning on a Small Dataset

Author: Lawrence O. Hall, Rahul Paul, Dmitry B. Goldgof, and Gregory M. Goldg

<u>Identification</u>

This paper describes the current testing technique by explaining that the tests require a significant amount of time to produce results with a 30% of false positive rates. COVID-19 has been an issue for everyone and affected each and every sector. The biggest problem is that testing demands testing tools and kits which are unable to match with the demand. X-Ray machines are widely available and provide images for diagnosis quickly. X-Ray tests can be performed without increased risk, unlike laboratory tests that involve probing the patient's respiratory system. This paper explains the usefulness of X-Ray images for the diagnosis.

Details of the dataset used:-

1. 135 chest X-Ray of COVID-19.
2. 320 chest X-Ray of viral and bacterial pneumonia.

A pre-trained deep convolutional neural network, Resnet50 was trained on 102 COVID-19 and 102 pneumonia samples in 10-fold cross validation. The model has an overall accuracy of 89.2% with a COVID-19 true positive rate of .8039 and an AUC of 0.95.

An ensemble of the three types of CNN classifiers(Resnet50, VGG and other CNN models) was applied to a test set of 33 unseen COVID-19 and 218 pneumonia cases. The overall accuracy was 91.24% with the true positive rate for COVID-19 of 0.7879 with 6.88% false positives for a true negative rate of 0.9312 and AUC of 0.94. In this model the last layer has been removed and replaced by a trainable part which consists of global average pooling followed by a fully connected layer of 64 units with dropout and finally a classification layer with sigmoid function.

- This paper provides the information of the models used and other hybrid models.
- It also has a comparative study about the CT scan and X-Ray images findings.
- Proper explanation of how the false positive rate can be decreased is also mentioned.
- 6% of false positive rate which is not feasible to make the model for real time use.
- Dataset size is small which is the biggest disadvantage the model faced while training.

Title: Convolutional neural networks for multi-class brain disease detection using MRI images[3]

Author: Muhammed Talo, Ozal Yildirima,Ulas Baran Baloglub, Galip Aydinc, U Rajendra Acharya

Identification:-

This paper is based on the classification of brain diseases using MRI images. It is difficult for the manual diagnosis of the brain abnormalities as it is difficult to observe the minute changes in the MRI images in the early stages. The challenging task is to select the features and classifiers to obtain the high performance. Hence, deep learning models have been widely used for medical image analysis over the past few years.

The work proposed is related to employing many pre-trained models like AlexNet, Vgg-16, ResNet-18, ResNet-34 and ResNet-50 to classify MRI images into normal, cerebrovascular, neoplastic, degenerative, and inflammatory diseases classes.

Here again the state-of-the-art is described as deep learning transfer learning models. Among all the above five models ResNet50 wins with the accuracy of 95.23% ± 0.6. They confirm that their model is ready to be tested with real time MRI images to detect abnormalities.

The main problem has been highlighted here about the availability of the labelled data. Previous studies in the literature had to deal with feature extraction, and this arises performance and accuracy drawback for the developed hybrid solutions. Both the above problems can be solved by using pre-trained models as they already know how to classify the data fed.

Their contribution is that being the first study which involves five brain classes: degenerative disease, inflammatory disease, cerebrovascular disease, neoplastic disease, and normal class and they almost doubled the number of images used(1074 images).

They used 2 major steps to train the model with MRI images:

1. They have only trained the attached few layers of the models for 15 epochs and set the learning rate hyper-parameter to the value of 1e-3.They fine-tune both convolutional base and fully connected layers by unfreezing all layers.
2. Fine-tuning term is used to unfreeze all the layers of pre-trained models. In other words, initially, only the attached layers of pre-trained models are trained for 15 epochs, then the whole network is unfreezed to re-train all layers.

The model presented in the paper has an accuracy of 95.23% ± 0.6 with MRI images.

The model is classifying into normal, cerebrovascular, neoplastic, degenerative, and inflammatory diseases classes with such great accuracy.

The main problem is the lack of availability of labelled data.

Title: COVID-19 detection from chest X-Ray images using Deep Learning and Convolutional Neural Networks[4]

Author: Antonios Makris**,** Ioannis Kontopoulos, Konstantinos Tserpes

Identification

This paper tells about the state-of-the-art that pre-trained convolutional neural networks were evaluated as of their ability to detect infected patients from chest X-Ray images. due to the tiny number of samples, they used transfer learning, which transfers knowledge extracted by pre-trained models to the models to the model to be trained. A dataset consisting of 336 X-Ray images was created by mixing available X-ray images from patients with confirmed COVID-19 disease, common bacterial pneumonia and healthy individuals. The experimental results demonstrate that the classification performance can reach an accuracy of 95% for the simplest two models.

The proposed model during this paper incorporates an outsized number of CNN architectures in an effort to not only distinguish X-Rays between COVID-19 patients and other people without the disease, but also find the pneumonia patients. The model is totally a classifier for respiratory diseases.

A brief description about Deep learning approaches for COVID-19 detection supported image classification is introduced. The proposed CNN model is predicated on pre-trained transfer models (ResNet50, InceptionV3 and Inception-ResNetV2). In terms of getting high accuracy from the tiny dataset sample of X-ray images a transfer learning technique is applied by employing the ImageNet dataset. The result after training and testing was that ResNet50 was found to be superior.

The ResNet18 pre-trained ImageNet network is used and the results showed an accuracy of 95.12% on CXR images. A deep convolutional neural network called COVID-Net showed a high sensitivity (87.1%) and a precision of 96.4% for COVID-19 cases.

The results demonstrated a robust correlation between estimated uncertainty in prediction and classification accuracy, thus enabling false predictions identification. Finally, after the evaluation of the performance of 5 pre-trained CNN networks regarding the detection of COVID-19 from CXR. The results showed that VGG19 and MobileNetv2 achieved the higher accuracy, 93.48% and 92.85% respectively.

- The experimental results demonstrate that the classification performance can reach an accuracy of 95% for the simplest two models.
- The results showed that VGG19 and MobileNetv2 achieved the higher accuracy, 93.48% and 92.85% respectively.

Title: Detection of coronavirus Disease (COVID-19) based on Deep Features[5]

Author: Prabira Kumar Sethy, Santi Kumari Behera

Identification:-

This research paper states the implementation of SVM classifier. The suggested classification model, i.e. resnet50 plus SVM achieved accuracy, FPR, F1 score, MCC and Kappa are 95.38%,95.52%, 91.41% and 90.76% respectively for detecting COVID-19 (ignoring SARS, MERS and ARDS). It also states that the model is superior compared to other classification models. The dataset is collected from various resources like Github, Kaggle and Open-i in the form of X-Ray images. The model is based on deep CNNs for the identification of COVID-19 as a classification task.

They prepared two dataset first 25 X-Ray COVID-19 images from Github and Kaggle and the second contains 133 X-Ray images from Open-i. These two dataset are examined separately and the features were extracted based on deep learning architectures such as AlexNet, VGG16, VGG19, GoogleNet, ResNet18, ResNet50, ResNet101, InceptionV3, InceptionResNetV2, DenseNet201 and XceptionNet. The deep features obtained are classified by SVM.

The deep features are extracted from fully connected layers and fed to the classifier for training purposes. The deep features obtained from each CNN network are used by SVM classifiers.

Discussing the results ResNet50 with SVM gives the highest accuracy of 95.38% and in terms of F1 Score, MCC and Kappa, again stands apart from others. Hence, resnet50 and SVM result in better classification for detection of COVID-19 with accuracy, FPR, F1 score, MCC and Kappa are 95.38%,95.52%, 91.41% and 90.76% respectively.

- ResNet50 with SVM gives the highest accuracy of 95.38%.
- Other characteristics that show great results such as FPR, F1 score, MCC and Kappa are 95.38%,95.52%, 91.41% and 90.76% respectively.
- The models are suffering from a small size dataset.

Title: CovidAID: COVID-19 Detection Using Chest X-Ray[12]

Author: Krithika Rangarajan, Vinay P. Namboodiri, Chetan Arora

Identification:-

As the number of cases is rapidly increasing day by day and with the limited testing kit for diagnosis, it is impossible for every patient with respiratory illness to be tested using conventional techniques, as conventional techniques take more time for diagnosis it is difficult to give faster results. In this work, we proposed the use of chest X-Ray to detect COVID-19 infection as this will help quarantine high-risk patients which have COVID-19 infection detected in their chest X-Ray as X-Ray machines are easily accessible in many hospitals. We can prioritize the selection of patients by the use of chest X-Ray to decide whether to keep the patient in the ward along with other patients or isolate them in COVID-19 areas.CheXNet is a 121-layer DenseNet based model trained on the Chest X-ray14 dataset comprising of 112,120 frontal-view chest X-Ray images which can classify into the following classes: Normal, Bacterial Pneumonia, Viral Pneumonia and COVID-19. Our model is trained in two divisions, the one which classifies into the above four classes, and the other configuration with three classes (clubbing viral and bacterial pneumonia into one).Our model gives 90.5% accuracy with covid-chestxray-dataset.

- X-ray imaging is much more widespread and cost effective than conventional diagnostic tests.

Title: Classification of COVID-19 in chest X-ray images using DeTraC deep convolutional neural network[15]

Author: Asmaa Abbas, Mohammed M. Abdelsamea, MohamedMedhat Gaber

Identification

Chest X-ray is the first imaging technique that plays an important role within the diagnosis of COVID-19 disease. CNN architecture is one of the only deep learning approaches as its ability to seek out out features automatically from domain-specific images. to train CNN architecture the favored strategy is transfer learned knowledge from a pre-trained network. Three major scenarios to accomplish Transfer Learning-

- shallow tuning
- deep tuning
- fine-tuning

This paper uses Decompose, Transfer, and Compose (DeTraC), for the classification of COVID-19 chest X-ray images. The DeTraC model consists of three phases. To extract deep local features from each image we train the pre-trained CNN model of DeTraC.For simplification of local structure we apply the class-decomposition layer of DeTraC.We use a category composition layer to refine the last word classification of the photographs. The dataset used consists of 80 samples of normal CXR images.CXR images which contain 105 and 11 samples of COVID-19 and SARS.

