COVID-19 DIAGNOSIS FROM CT SCANS USING DEEP LEARNING

A PROJECT REPORT

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DECLARATION

I undersigned hereby declare that the project report on "COVID-19 DIAGNOSIS FROM CT SCANS USING DEEP LEARNING", submitted for partial fulfillment of the requirements for the award of the degree of M.C.A of the APJ Abdul Kalam Technological University, Kerala is a bonafide work done by me under supervision of Prof.Dr. Nadera Beevi S. This submission represents my ideas in my own words and where ideas or words of others have been included; I have adequately and accurately cited and referenced the original sources. I also declare that I have adhered to the ethics of academic honesty and integrity and have not misrepresented or fabricated any data or idea or fact or source in my submission. I understand that any violation of the above will be a cause for disciplinary action by the institute and/or the University and can also evoke penal action from the sources which have thus not properly cited or from whom proper permission has not been obtained. This report has not been previously formed the basis for the award of any degree, diploma, or similar title of any other University.

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C E R T I F I C A T E

This is to certify that, this report titled ***COVID-19 DIAGNOSIS FROM CT SCANS USING DEEP LEARNING*** is a bonafide record of the **Project Work** presented by **SRUTHIMOL BIJU (TKM19MCA023)**, under our guidance and supervision, in partial fulfillment of the requirements for the award of the degree, **MASTER OF COMPUTER APPLICATIONS** in **APJ Abdul Kalam Technological University** .

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Abstract

SARS-CoV-2 is a novel virus, responsible for causing the COVID-19 pandemic that has emerged as a pandemic in recent years. Humans are becoming infected with the virus. In 2019, the city of Wuhan reported the first-ever incidence of COVID-19. COVID-19 infected people have symptoms that are related to pneumonia, and the virus affects the body's respiratory organs, making breathing difficult. A real-time reverse transcriptase-polymerase chain reaction (RT-PCR) kit is used to diagnose the disease. Due to a shortage of kits and the delay caused in obtaining the result suspected patients cannot be treated promptly, resulting in disease spread. To develop an alternative, radiologists looked at the changes in radiological imaging, like CT scans, that produce comprehensive pictures of the body of excellent quality. The suspected patient's computed tomography (CT) scan is used to distinguish between a healthy individual and a COVID-19 patient using deep learning algorithms. A lot of deep learning methods have been proposed for COVID-19. The proposed work utilizes CNN architectures like Xception and InceptionV3. The dataset contains 750 CT scan images of "COVID" and "Non-COVID" types. The dataset is divided into train and test sets. Accuracies obtained for Xception is 95%, and InceptionV3 is 93%, respectively. From the obtained analysis, the results show that the Xception architecture gives better accuracy compared to InceptionV3 for the quick identification of the COVID-19 patients.

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Chapter 1

Introduction

COVID-19, more commonly known as the Novel Coronavirus disease is a highly infectious disease that appeared in China towards the end of 2019. This disease is caused by SARS-CoV-2, a virus that belongs to the large family of coronaviruses. The disease first originated in Wuhan, China in December 2019 and soon became a global pandemic. The World Health Organization (WHO) announced COVID-19 as a Public Health Emergency of International Concern (PHEIC) on January 31, 2020. On 23rd April, the COVID-19 update by the WHO announced that globally, Coronaviruses are zoonotic, which means they can be transmitted between animals and people, and the spreading rate is also high.Corona viruses cause infections in the lungs and lead to more severe Middle East Respiratory Syndrome and Severe Acute Respiratory Syndrome cases. It is essential to diagnose the disease so that the patient can be isolated as soon as possible.

Many methods have been used to confirm the suspected COVID-19 cases by clinicians, like real-time Reverse Transcription Polymerase Chain Reaction (RT-PCR), and nonPCR tests such as isothermal nucleic acid amplification technology, non-contrast chest Computed Tomography (CT) and radiographs . etc. The RT-PCR test has been widely used to confirm COVID-19. The most common symptoms of COVID-19 are fever, dry cough, and tiredness. Other symptoms that people may experience include aches, pains, or difficulty in breathing. Most of these symptoms show signs of respiratory infections and lung abnormalities that can be detected by radiologists.