High accuracy of 93.1% (with a sensitivity of 100%) was achieved by DeTraC within the detection of COVID-19 X-ray imagesDeTraC can affect any irregularities within the image dataset by investigating its class boundaries using a class decomposition mechanism.Validating the method with larger datasets isn't possible.

Title: Unveiling COVID-19 from Chest X-ray with deep learning: a hurdles race with small data[11]

Author: Enzo Tartaglione, Carlo Alberto Barbano, Claudio Berzovini, Marco Calandri, and Marco Grangetto.

Identification

In this work, possible obstacles have been highlighted in successfully training a deep model, ranging from the proper choice of the architecture to-be-trained to handling removable biases in medical datasets. The model consists of certain phases. First pre-processing of chest images and lung segmentation will help in removing any bias present in the data. Deep models will be Pre-trained on the feature extractor.

Extensive experiments show that extracting a “COVID” feature from CXR isn't a simple task. Such a problem should be addressed very carefully: it's very easy to misinterpret excellent results on test-data, still showing poor generalization on new data within the same domain. Such a test can be performed thanks to the possibility of using CORDA, a larger dataset comprising COVID cases. Of course, the quantity of available data is still limited but allowed us to find some promising seminal classification results. The ongoing collection and sharing of an outsized amount of CXR data is the only way to further investigate if promising CNN results can aid within the fight to COVID pandemic.

- The only way introduced in the paper is through CXR with CNN.

Title: A Critic Evaluation of Methods for COVID-19 Automatic Detection from X-Ray Images[13]

Author: Gianluca Maguolo , Loris Nanni

Identification

In this research paper two experiments were conducted in both cases our training and test sets consist in combinations of the four datasets - NIH dataset, CHE dataset, KAG dataset, COV dataset. In this paper,different testing protocols used for automatic COVID-19 diagnosis are compared and evaluated from X-Ray images in the recent literature. Which shows that similar results can be obtained using X-Ray images that do not contain most of the lungs. The lungs are removed from the pictures by turning to black the middle of the X-Ray scan and training our classifiers only on the outer part of the pictures.

Dataset used:

- NIH dataset
- CHE dataset
- COV dataset

Hence, it is deduced that several testing protocols for the recognition are not fair and that the neural networks are learning patterns in the dataset that are not correlated to the presence of COVID-19. The validity of the usual testing protocols is discussed in this paper as most papers dealing with the automatic diagnosis of COVID-19. This paper showed that these protocols might be biased and learn to predict features that depend more on the source dataset than they do on the relevant medical information..

Title: COVID-19 detection from chest X-ray images using CNNs models: Further evidence from Deep Transfer Learning[14]

Author: Mohamed Samir Boudrioua

Identification

The paper describes reducing COVID-19 spread around the world by bringing early diagnosis of the novel coronavirus can be really helpful with the help of detection of COVID-19 infection from chest X-ray images using Deep Learning. Details of the dataset used:

Split	COVID-19	Healthy	Pneumonia
Training set	247	799	1598
Testing set	62	201	402

Due to the small dataset it is tough to train CNN models from scratch, so they've proposed a deep transfer method in this study as it can extract features learned on one problem and can use them on a new one. To make the model ideal for feature extraction, they have not included the classification layers at the top and create a new classifier and add it at top of the model. At last before training they froze the convolutional base.

Title: Comparative study on the clinical features of the coronavirus 2019 pneumonia with other pneumonia[6]

Author: Dahai Zhao, Feifei Yao, Lijie Wang, Ling Zheng, Yongjun Gao, Jun Ye, Feng Guo, Hui Zhao, Rongbao Gao

<u>Identification</u>

This paper provided a study between covid-19 pneumonia and non-covid-19 pneumonia patients, All patients had a history of exposure to COVID-19 patients or travelled back from Hubei before their illness. Similar symptoms were presented by both groups of patients including fever and cough, these symptoms are also common in other acute respiratory infections, such as influenza, respiratory syncytial virus, and other respiratory viruses as well.

Most COVID-19 patients but non-COVID-19 patients had bilateral pneumonia with the feature of multiple mottling and ground-glass opacity on CT images. This result suggests that COVID-19 infection has similar features with many other respiratory virus infections, triggered a strong innate inflammatory immune response, and caused depletion of lymphocytes after infection. The ratio of the mean of neutrophils was more in COVID-19 than in non-COVID-19 patients, although there was no statistical difference between them. Previous studies show that high neutrophils contribute to acute lung damage, and are associated with severe disease in patients with influenza infection. Previous reports showed that a proportion of COVID-19 patients had differing degrees of liver function abnormality. The results suggested that patients with COVID-19 may have multiple tissue or organ damage besides a liver injury.

- Patients with Covid-19 patients showed similar abnormalities in other acute respiratory infections.
- Although they slighter higher neutrophils which contributed to other severe diseases in patients with other influenza diseases.
- The limitations of this research was lack of data.
- Some laboratory tests were not conducted in some patients because the COVID-19 patients were from 2 hospitals.
- There was a lack of severe infection to compare findings with severe infection with mild infection
- There was a lack of a pediatric population.

Title: Efficient Pneumonia Detection in Chest X Ray Images Using Deep Transfer Learning[7]

Author: Mohammad Farukh Hashm, Satyarth Katiyar ,Avinash G Keskar 3 ,Neeraj Dhanraj BokdeandZong Woo Geem

Identification

This paper described how CT scans can be utilised to diagnose Covid-19 in early stages, the paper also describes the best comparative study between multiple implementations. As the dataset was very less so using data augmentation techniques, a larger dataset was created. The chest x-ray images were passed through the process of scan line optimization such that it eliminates all the other body parts.

Multiple existing models are taken into consideration including Dense CNN, GoogleNet121, ResNet etc.

Following architecture was discussed:

- **Transfer learning:** In transfer learning, a model that is trained for a particular task is employed as the starting point for solving another problem.
- **Data Augmentation:** Duplicating dataset to make sure the model doesn't overfit.
- **Fine tuning the architecture:** SGD(Stochastic Gradient Optimizer) was used to provide better generalisation and models were trained for 25 epochs.
- On multiple implementations, it was turned that all models had 99% or more accuracy and 0.03% except the Xception model.
- DenseNet121 turned out to be best among, but using a single model wasn't able to solve the problem completely.
- A weighted matrix was used with multiple models, resulting in each model contributing to 97% accuracy with 0.087% loss.
- Weighted matrix results outweighed others in confusion matrix.
- Following analysis shows that using a deep learning model can provide faster diagnosis.

Title: A Deep Learning System to Screen Novel Coronavirus Disease 2019 Pneumonia[8]

Author: Xiaowei, XiangaoJiang, ChunlianMa,PengDu, XukunLi, ShuangzhiLv, LiangYuaQinNi, YanfeiChen, JunweiSu, GuanjingLang, YongtaoLi, HongZhao, JunLiu, KaijinXu, LingxiangRuan, JifangSheng, YunqingQiu, LanjuanLi

Identification

This paper described Covid-19 detection from pneumonia using CT scans. CT scans were routinely performed on every patient with fever and respiratory symptoms in the early stage and was repeated for dynamic observation since it was cheap and easy to operate. Using CT images to screen patients can improve the early detection of COVID-19, and ease the pressure on laboratory nucleic acid testing.

The CT imaging of COVID-19 presents several distinct features, according to past studies. These features include focal ground-glass shadows mainly distributed along the pleura, multiple consolidation shadows accompanied by the "halo sign" of the surrounding ground-glass shadow, multiple consolidations of different sizes, and grid-shaped high-density shadows.In this study, deep learning technology was used to design a classification network for distinguishing COVID-19 from IAVP. In terms of the network structure, the classical ResNet was used for feature extraction. A comparison was made between models with and without an added location-attention mechanism. The experiment showed that the aforementioned mechanism could better distinguish COVID-19 cases from others. Furthermore, multiple enhancement methods were involved in our studies, such as image patch vote and Noisy-OR Bayesian function, in order to determine the dominating infection types. Models with a location-attention mechanism can classify COVID-19, IAVP, and healthy cases with an overall accuracy rate of 86.7%, and would be a promising supplementary diagnostic method for frontline clinical doctors.

- Covid-19 infected patients showed various abnormalities in lungs including ground glass opacities or mixed ground glass opacities.
- ResNet120 + SVM showed better accuracy than other models.
- The following implementations had some weakness, which includes that it doesn't work properly in blurry images or images where patients had other infectious diseases as well.
- The overall accuracy turned out to be 86.7% for CT scans.

Title: COVIDX-Net: A Framework of Deep Learning Classifiers to Diagnose COVID-19 in X-Ray Images[9]

Author: Ezz El-Din Hemdan1 , Marwa A. Shouman1 , and Mohamed Esmail Karar 2,3 , IEEE, Member

Identification:-

This paper discusses the disadvantages of using CT scans to detect Covid-19 in patients and how X-ray images can be utilised to detect Covid-19 in real time.

The main disadvantage of using CT scans is the higher risk of ionization and cost. But X-ray images cannot easily distinguish soft tissue with a poor contrast to limit the exposure dose to the patients.

To overcome these limitations, Computer-Aided Diagnosis systems have been developed to assist physicians to automatically detect and quantify suspected diseases of vital organs in X-ray images and in recent years.

The paper aims to develop a new framework COVIDX-Net which utilises multiple existing implementations to provide a generalised solution for detecting the virus.

The proposed framework includes three main steps to accomplish the requirements:

- **Preprocessing** : All X-ray images have been collected in one dataset and loaded for scaling at a fixed size of 224 X 224 pixels to be suitable for further processing within the deep learning pipeline.
- **Training model and validation** : In order to start the training phase of selected and/or tuned one of seven deep learning models, the preprocessed dataset is 80-20 split according to the Pareto principle.
- **Classification** : In the final step of the proposed framework, the testing data is fed to the tuned deep learning classifier to categorize all the image patches into one of two cases: confirmed positive COVID-19 or normal case (negative COVID-19).

Using X-ray images is more feasible than CT scans. Most existing models fail when it comes to detecting normal cases properly.The highest precision of deep learning classifier to detect only positive COVID-19 was achieved by ResNetV2, InceptionResNetV2, Xception, and MobileNetV2, but their corresponding performances were worst to classify the normal cases correctly.