It's possible to use Machine Learning algorithms to detect the disease from images of Chest X-rays and CT scans. Automated applications can be created to help support radiologists. This work is an attempt to diagnosis COVID-19 from CT images using two Deep Learning algorithms, namely: InceptionV3 and Xception.

1.1 Problem Definition

Diagnosing COVID-19 usually undergoes a complicated and time-consuming process. Here present a model for the automatic detection of COVID-19 using better architecture along with high accuracy. By using pre-trained transfer learning model on large-scale datasets, important features can be learned which can be used in image classification. The image can be classified into types of classes COVID-19 and Non-COVID 19.

1.2 Objective

Infectious COVID-19 disease shocked the world and is still threating the lives of billions of people. The following objectives are identified for the project:

- A new framework has been proposed to automatically identify or confirm COVID-19 in 2-D CT images based on two deep learning classifiers; namely InceptionV3,Xception.
- Both the models are tested and evaluated its accuracy.
- Deploying the model with higher accuracy using a Flask API

Chapter 2

Literature Survey

The literature review is the comprehensive study and interpretation of literature that relates to a particular topic. When one uses literature review research questions are identified, then one seeks to answer these research questions by searching for and analyzing relevant literature. Some importance of literature reviews is that new insights can be developed by re-analyzing the results of the study. A literature review is both a summary and explanation of the complete and current state of knowledge on a topic as found in academic books and journal articles. There are two kinds of literature reviews you might write at university: one that students are asked to write as a stand-alone assignment in a course, and the other that is written as part of an introduction to, or preparation for, a longer work, usually a thesis or research report. The focus and perspective of your review and the kind of hypothesis or thesis argument you make will be determined by what kind of review you are writing. One way to understand the differences between these two types is to read published literature reviews or the first chapters of theses and dissertations in your own subject area. Analyses the structure of their arguments and notes the way they address the issues.

2.1 Purpose of the Literature Review

1. It gives readers easy access to research on a particular topic by selecting high-quality articles or studies that are relevant, meaningful, important and valid and summarizing them into one complete report.
2. It provides an excellent starting point for researchers beginning to do research in a new area. by forcing them to summarize, evaluate, and compare original research in that specific area.
3. It ensures that researchers do not duplicate work that has already been done.
4. It can provide clues as to where future research is heading or recommend areas on which to focus.
5. It highlights the key findings.
6. It identifies inconsistencies, gaps and contradictions in the literature.
7. It provides a constructive analysis of the methodologies and approaches of other researchers.

2.2 Related Works

The section mainly describes related study modes in the area of COVID-19 detection. And some of them are listed below.

In recent years, A number of works were reported for the detection of COVID-19 from X-ray and CT scan image data set. The COVID-19 diagnosis and severity detection from CT images using transfer learning and back propagation neural network was developed by AswathyA.L et. al[1], this method for COVID-19 diagnosis gave an accuracy of 98.5% compared with the state-of-the-artmethods. The COVIDXNet, a deep learning framework was developed by Hemdan et.al[2]. In this work, they analysed the performance of DenseNet-201,VGG19, InceptionV3, ResNetV2, Inception, Xception ResNetV2,and MobileNetV2. The results obtained from VGG19 and DenseNet-201 models are processing well with an accuracy of 90 %.

A tailored deep learning-based framework, COVID-Net, was developed by Wang and Wong to detect COVID-19 from chest X-ray images[3] . The architecture consists of 1×1 convolutions, depth-wise and residual architecture. They proposed a multi-classification as normal, viral infection,bacterial infection, and COVID-19 infection. and got an accuracy of 83.5%.

A study conducted by Aditya Borakati et al. analyzed the efficiency of common imaging modalities, chest X-ray (CXR) and CT, for diagnosis of COVID-19[4]. In conclusion, the CT has more diagnostic performance than the CXR for COVID-19. CT should be strongly considered in the initial assessment for suspected COVID-19. There exist many methods for the detection of COVID-19 from the CT images. To diagnose COVID-19, self-supervised learning with transfer learning was proposed by He et al.[5], Zhao et al. proposed a multi-tasking learning approach for the binary classification for COVID-19[6].

To avoid the scarcity of the limited benchmark data sets for COVID-19, especially in chest CT images. Loey et al. proposed a method that uses data augmentation and CGAN to generate more CT images[7]. Liu et al. proposed a Lesion-Attention Deep Neural Network to perform the binary classification from the chest CT images.The machine learning methods were explored by Barstugan et al. by making use of different feature extraction methods and support vector machine as a classifier[8].

Wang et al. proposed a method which utilizes a weakly supervised framework for COVID-19 classification [9]. They used the UNet architecture and got an accuracy of 90.10 %

Pathak et al. developed a Deep Transfer Learning method based on ResNet-50 and the 2D Convolutional Neural Network (CNN)[10]. An attention-based deep learning method was proposed by Harmon et al[11]. Harmon et al. developed a lung segmentation algorithm to identify and localize whole lung regions for the prediction of COVID-19 disease[12] .COVID-19 can lead to pneumonia, Acute Respiratory Distress Syndrome (ARDS), and similar life-threatening situations.
The advantages and limitations of recent related works are summarized in Table 2.1.

Sl. No	**Title of the Paper, Journal name, Publisher, Year**	**Pros of that Paper**	**Cons of that paper**
1	AswathyA.L,AnandHareendran.S,Vinod ChandraS.S", COVID-19 diagnosis and severity detection from CT-images using transfer learning and back propagation neural network"Journal of Infection and Public Health,Elsevier(2021)	• This work advances state-of-the-art methods in COVID-19 detection and severity prediction. • It's overcome gradient vanishing problem.	severity detection from 3D CT volumes.
2	,MedRxiv, He X, Yang X, Zhang S, Zhao J, Zhang Y, Xing E, et al., "Sample-efficient deep learning for COVID-19 diagnosis based on CT scans", Comput. Biol. Med. v,IEEE,2021	• Achieved high diagnosis accuracy. • This work done on publicly available dataset.	Limited dataset
3	Wang L, Wong A,"Covid-net: a tailored deep convolutional neural network design for detection of COVID-19 cases from chest radiography images", Scientific Reports, nature research, 2021.	They proposed a multi-classification as normal,viral infection, bacterial infection, and COVID-19 infection.	It's not a highly accurate yet practical deep learning solutions.
4	Loey.M,Smarandache.F,Khalifa,NEM.,"A deep transfer learning model with classical data augmentation and CGAN to detect COVID-19 from chest CT radiography digital images" Springer,nature,2020.	Avoid the scarcity of the limited benchmark datasets for COVID-19, especially in chest CT images.	The major drawback is not trying most of deep learning models to get highest performance measurement.
5	Hemdan EE-D, Shouman MA, Karar ME ,"Covidx-net: a framework of deep learning classifiers to diagnose COVID-19 in X-ray images". J. Med. Syst., IEEE, 2020.	This study demonstrated the useful application of deep learning models to classify COVID-19 in X-ray images based on the proposed COVIDX-Net framework.	This study validated on less data set.

Table 2.1: Related works

Chapter 3

Methodology

COVID-19 detection can be performed using different classifiers and a multitude of techniques have been used in the past for this purpose. In this study, the classifiers that were used for performing the detection were InceptionV3 and Xception. The results of both the classifiers were used to find the best performing model and for the detection of COVID-19 from the dataset.

3.1 Algorithm

The algorithm includes:-

- Step1: Load images.
- Step2: Define size for the images are to be resized.
- Step3: Fetch images and class labels from files.
- Step4: Normalization for modelling.
- Step5: Split into training and testing sets.
- Step6: Image Augmentation.
- Step7: Building and training the model.
- Step8: Prediction of the image Class.
- Step9:Save model for future use.