VGG19 and DenseNet201 models to be applied for in the CAD systems to identify the health status of patients against the COVID-19 in X-ray images.

Title: Imaging Profile of the COVID-19 Infection: Radiologic Findings and Literature Review[10]

Authors: Ming-Yen Ng, Elaine YP Lee, Jin Yang, Fangfang Yang, Xia Li, Hongxia Wang, Macy Mei-sze Lui, Christine Shing-Yen Lo, Barry Leung, Pek-Lan Khong, Christopher Kim-Ming Hui, Kwok-yung Yuen, Michael David Kuo

Identification

This paper describes various findings in covid-19 patients from Shenzhen and Hong Kong.

All patients had at least one chest CT performed, while four patients also had follow-up CT. Five patients had chest radiographs (CXR), three of which had CXR on a daily basis. Two patients had six CXR and one patient had ten follow-up CXR.

These tests had limitations, as the number of patients were very less and analysing was time taking.

All tests were taken into consideration and following results were analysed:

- They found out that the most common findings on chest CT were bilateral ground-glass opacities with or without consolidation in the lung periphery.
- Pleural effusions and lymphadenopathy were absent in all patients.
- They found out many similarities with SARS, Both pathogens demonstrate predominantly ground-glass opacities.

In Chest Radiograph scans, they found out of fiive patients had CXR along with CT thorax examinations that:

- Two patients showed normal CXR findings, despite also having CT examinations performed on the same day showing ground glass opacities.
- The other three CXR examinations showed consolidation.
- One CXR showed lower zone predominance, whilst the other two CXR examinations did not show any zonal predominance.

Title: Deep-COVID: Predicting COVID-19 from chest X-ray images using deep transfer learning[18]

Authors: Shervin Minaeea, Rahele Kafiehb, Milan Sonkac, Shakib Yazdani d, Ghazaleh Jamalipour Soufie

Identification

Since December 2019, a novel corona-virus (SARS-CoV-2) has spread from Wuhan to the whole China, and many other countries.Asymmetric patchy or diffuse airspace opacities are reported for COVID-19 (Rodrigues, 2020).Such subtle abnormalities can only be interpreted by expert radiologists.Considering huge rate of suspected people and limited number of trained radiologists, automatic methods for identification of such subtle abnormalities can assist the diagnosis procedure and increase the rate of early diagnosis with high accuracy.

Artificial intelligence (AI)/machine learning solutions are potentially powerful tools for solving such problems. We fine-tuned each model for 100 epochs. The batch size is set to 20, and ADAM optimizer is used to optimize the loss function, with a learning rate of 0.0001. All images are downsampled to 224 × 224 before being fed to the neural network. We reported a deep learning framework for COVID-19 detection from Chest X-ray images, by fine-tuning four pre-trained convolutional models (ResNet18, ResNet50, SqueezeNet, and DenseNet121) on our training set. Due to the limited number of COVID-19 images publicly available so far, further experiments are needed on a larger set of cleanly labeled COVID-19 images for a more reliable estimation of the accuracy of these models.

Title: Coronavirus disease (COVID-19) detection in Chest X-Ray images using majority voting based classifier ensemble[17]
Authors: Tej Bahadur Chandra, Kesari Verma, Bikesh Kumar Singh, et al.

<u>Identification</u>

As per the expert's opinion, the virus mainly infects the human tract resulting in severe bronchopneumonia with symptoms of fever, dyspnea, dry cough, fatigue, and respiratory failure, etc. The limited availability of test-kits and domain experts within the hospitals and rapid increase within the number of infected patients necessitates an automatic screening system. They have aggregated a dataset from three public repositories – COVID-Chestxray set, Montgomery set, and NIH ChestX-ray14 set. All input images are preprocessed, which incorporates image resizing (512 × 512 pixels), format conversion (Portable Network Graphics), and colour space conversion (Gray Scale). The augmented images alongside the first CXR images were wont to re-train the models and classification performance was evaluated.

From the obtained results shown in, it had been observed that the supervised models trained using augmented images performed signifi-cantly better compared to the models trained using original CXR images for both the phases

The obtained promising performance using augmented images are often justified by the very fact that the augmented images provide sufficient instances to coach the model for possible variations in input CXR images, which could occur thanks to diverse imaging parameters and platforms in several hospitals.

Title: Automatic Detection of Coronavirus Disease (COVID-19) Using X-ray Images and Deep Convolutional Neural Networks[16]

Authors: Ali Narin, Ceren Kaya, Ziynet Pamuk, et al.

Identification

The virus that causes COVID-19 infectious disease is named severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2). Deaths from pneumonia developing thanks to the SARS-CoV-2 virus are increasing day by day. .We performed 3-different binary classifications with 4 different classes (COVID-19, normal, viral infection and bacterial pneumonia). 5-fold cross-validation method has been utilized in order to urge a strong end in this study performed with 5-different pre-trained models that are InceptionV3, ResNet50, ResNet101, ResNet152 and Inception-ResNetV2.While 80% of the info is reserved for training, the remaining 20% is reserved for testing.

The use of artificial intelligence-based systems is extremely common in detecting those caught within the COVID-19 epidemic.They have achieved 95.7% accuracy with the approach without pre-training and 98.3% accuracy with pre-trained COVID-CAPS.Furthermore they proposed a deep transfer learning-based approach using Chest X-ray images obtained from normal, COVID-19, bacterial and viral infection patients to predict COVID-19 patients automatically. The classification performance of various CNN models are often tested by increasing the amount of COVID-19 Chest X-ray images within the dataset

In a future study, studies are going to be conducted to work out the demographic characteristics of patients and COVID-19 possibilities with artificial intelligence-based systems.

Title: CVDNet: A novel deep learning architecture for detection of coronavirus (Covid-19) from chest x-ray images[19]

Authors: Chaimae Ouchicha, Ouafae Ammor, Mohammed Meknassi

Identification

The following paper describes the dataset used in the study and detailed distribution of the images to train, test and validate. Moving on, they propose their model CVDNet to classify patients and healthy persons using chest X-ray images. They've used a dataset from Kaggle's COVID-19 Radiography Database which is an aggregated dataset of patients infected with COVID-19, chest x-ray images of cases with viral pneumonia and Chest x-ray images of healthy parsons (Normal).

They performed experiments to assess the performance of the proposed CVDNet, which is trained to classify chest x-ray images. Four out of five sets were used to train and validate our model whereas the remaining set was employed for the test (i.e. 70% of chest X-ray images are used for training, 10% for validation and 20% for testing).All experiments were implemented in Tensorflow and the proposed CVDNet was trained for 20 epochs with a batch size of 8.

They also proposed a novel deep convolutional neural network (CVDNet) model for the detection of COVID-19 cases, in order to distinguish more precisely the patients affected by COVID19 from healthy persons and viral pneumonia patients using chest X-ray images.It was observed that CVDNet achieved an average accuracy of 97.20% for detecting COVID-19 and an average accuracy of 96.69% for three-class classification (COVID-19 vs normal vs viral pneumonia), which exhibit superior and promising performance in classifying COVID-19 cases.

Title: A new approach for classifying coronavirus COVID-19 based on its manifestation on chest X-rays using texture features and neural networks[20]
Authors: Sergio Varela-Santos, Patricia Melin

Identification
The paper describes how X-ray imaging plays a vital role when it comes to diagnosis of any disease.
Medical Imaging is a tool for disease diagnosis and detection, and AI based medical diagnosis tools have recently been put forward for the task of automatic diagnosis and abnormality localization.
The paper also discusses the utilisation of public data repositories which consists of 7 types of lung images related to Covid-19.
The paper furthermore discusses various data repositories from known sources and puts up analytics from it. They also discuss each phase of analysis in detail.
The first method corresponds to flattening all the images in a unidimensional vector and using the vector as input values to a feed-forward 4-layer shallow neural network.
The obtained results look promising for achieving in the near future the automated chest X-rays and computerized tomography analysis for COVID-19 diagnosis.This experimentation can be further improved by adding more balanced classes, which are translated to more states or diseases that can appear in the lungs in X-rays and CT scans.

Title: Convolutional capsnet: A novel artificial neural network approach to detect COVID-19 disease from X-ray images using capsule networks[25]

Authors: Suat Toramana Talha Burak Alakus Ibrahim Turkoglu

Identification

Pneumonia is an infection that causes inflammation in the lungs, and besides the covid-19 virus, bacteria, fungi, and other viruses often play a role in causing this disease

The high resolution images require a powerful system to analyze the images with the original size by using capsule networks.

They described the need of larger datasets in order to analyse the performance of the proposed model. The results showed that capsule networks can effectively classify even in a less amount dataset. Since the datasets consist of images from different sources, all images were first resized into the same size.

The final accuracy of 91.2%, and 97.2% for binary class problems without data augmented and with data augmented, respectively. Capsule networks are planned to be trained with larger datasets to achieve the level of success that can assist medical staff in the diagnosis of the virus.

Title: COVID-19 Prediction and Detection Using Deep Learning[29]

Authors: Moutaz Alazab, Albara Awajan1 , Abdelwadood Mesleh , Ajith Abraham, Vansh Jatana , Salah Alhyari

Identification

This paper describes the process of covid-19 detection X-ray images and how it can further be modified to forecast new Covid-19 confirmations, recoveries and deaths, The standard diagnostic technique is the reverse transcription polymerase chain reaction method but it's not accurate enough.CTscans and Xrays show better results but due to the limited number of radiologists they cannot be substituted completely, hence AI can be used to pace up their procedure speed.Almost all covid-19 patients exhibited similar features including ground-glass opacities in the early stages and pulmonary consolidation in the later stage.

The paper also describes the other related works for example

- Narin et al, proposed CNN based models to detect covid-19 patients using 100 chest X-ray images with 50% of infected and 50% of healthy ones, they evaluated three CNN models- ResNet-50, Inception-v3 and Inception-ResNet-v2—using five-fold cross-validation a reported that ResNet-50 had the best detection accuracy (98%).

Even other implementations were able to reach 96% accuracy. The main disadvantage with CT scan is that it is expensive, compared to X-rayFor covid-19 forecasting, they researched multiple algorithms(PA, ARIMA and LSTM) to predict confirmation, recoveries and death due to Covid-19 over the next 7 days, and PA delivered the best performance.For diagnosis, the model using VGG16 was proposed due to rapid and reliable detection enabling it to achieve 99% accuracy.

Title: A deep learning approach to detect Covid-19 coronavirus with X-Ray images[28]

Authors: Govardhan Jain, Deepti Mittal , Daksh Thakur, Madhup K.Mittal

Identification

In the following paper, challenges and deep learning approaches to detect Covid-19 were discussed.The proposed method is implemented in four phases viz, data augmentation, preprocessing, stage-1 and stage-2 deep network model designing.They discussed challenges faced, the similarity between pneumonia and covid makes it harder to classify between pneumonia and covid patients. The other issue was lack of dataset, which prevented implementation to bring better and accurate results.

They proposed a two-stage model where the first model uses ResNet-50 shows 93.01% for differentiating healthy and bacteria-induced pneumonia people. Later on, they moved on to building a second stage model with an accuracy of 97.22%. The last implementation utilises deep learning techniques which can distinguish between Covid-19 patients and healthy patients.

Title: Automated Deep Transfer Learning-Based Approach for Detection of COVID-19 Infection in Chest X-rays[27]

Authors: lN.Narayan, DasaN.Kumar, M.Kaur, V.Kumar, D.Singh

Identification

In the following paper, the authors describe the lesser sensitivity of RT-PCR with overhead of time consumptions.

The paper compares between X-ray and CT scans, X-rays takes more advantages than CT-scans which includes:

- Faster results
- Lesser ionisation than CT-scans.

- More availability
- Cost friendly.

But manual testing is very time consuming so to tackle this, the paper proposes the need for automatic testing using deep learning-based approaches. Such approaches can train over the weights of networks on large datasets as well fine tuned in smaller datasets. In this paper, deep transfer learning methods have been discussed and performances were analysed on the basis of f-measures, sensitivity, specificity and kappa statistics.

Moreover, it discusses that in the near future various initial parameters can be tuned by various approaches to provide better results.

Title: Extracting Possibly Representative COVID-19 Biomarkers from X-ray Images with Deep Learning Approach and Image Data Related to Pulmonary Diseases[16]

Author: Ioannis D. Apostolopoulos, Sokratis I. Aznaouridis & Mpesiana A. Tzani

<u>Identification</u>

The paper describes finding low-cost, rapid and automatic detection of Covid-19. It was demonstrated that the various infections may be distinguished by a computer-aided diagnostic system, utilising deep features extracted by Deep Learning methods.

This strategy may be beneficial for medical-decision assisting tools to provide a second opinion in challenging cases. It could be also applied to achieve a first assessment of the likelihood of disease in patients with less or no symptoms. Besides, the advantage of automatic detection of COVID-19 from X-ray or CT-Scan images reduces the exposure of medical staff to the virus.The paper moreover talks about using CNNs from scratch as it outperforms other transfer learning techniques, both in distinguishing X-rays between the seven classes and between Covid-19 and non Covid-19. A classification accuracy 87.66% was achieved.

The results suggest that training CNN models from scratch may reveal vital biomarkers related but not limited to the COVID-19 disease only, while the top classification accuracy suggests further examination of the X-ray imaging potential.

Title: Artificial Intelligence-Based Classification of Chest X-Ray Images into COVID-19 and Other Infectious Diseases[30]

Author: Arun Sharma , Sheeba Rani and Dinesh Gupta

Identification

The page talks about multiple characteristics in X-ray images of the chest in Covid-19 infected patients. All the methods mentioned above have some limitations such as time required, costs, equipment dependence, shortage of testing kits, availability of trained healthcare workers, interoperator variabilities, especially in a pandemic like this, making them cumbersome diagnostic procedures.

Faster diagnosis of the COVID-19 patients can enable help in the optimization of available resources, including trained human resources, for all the supportive measures required for confirmed patients. Automated AI-based chest X-ray classification has such great potential for this need, as found out from various researches. The most commonly used radiological diagnostic imaging is chest X-rays, as compared to computed tomography (CT) and magnetic resonance imaging (MRI), due to its low cost and less processing time and lower radiation exposure. Their paper focuses on the generalisation of the approaches, to use the best from machine learning and deep learning concepts while providing augmented datasets. Due to the limited availability of chest X-ray images for COVID-19, the AI-based models trained on fewer images have the chance of overfitting in the classification models. However, the performance of our models on independent datasets rules out any indication of overfitting of the models.

In the future, the model training will be enhanced further by incorporating a larger dataset to develop more robust and more scalable classification models. The currently developed AI models in the study are CPU powered, hence slow in the classification of chest X-rays, in future they also discuss moving toward GPU powered solutions

2.2 Integrated summary of the literature studied

After going through the literature survey many models have been built to classify X-Ray images into COVID or NORMAL. But, some or the other models have flaws like training the images on deep neural architecture which led to less accuracy, high false positive or high false negative rates. Some of the studies focused on data augmentation, used pre-trained architectures like VGG-16, VGG-19, NobileNet-V2, Inception ResNet-V2, Xception, etc. but all some of them failed to overcome the problem of classification.

Type of Model	Accuracy
COVID-CAPS	98.3%
ResNet	98%
CVDNet	97.20%
ResNet+SVM	95.38%
VGG-19	93.48%
COVID-Net	93.3%
MobileNetv2	92.85%
ResNet50 + VGG+ CNN	91.24%

Table 2.1 Accuracy Comparison of Implemented Model in the Literature

CHAPTER 3: REQUIREMENT ANALYSIS AND SOLUTION APPROACH

3.1 Overall description of the project

This project is built keeping in mind the overall need of the time. This pandemic required an instantly testing technique. So, this Deep Learning CNN model is built. We have named the model as CovidLight as it has comparatively less number of training layers to avoid the model from overfitting or underfitting. To support the user interactivity we have made a Flask based Web Application to facilitate users to upload images and receive the classification output in a more understandable way. We do not emphasize that this model is accurate and can be used for diagnosis purposes as we are working on the task to test model on more realtime and new images. Although the testing accuracy till now is far much better, the accuracy is 98.86%. The model has less False Positive and False Negative Rates. The project is a complete package inself.

3.2 Requirement Analysis

The requirement analysis was done in four phases:

- Eliciting requirements: We've gathered multiple research papers and found out that usually the existing solutions were too expensive, usually not accessible by everyone and very slow.
    - Manual tests cannot be taken frequently and not accurate.
    - Imaging procedure comes with risk of radiation and cost.
- Analyzing requirements: We analysed every requirement and came up with an idea to provide a free and open source solution where users can analyse their X-ray image with minimal interface.
- Requirements modeling: We've modelled multiple user cases and explained for better coverage.
- Review and retrospective: We've kept iterating above phases to make sure we keep our workflow flexible over time.

3.3 Solution Approach

Our approach is to build a simple UI server where the end user can upload X-ray images and our pre-trained deep learning model will distinguish whether the image is covid-19 infected or not.

The advantage of using pre pre-trained model is that it's light weight and provides results instantly.

For building model, we've utilised multiple models as layers to provide a generalised model for more accurate results.