3.2 System Architecture

The system architectural design is used to abstract the overall outline of the software system and the relationships, constraints, and boundaries between components. It is an important tool as it provides an overall view of the physical deployment of the software system. This study uses two well-known convolutional neural network models Xceptionand and InceptionV3 for detection of COVID. This demonstrates that using pre-trained models for image classification is an effective way to detect COVID. The data flow diagram of the proposed model is shown in fig 3.1. The proposed system consist of four major phases:

- Data preprocessing and data augmentation
- Training the data set
- Evaluation of the model
- Deploying the model using Flask app

3.2.1 Data sets

The dataset used for COVID-19 diagnosis is based on a CT scans dataset which is released by the radiological department/society on the Kaggle website. The Keras open-source deep learning framework along with the TensorFlow backend is employed to build and train the Convolutional Neural Network. The dataset obtained consists of the training andtesting images, each divided by the two classes. A total of approximately 730 images of CT scans are present. The data is partitioned into the training and testing sets, 80% of the images were used for training the models and the remaining 20% for testing the accuracy of the models.

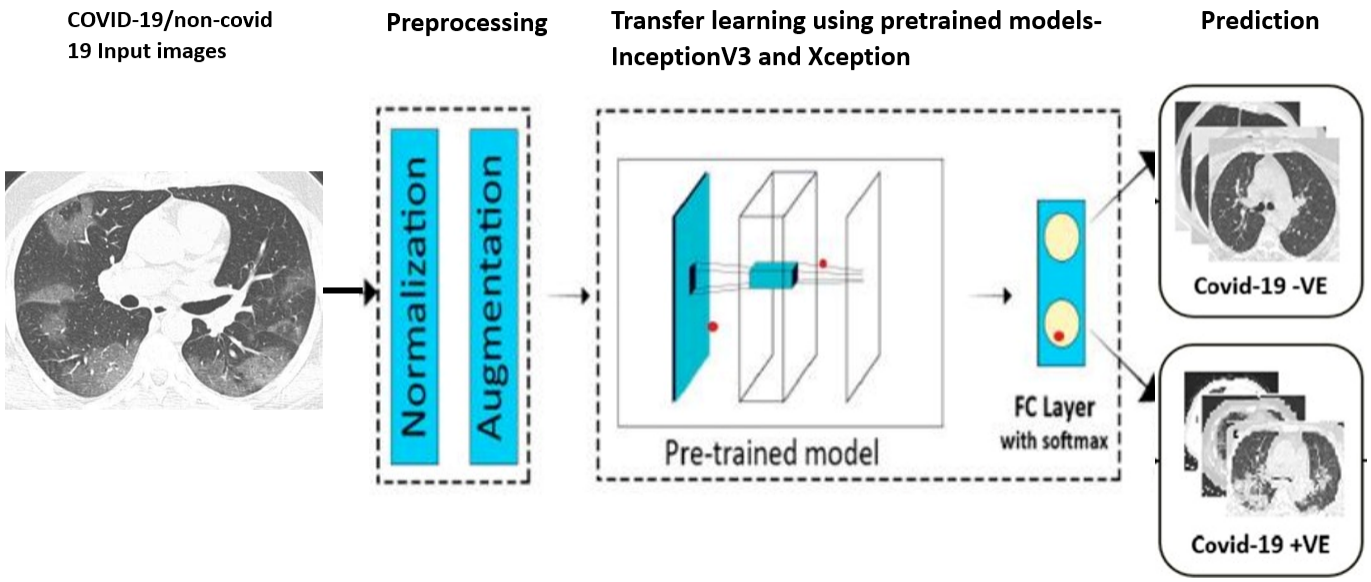

Figure 3.1: COVID-19 Diagnosis Block Diagram

3.2.2 Data Preprocessing and augmentation

Data preprocessing is an integral step in Machine Learning as the quality of the data and the useful information that can be derived from it directly affects the ability of the model to learn; therefore,it is extremely important,for that preprocess our data before feeding it into the model. Data preprocessing is a process of preparing the raw data and making it suitable for a deep learning model. It is the first and crucial step while creating a deep learning model. For achieving better results from the applied model in Deep Learning projects the format of the data has to be in a proper manner.