CHAPTER 4: MODELING AND IMPLEMENTATION

4.1 Design Diagrams

4.1.1Use Case diagrams

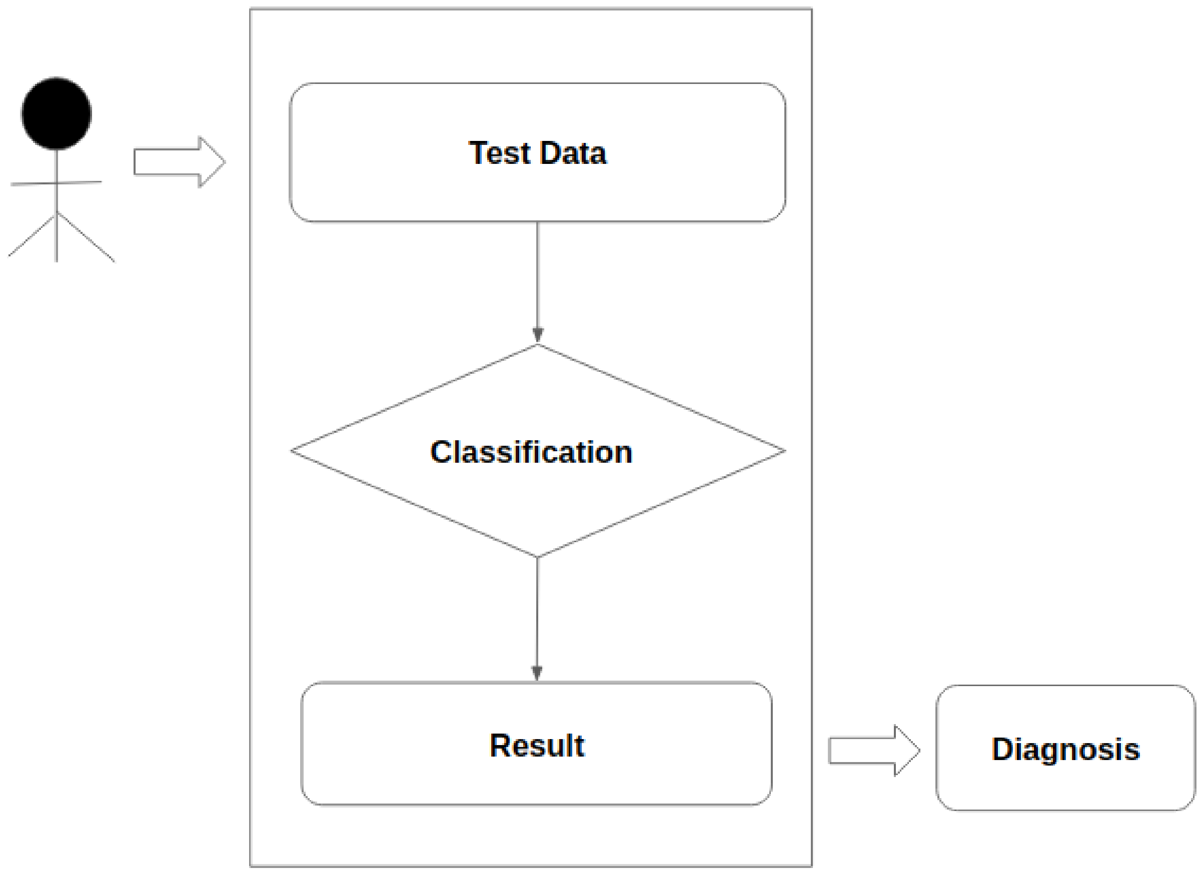

Fig 4.1. Use Case Diagram

4.1.2 Control Flow Diagrams

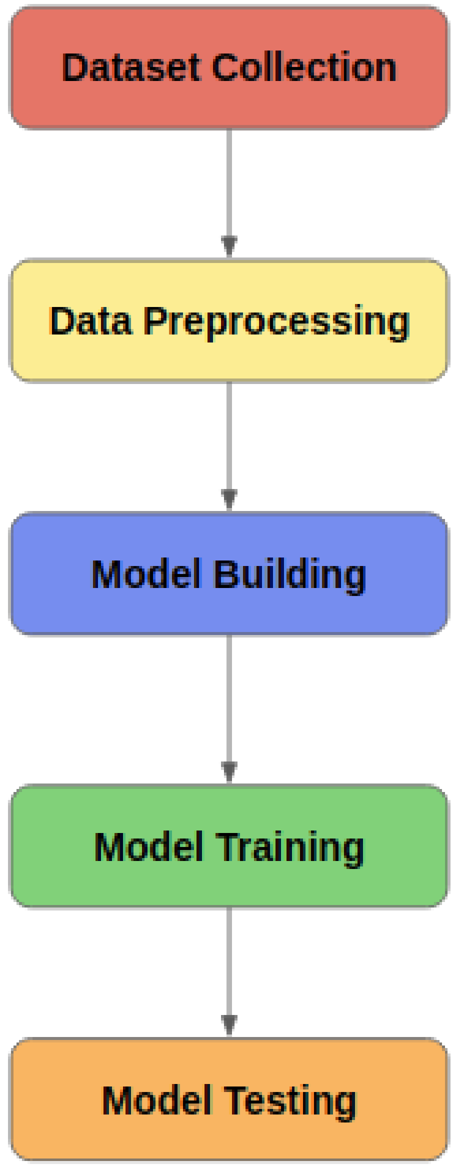

Fig 4.2. Control Flow Diagram.

4.1.3 Sequence Diagram

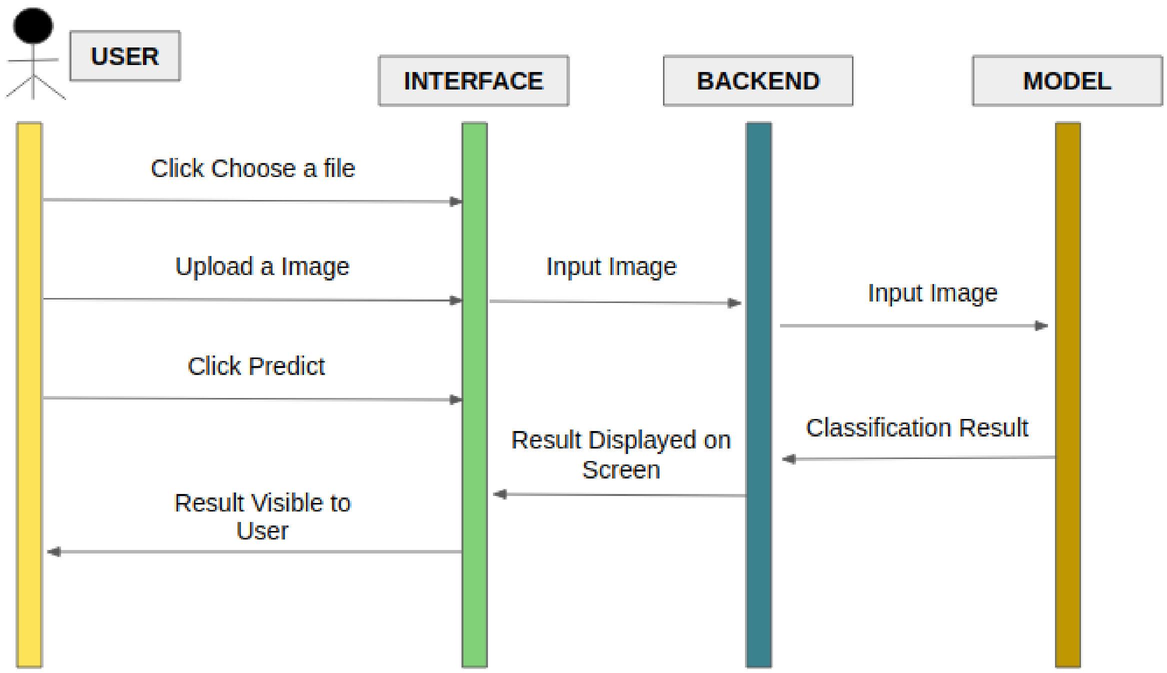

Fig 4.3 Sequence Diagram

4.2 Implementation Details and Issues

We have utilized the COVID-19 Radiography Database for the CNN model preparation and testing. The COVID-19 Radiography Database is the winner of COVID-19 Dataset award by kaggle community. The dataset consists of following X-Ray images:

Types of Images	Number of Images
COVID-19 Positive	219
Normal Images	1341
Viral pneumonia	1345

Table 4.1. Dataset Description

The X-Ray images in the dataset are in PNG file format and have the resolution 1024-by-1024 pixels. A team of researchers from Qatar University, Doha, Qatar and the University of Dhaka, Bangladesh along with their collaborators from Pakistan and Malaysia in collaboration with medical doctors have created a database of chest X-ray images for COVID-19 positive cases along with Normal and Viral Pneumonia images.

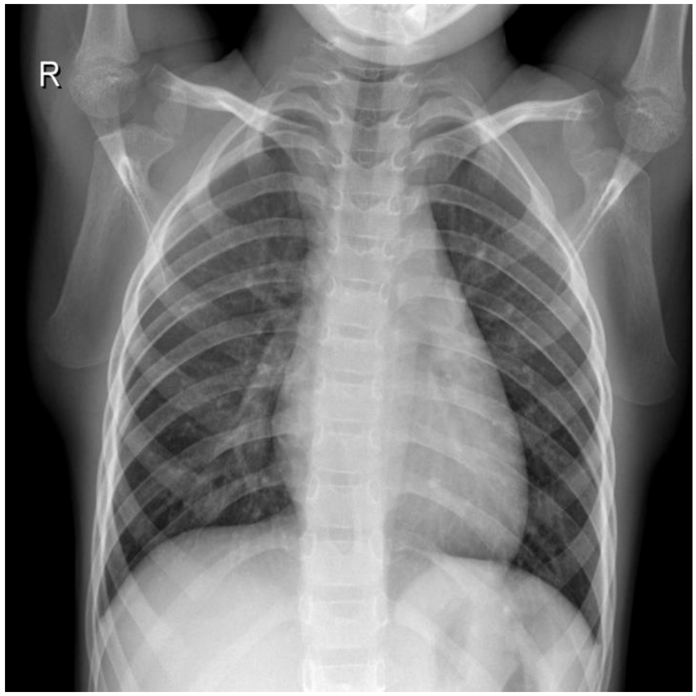

Fig. 4.4 Chest X-Ray Image

4.2.1 Implementation Steps:

Step 1:
Downloaded the dataset from Kaggle named as COVID-19 Radiography Database. Randomly visualized the dataset to know what is present exactly in the dataset.

Step 2:
We have built the binary classifier to predict the outcome as (0-NORMAL, 1-COVID) so we used only COVID-19 and NORMAL images from the dataset.

Step 3:
In the next steps the images are resized into 224-by-224 using the OpenCV python library. The original image present in the dataset has size 1024-by-1024 pixels.

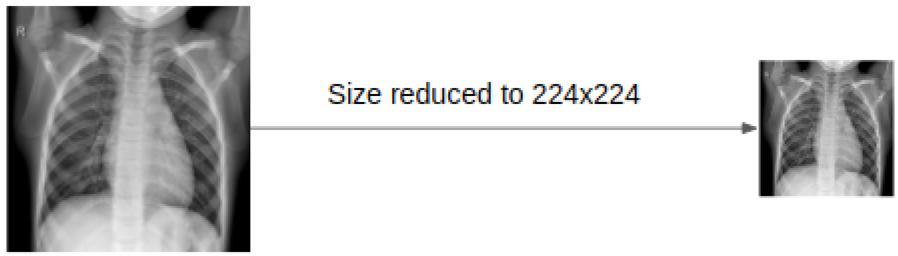

Fig 4.5 Image Preprocessing

Step 4:

In the next step we converted the features of images into numerical values and stored into the Numpy arrays. Numpy makes the feature learning easy as it supports large and multi-dimensional arrays.

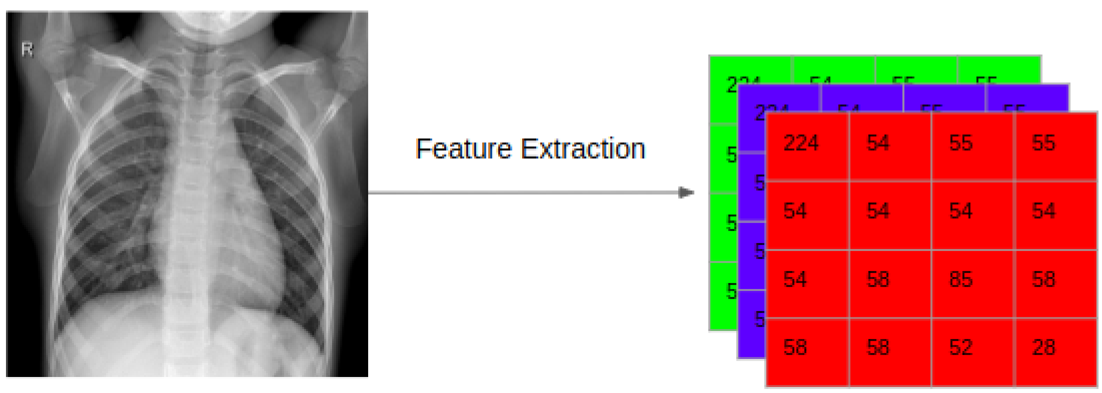

Fig 4.6 Feature Extraction

Step 5:

The next step involves the normalization process on the values of the Numpy array created in the previous step to bring the values into the same scale. The final data is split into training and test set in the ratio of 8:2 (Training set 80% and Test set 20%).

Step 6:

A 2-dimensional convolution neural network has been used to classify X-Ray images into one of binary classes (0-NORMAL, 1-COVID). We used CNN Sequential model with the activation function named ‘RELU’(Rectified Linear Unit), Softmax, MaxPooling, Dropout, and Flatten for training the model and below is whole Summary:

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d (Conv2D)              (None, 220, 220, 64)      4864
_________________________________________________________________
max_pooling2d (MaxPooling2D) (None, 110, 110, 64)      0
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 106, 106, 32)      51232
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 53, 53, 32)        0
_________________________________________________________________
flatten (Flatten)            (None, 89888)             0
_________________________________________________________________
dense (Dense)                (None, 2)                 179778
=================================================================
Total params: 235,874
Trainable params: 235,874
Non-trainable params: 0
```

Fig 4.7 Model Summary

Step 7:

The next step involves the training of the CNN model. The data is then fit into the model with
Number of Epochs = 20
Number of Steps per Epochs = 28
Test Accuracy after fitting the model = 98.86%.

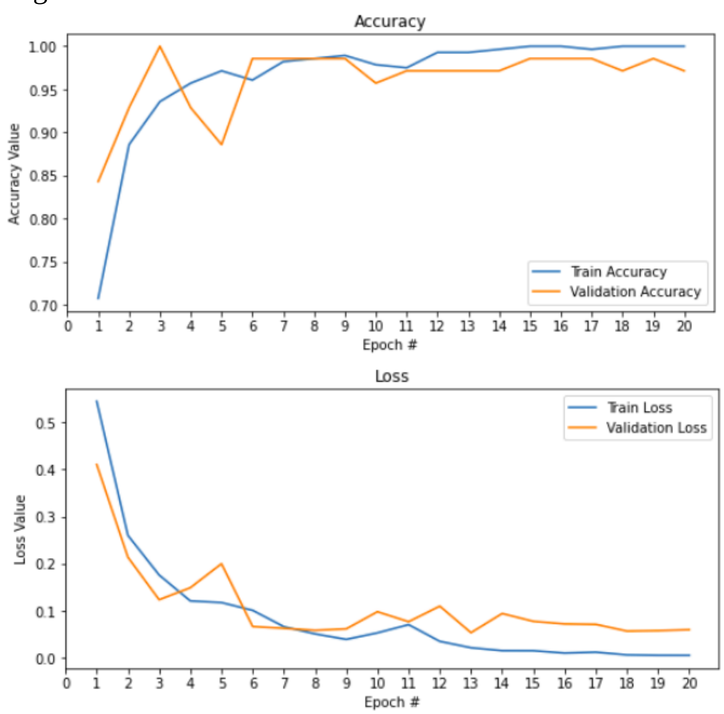

Fig 4.8 Accuracy and Loss Graph

Step 8:

To make the whole process of classification of COVID-19 detection using X-Ray smooth and more practical, we have designed a Flask based web application. The application is user friendly and easy to use. A user just needs to upload an image of a X-Ray and the trained model will classify the X-Ray into its correct class(0-NORMAL, 1-COVID).

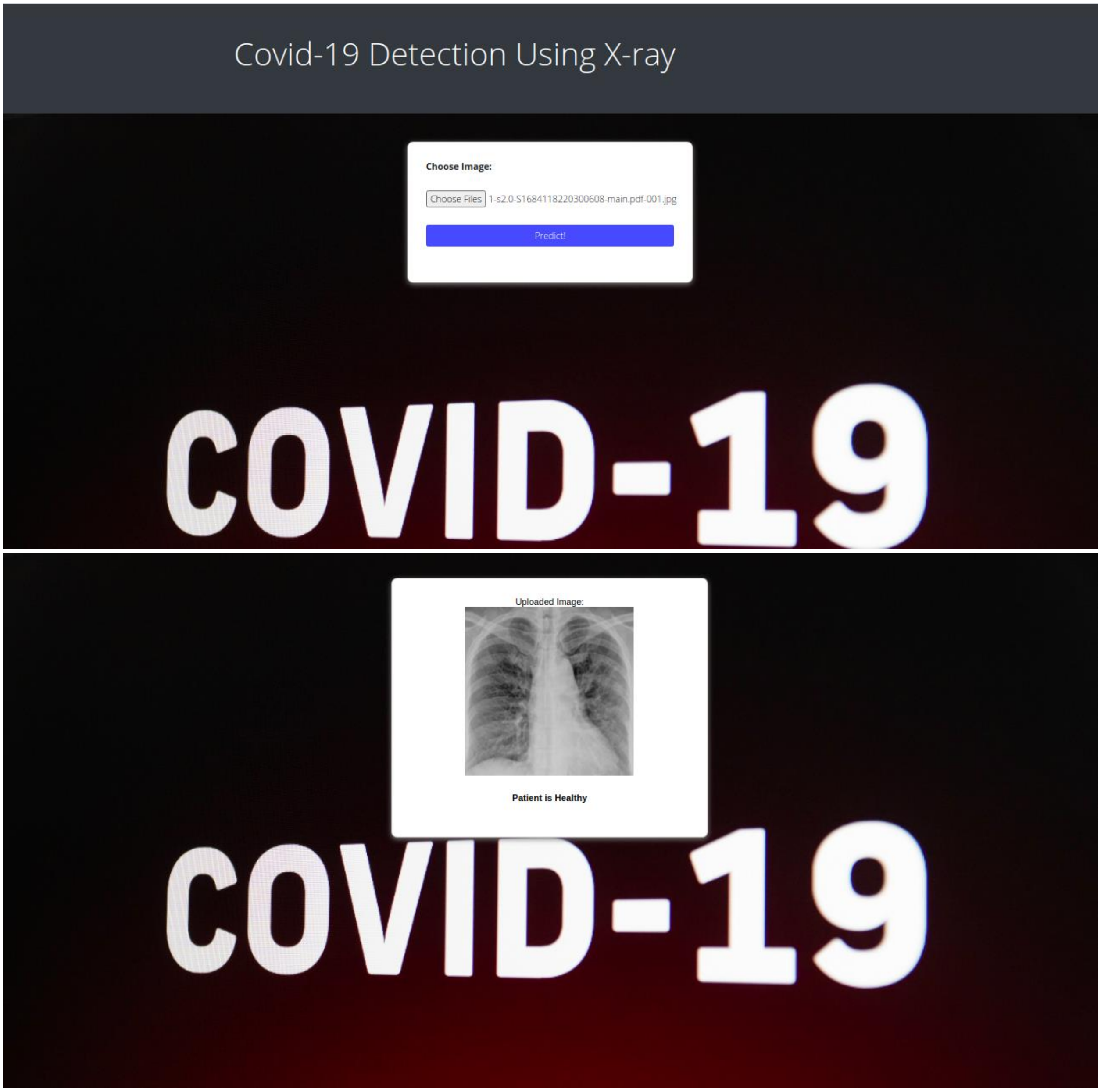

Fig 4.9 User Interface(Flask Based Web Application)

4.2.1 Working of applied model:

We have implemented a lightweight CNN model in keeping the mind that the model can be trained in no less time compared to other models. As the available dataset of images is less in number so, when the number of images increases the model can be trained again. Model architecture is defined below.

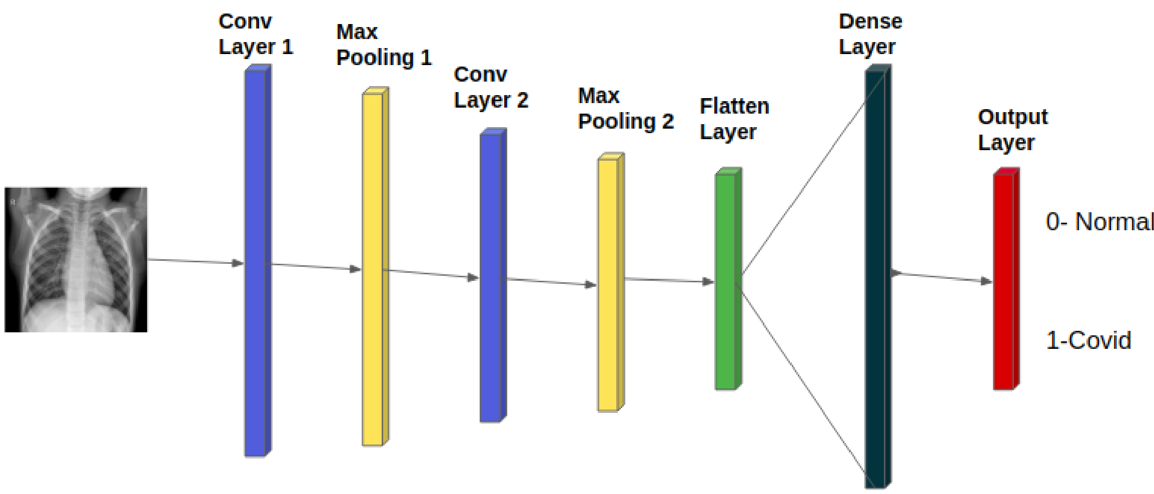

Fig 4.10 Convolutional Neural Network

One of the main processes required to extract feature from the image(image preprocessing) and convert into Numpy array.

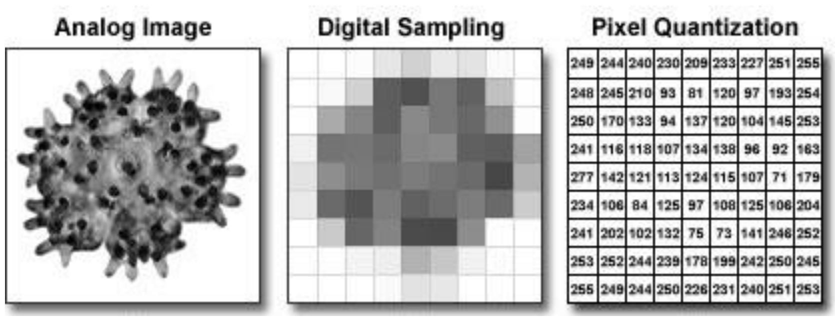

Fig 4.11 Image Preprocessing

Now convolutional is just the integration of two combined functions and shows how one function modifies the shape of others. Now, we will be deciding on a feature detector or we can say filter or kernel(3x3) to reduce the size of the matrix to make our model work faster. In the above-converted image, we will apply a kernel, we have used an initializer so that our weights are initialized randomly.

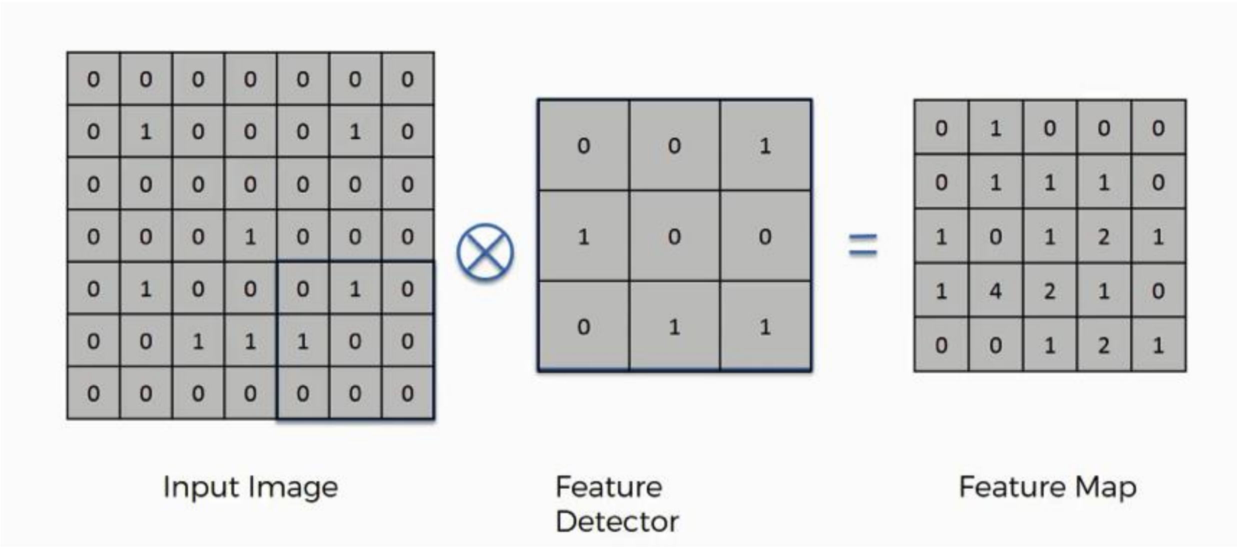

Fig 4.12 Applying filter to Image

Now, we have used the Relu(Rectified Linear Unit) activation function in our model since we want our model to predict to binary classes(0,1). Next, we have used Max Pooling 2D, this just to make all images features to be extracted easily and also to reduce the size of the feature mapping.

Flattening is just used to convert the whole 2D array to a single array or say all weights into a 1D array to make the prediction easily.

After this, we have used softmax activation since we want that all values sum to 1 so that we can also use this training model later to make a prediction for the image.

Next, we have used Max Pooling 2D, at last, this just to make all images features to be extracted easily and also to reduce the size of the feature mapping.

Flattening is just converting the whole 2D array to a single array or say all weights into a 1D array to make the prediction easily. To compute the loss in the data we have used cross-entropy.

Lastly, the model is forming a full convolutional to take out all the hidden layers using steps_per_epochs and in this, our model gets to know on which factor does it have to depend on prediction.

4.2.2 Implementation Issues:

- Availability of small dataset size.
- Due to small dataset size the model building faced an issue of overfitting when trained over the model with extra added layers.

CHAPTER 5: Testing

5.1 Testing Plan

Type of Testing	Performed (Yes/No)	Explanation	Software Components
Requirement	Yes	Requirement specification must contain all the requirements that are needed by our system.	Manual work needs to plan out all the software requirements, the time needed to develop, technology to be used, etc.
Unit	Yes	Testing technology using which individual modules are tested to determine if there are any issues, by the developer itself.	Unit tests have been written to ensure automated testing of the application.
Integration	Yes	Testing where individual components are combined and tested as a group.	Compiling full code and testing it together using CI/CD pipelines on Jenkins
Performance	Yes	Testing to evaluate the input where the best and most optimal output is yielded by the system.	Testing results ensure this.

Table 5.1. Testing Plan

5.2 Component Decomposition and Types of Testing

Sr. No.	List of Modules Required for Testing	Types of Tests Required	Techniques used for Testing
1	Image Generation	Requirement, Unit, Performance, and Integration	White Box
2	Data Augmentation		White Box
3	CNN Model		White Box
4	Web Application	Integration	Black Box

Table 5.2. Components and Types of Testing

5.3 Test Cases

To test and train the CNN model. The data is then fit into the model with data which is split into training and test set in the ratio of 80:20 (Training set 80% and Test set 20%).
Number of Epochs = 20
Number of Steps per Epochs = 28
Test Accuracy after fitting the model = 98.86%.

After going through the confusion matrix, which clearly describes the model performance.
True positive = 217
False positive = 2
False negative = 1
True negative = 218

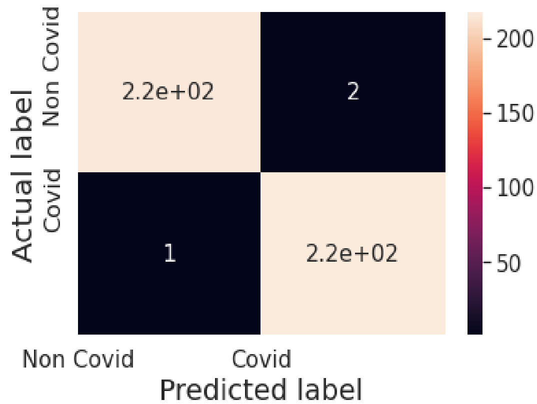

Fig 5.1 Confusion Matrix

Now checking the classification report of the model which is shown below

	precision	recall	f1-score	support
Class 0	1.00	0.98	0.99	47
Class 1	0.98	1.00	0.99	41
accuracy			0.99	88
macro avg	0.99	0.99	0.99	88
weighted avg	0.99	0.99	0.99	88

Fig 5.2 Classification Report

CHAPTER 6: FINDINGS, CONCLUSION AND FUTURE WORK