The images in the dataset were of different sizes. Thus, needed to resize them to a fixed size before they can be fed to the deep learning models for training. Resized the images to a size of 224 x 224 px which is considered to be the ideal size for the ResNet50 model. Therefore, Added the input tensor of shape (224, 224 , 3) to the pretrained models namely :Xceptionand InceptionV3, 3 being the number of channels. Also, normalize the image pixels by dividing by 225.

Data Augmentation techniques are extensively used to enhance the performance of deep learning algorithms. Data augmentation is primarily used to improve the performance of the convolutional neural network model, used to classify the CT scans. Data Augmentation is implemented on the training data, which are images in this case, to enhance and augment the quality, adeptness, and size of the data. Numerous operations are carried out to increase the size of the data and help the Deep Learning model capture multiple nuances in the training images. Convolutional Neural Networks are fed with the augmented data to prevent over fitting of the data i.e, to optimize the performance of the model. Over fitting is an undesirable condition where a machine learning or deep learning model performs well on the training set but yields undesirable results on the testing and validation sets. Thus, over fitting of the model is not advisable and should not occur during the implementation. Increasing the training dataset enables the Deep Learning and Computer Vision algorithms to fit the models more efficiently. There are various data augmentation techniques, which have been used to train the model. This practically does not change the original dataset and is only implemented during the run time, without any unnecessary disk space being utilized to store the modified and augmented images. Here, defined an Image Data Generator to train the models at modified versions of the images, such as at different angles, flips, rotations or shifts

3.2.3 Building and Training the Model

For building model, first added 3 custom layers to the pretrained models so that they can be trained on our dataset.Next, Added a Flatten layer to flatten all our features and a Dropout layer to overcome overfitting. Finally, Added the Dense output layer using softmax function as the activation function. Since the first half of the model is already pretrained, the trainable attribute of the previous layers was set to False. Finally, Compiled the model with the adam optimizer and using categorical crossentropy as the loss function.

. Next, training of the model was performed, with all the required parameters.Both Xceptionand and InceptionV3 models are trained separately trained the model for 500 epochs with a batch size of 32 images and these models are saved as H5 files.

3.2.4 Testing the model

The proposed Xceptionand and InceptionV3 models are tested with testing data images for performing the COVID diagnosis from CT images. Testing accuracy is most important performance matrix of classification algorithm.The accuracy of proposed Xception and is higher than InceptionV3 in testing.

3.2.5 Deploying the model in Flask App

Here, we developed a basic API using Flask where user can upload CT image COVID-19 suspected patients and the system predicts whether it is affected from COVID or not.

3.3 Flask API

Flask is a web application framework written in Python. Flask is based on Werkzeug WSGI toolkit and Jinja2 template engine. Python 2.6 or higher is usually required for installation of Flask. Although Flask and its dependencies work well with Python 3 , many Flask extensions do not support it properly. Hence, it is recommended that Flask should be installed on Python 3.8.5 Flask is an API of Python that allows us to build up web-applications. It was developed by Armin Ronacher. Flask's framework is more explicit than Django's framework and is also easier to learn because it has less base code to implement a simple web-Application. Flask was designed to be easy to use and extend. The idea behind Flask is to build a solid foundation for web applications of different complexity. From then on you are free to plug in any extensions you think you need. Also you are free to build your own modules. Flask is great for all kinds of projects. It's especially good for prototyping. Flask depends on two external libraries:the Jinja2 template engine and the Werkzeug WSGI toolkit.