- The proposed model design is found to be efficient in classifying COVID-19 and NORMAL patients. The use of CNN model for classification made the process more convenient and efficient.
- The data(X-Rays images) found for the COVID-19 were less in number and the pixel size of images were 1024x1024.
- It shows that Deep Learning gives better results than contemporary Machine Learning techniques as the feature extraction from the image is more and leads to better model accuracy.

Sr. No.	Model	Test Accuracy
1	CNN	98.86%
2	Inception ResNet-V2	75.55%

Table 6.1 Model Accuracies

6.2 Conclusion

The aim of this project was to classify the input X-Ray image into binary class(0-NORMAL, 1-COVID). Due to availability of small sized dataset building a model was a tough task as sometimes the model was overfitted or under fitted which lead to high False Positive and high False Negative Rates. We have built this model keeping in mind the above stated problems. The built model is lightweight and can be trained again in less time whenever the size of the dataset increases. The model also has low False Positive and False Negative Rates respectively(.9%, .4%). For both the classes(0-NORMAL, 1-COVID-19) precision are(1.00, 0.98) , recall(0.98, 1) and f1-scores(0.99, 0.99). The test accuracy achieved by the model is 98.86%. But since we have managed to obtain a decent model with decent accuracy, it can be concluded that the model will definitely perform better if trained on a bigger dataset. This model is enough to diagnose COVID-19 in the early stage. The support with the Web Application built on Flask is user friendly and scalable.

6.3 Future Work

On considering the available dataset this model will definitely perform better. But, to increase its integrity and scalability of the model we will work in adding following features-

- We will work on increasing the COVID-19 images which could be contributed towards addition to the dataset.
- Our future will contribute to develop a model which will help to find out how severe is the current patient condition and percentage of lungs damaged. Accordingly he can be recommended to be hospitalized.
- We will perform further testing to get better results about its negative sides as it can be used by the radiologists for testing purposes.

CHAPTER 7: REFERENCES

[1] Dinggang Shen,Guorong Wu,Heung-Il Suk " Deep Learning in Medical Image Analysis", Department of Radiology, University of North Carolina at Chapel Hill, Department of Brain and Cognitive Engineering, Korea University, Seoul, Republic of Korea, June, 2017.

[2] Lawrence O. Hall, Rahul Paul, Dmitry B. Goldgof, and Gregory M. Goldg, "Finding COVID-19 from Chest X-rays using Deep Learning on a Small Dataset", Department of Computer Science and Engineering, University of South Florida, Dept. of Laboratory Medicine University of California, San Francisco, 2020.

[3]Muhammed Talo, Ozal Yildirima,Ulas Baran Baloglub, Galip Aydinc, U Rajendra Acharya, "Convolutional neural networks for multi-class brain disease detection using MRI images", Department of Computer Engineering, Munzur University, Tunceli, Turkey, f International Research Organization for Advanced Science and Technology (IROAST), Kumamoto University, Kumamoto, Japan, October, 2019.

[4]Antonios Makris**,** Ioannis Kontopoulos, Konstantinos Tserpes, "COVID-19 detection from chest X-Ray images using Deep Learning and Convolutional Neural Networks", Department of Informatics and Telematics Harokopio University of Athens Tavros, Greece, May,2020.

[5]Prabira Kumar Sethy, Santi Kumari Behera, "Detection of coronavirus Disease (COVID-19) based on Deep Features", International Journal of Mathematical, Engineering and Management Sciences, April,2020.

[6] Dahai Zhao, Feifei Yao, Lijie Wang, Ling Zheng, Yongjun Gao, Jun Ye, Feng Guo, Hui Zhao, Rongbao Gao, "Comparative study on the clinical features of the coronavirus 2019 pneumonia with other pneumonia**"**,Department of Respiratory and Critical Care Medicine, The Second Affiliated Hospital, Anhui Medical University, Hefei, China, March, 2020.

[7] Mohammad Farukh Hashm, Satyarth Katiyar ,Avinash G Keskar 3 ,Neeraj Dhanraj BokdeandZong Woo Geem, "Efficient Pneumonia Detection in Chest X Ray Images Using Deep Transfer Learning", Department of Electronics and Communication Engineering, National Institute of Technology, Warangal 506004, India, June, 2020.

[8] Xiaowei, XiangaoJiang, ChunlianMa,PengDu, XukunLi, ShuangzhiLv, LiangYuaQinNi, YanfeiChen, JunweiSu, GuanjingLang, YongtaoLi, HongZhao, JunLiu, KaijinXu, LingxiangRuan, JifangSheng, YunqingQiu, LanjuanLi, **"**A Deep Learning System to Screen Novel Coronavirus Disease 2019 Pneumonia", State Key Laboratory for Diagnosis and Treatment of Infectious Diseases, National Clinical

Research Center for Infectious Diseases, Collaborative Innovation Center for Diagnosis and Treatment of Infectious Diseases, the First Affiliated Hospital, College of Medicine, Zhejiang University, Hangzhou 310003, China, June, 2020.

[9] Ezz El-Din Hemdan1 , Marwa A. Shouman1 and Mohamed Esmail Karar, "COVIDX-Net: A Framework of Deep Learning Classifiers to Diagnose COVID-19 in X-Ray Images" Department of Computer Science and Engineering, Faculty of Electronic Engineering, Menoufia University, Egypt, March, 2020.

[10] Ming-Yen Ng, Elaine YP Lee, Jin Yang, Fangfang Yang, Xia Li, Hongxia Wang, Macy Mei-sze Lui, Christine Shing-Yen Lo, Barry Leung, Pek-Lan Khong, Christopher Kim-Ming Hui, Kwok-yung Yuen, Michael David Kuo, "Imaging Profile of the COVID-19 Infection: Radiologic Findings and Literature Review", University of Hong Kong, Diagnostic Radiology, Hong Kong, Feb, 2020.

[11]Enzo Tartaglione, Carlo Alberto Barbano, Claudio Berzovini, Marco Calandri, and Marco Grangetto, "Unveiling COVID-19 from Chest X-ray with deep learning: a hurdles race with small data",University of Turin, Computer Science dept., Torino, Italy,University of Turin, Oncology Department, AOU San Luigi Gonzaga, Orbassano, Italy, April,2020.

[12]Arpan Mangal, Surya Kalia, Harish Rajgopal, Krithika Rangarajan, Vinay Namboodiri, Subhashis Banerjee, Chetan Arora," CovidAID: COVID-19 Detection Using Chest X-Ray", Indian Institute of Technology Delhi, Indian Institute of Technology Kanpur, All India Institute of Medical Sciences Delhi, University of Bath, UK, April,2020.

[13]Gianluca Maguolo , Loris Nanni,"A Critic Evaluation of Methods for COVID-19 Automatic Detection from X-Ray Images",2020.

[14]Mohamed Samir Boudrioua, "COVID-19 detection from chest X-ray images using CNNs models: Further evidence from Deep Transfer Learning",Ronin institute, Montclair, USA,2020.

[15]Asmaa Abbas, Mohammed M. Abdelsamea , Mohamed Medhat Gaber, "Classification of COVID-19 in chest X-ray images using DeTraC deep convolutional neural network",Mathematics Department, Faculty of Science, Assiut University, Assiut, Egypt,School of Computing and Digital Technology, Birmingham City University, Birmingham, UK,September, 2020.

[16]Ali Narin Ceren Kaya Ziynet Pamuk. "Automatic Detection of Coronavirus Disease (COVID-19) Using X-ray Images and Deep Convolutional Neural Networks" Department of Electrical and Electronics

Engineering, Zonguldak Bulent Ecevit University, 67100, Zonguldak, Turkey, Department of Biomedical Engineering, Zonguldak Bulent Ecevit University, 67100, Zonguldak, Turkey,2020.

[17]Tej Bahadur Chandraa Kesari Vermaa Bikesh Kumar Singh Deepak Jain Satyabhuwan Singh Netam "Coronavirus disease (COVID-19) detection in Chest X-Ray images using majority voting based classifier ensemble" Department of Computer Applications, National Institute of Technology Raipur, Chhattisgarh, India, Department of Biomedical Engineering, National Institute of Technology Raipur, Chhattisgarh, India,2020.

[18]Shervin Minaeea, Rahele Kafiehb Milan Sonkac Shakib Yazdani d, Ghazaleh Jamalipour Souf "Deep-COVID: Predicting COVID-19 from chest X-ray images using deep transfer learning" Snap Inc., Seattle, WA, USA, Medical Image and Signal Processing Research Center, Isfahan University of Medical Sciences, Iran,Iowa Institute for Biomedical Imaging, The University of Iowa, Iowa City, USA,2020.

[19]Chaimae Ouchichaa Ouafae Ammora Mohammed Meknassi,"CVDNet: A novel deep learning architecture for detection of coronavirus (Covid-19) from chest x-ray images",Department of Mathematics, Faculty of Science and Technology of Fez S.M.B. Abdellah University, P.O. Box 2202, Morocco, Department of informatics, Faculty of Sciences Dhar El Mehraz S.M.B. Abdellah University, P.O. Box 1796 Atlas Fez, Morocco,November 2020

[20]Sergio Varela Santos Patricia Melin,"A new approach for classifying coronavirus COVID-19 based on its manifestation on chest X-rays using texture features and neural networks"Division of Graduate Studies, Tijuana Institute of Technology, Tijuana, 22414 Baja CA, Mexico,September 2020

[21]Tulin Ozturka Muhammed Talo Eylul Azra Yildirim Ulas Baran Baloglu Ozal Yildirime U.Rajendra Acharyaf,"Automated detection of COVID-19 cases using deep neural networks with X-ray images", Department of Radiology, Medikal Park Hospital, Elazığ, Turkey, Department of Software Engineering, Firat University, Elazig, Turkey, April 2020.

[22]Jianpeng Zhang, Yutong Xie, Guansong Pang, Zhibin Liao, Johan Verjans,"Viral Pneumonia Screening on Chest X-ray Images Using Confidence-Aware Anomaly Detection",IEEE,DEC 2020.

[23]Emtiaz Hussaina Mahmudul Hasana Md Anisur Rahman Ickjai Lee Tasmi Tamanna Mohammad Zavid Parveza,"CoroDet: A deep learning based classification for COVID-19 detection using chest X-ray images"Department of Computer Science and Engineering, Brac University, Dhaka, Bangladesh,School of Computing & Mathematics, Charles Sturt University, Bathurst, NSW 2795, Australia,November 2020.

[24]Morteza Heidari Seyedehnafiseh Mirniaharikandehei Abolfazl Zargari Khuzani Gopichandh Danala Yuchen Qiua Bin Zhenga,"Improving the performance of CNN to predict the likelihood of COVID-19 using chest X-ray images with preprocessing algorithms",School of Electrical and Computer Engineering, University of Oklahoma, Norman, OK 73019, USA,September 2020.

[25]Suat Toramana Talha Burak Alakus Ibrahim Turkoglu "Convolutional capsnet: A novel artificial neural network approach to detect COVID-19 disease from X-ray images using capsule networks",Department of Informatics, Firat University, 23119, Elazig, Turkey,Department of Software Engineering, Kirklareli University, 39000, Kirklareli, Turkey,July 2020.

[25]Suat Toramana Talha Burak Alakus Ibrahim Turkoglu "Convolutional capsnet: A novel artificial neural network approach to detect COVID-19 disease from X-ray images using capsule networks",Department of Informatics, Firat University, 23119, Elazig, Turkey,Department of Software Engineering, Kirklareli University, 39000, Kirklareli, Turkey,July 2020.

[26]Ioannis D. Apostolopoulos, Sokratis I. Aznaouridis & Mpesiana A. Tzani,"Extracting Possibly Representative COVID-19 Biomarkers from X-ray Images with Deep Learning Approach and Image Data Related to Pulmonary Diseases",Journal of Medical and Biological Engineering,May 2020.

[27]N.Narayan Dasa N.Kumar M.Kaur V.Kumar D.Singh,"Automated Deep Transfer Learning-Based Approach for Detection of COVID-19 Infection in Chest X-rays",Department of Information Technology, School of Computing and Information Technology, Manipal University Jaipur, Jaipur, Rajasthan, 303007, India,Department Of Computer Science and Engineering, Maharaja Surajmal Institute of Technology, Janakpuri, New Delhi, 110058, India,July 2020.

[28]Govardhan Jain Deepti Mittal Daksh Thakur Madhup K.Mittal,"A deep learning approach to detect Covid-19 coronavirus with X-Ray images,Department of Electrical Engineering, Medical Engineering and Computer Science (EMI), Hochschule Offenburg, Offenburg, Germany,Department of Electrical and Instrumentation Engineering, Thapar Institute of Engineering & Technology, Patiala, Punjab, India,September 2020.

[29]Moutaz Alazab, Albara Awajan, Abdelwadood Mesleh, Ajith Abraham, Vansh Jatana, Salah Alhyari,"COVID-19 Prediction and Detection Using Deep Learning",Faculty of Artificial Intelligence, Al-Balqa Applied University, Al-Salt, Jordan,Machine Intelligence Research (MIR) Labs Auburn, WA, US, May, 2020.

[30]Arun Sharma, Sheeba Rani, Dinesh Gupta, “Artificial Intelligence-Based Classification of Chest X-Ray Images into COVID-19 and Other Infectious Diseases”,Translational Bioinformatics Group, International Centre for Genetic Engineering and Biotechnology (ICGEB), Aruna Asaf Ali Marg, New Delhi 110067, India,Oct 2020.

[31]Dataset-https://www.kaggle.com/tawsifurrahman/covid19-radiography-database