Flask has a lightweight and modular design, so it easy to transform it to the web framework need with a few extensions without weighing it down. Flask documentation is comprehensive, full of examples and well structured. It possible even try out some sample application to really get a feel of Flask. It is super easy to deploy Flask in production (Flask is 100% WSGI 1.0 compliant"),HTTP request handling functionality, High Flexibility. The configuration is even more flexible than that of Django, giving you plenty of solution for every production need.

3.4 Software Requirement and Specification

The softwares used for the project includes:

- Python
- Anaconda
- Google Colaboratory

3.4.1 Python

Python is an object-oriented programming language . It's ideally designed for fast prototyping of complicated applications. It has interfaces to several OS system calls and libraries and is protractile to C or C++. Several massive corporations use the Python programming language embody NASA, Google, YouTube, BitTorrent, etc. Python programming is widely utilized in AI, Natural Language Generation, Neural Networks and other advanced fields of computer science. Python is a powerful language that can be used develop games, write GUIs, and develop web applications. Reading and writing codes in Python is far like reading and writing regular English statements. As a result, they're not written in the machine-readable language, Python programs got to be processed before machines can run them. This implies that each time a program is run, its interpreter runs through the code and interprets it into machine-readable byte code. Everything in Python is, in fact, top-notch. All objects, data types, functions, methods, and classes take an equal position in Python. Programming languages are created to satisfy the requirements of programmers and users for an efficient tool to develop applications that impact lives, lifestyles,economy, and society. They assist build lives better by increasing productivity, enhancing communication, and rising potency.Here , python version 3.8.5 is used.

3.4.2 Anaconda

Anaconda is a free and open-source distribution of the Python and R programming languages for scientific computing (data science, machine learning applications, large-scale data processing, predictive analytics, etc.), that aims to simplify package management and deployment. Package versions are managed by the package management system conda. The Anaconda distribution includes data-science packages suitable for Windows, Linux, and MacOS. Anaconda distribution comes with more than 1,500 packages as well as the conda package and virtual environment manager. It also includes a GUI, Anaconda Navigator, as a graphical alternative to the command line interface (CLI). Big difference between conda and the pip package manager is in how package dependencies are managed, which is a significant challenge for Python data science and the reason conda exists.

3.4.3 Google Colaboratory

Google Colab was developed by Google to provide free access to GPU's and TPU's to anyone who needs them to build a machine learning or deep learning model. Google Colab can be defined as an improved version of Jupyter Notebook.Jupyter Notebook is an application that allows editing and running Notebook documents through a web browser or an Integrated Development Environment (IDE). Instead of files, it will work with Notebooks.Notebook documents can include executable lines of code along with text, images, figures, tables, graphs, equations, and much more graphical data. In simple words, Notebook documents are a way of creating human-readable executable documents. In a Notebook, cells are the building blocks. Everything in a Notebook is composed of cells. There are two types of :

- Text cell :- A text cell can contain text, images, links and much more. You can double-click a text cell to edit its contents. The text cell supports Markdown markup language.

- Code cell:- A code cell contains the executable code. A code cell has a run button to its left that lets you execute the contents of the cell. When you run a cell the output is displayed under the cell.

Google Colab provides tons of exciting features that any modern IDE offers, and much more. Some of the most exciting features are listed below.

- Interactive tutorials to learn machine learning and neural networks.
- Write and execute Python 3 code without having a local setup.
- Execute terminal commands from the Notebook.
- Import datasets from external sources such as Kaggle.
- Save Notebooks to Google Drive.
- Import Notebooks from Google Drive.
- Free cloud service, GPUs and TPUs.
- Integrate with PyTorch, Tensor Flow, Open CV.
- Import or publish directly from/to GitHub.

3.4.4 Transfer learning models

Transfer learning for machine learning is when existing models are reused to solve a new challenge or problem. Transfer learning is generally used:

- To save time and resources from having to train multiple machine learning models from scratch to complete similar tasks.
- As an efficiency saving in areas of machine learning that require high amounts of resources such as image categorisation or natural language processing.
- To negate a lack of labelled training data held by an organisation, by using pre-trained models.

Transfer learning means taking the relevant parts of a pre-trained machine learning model and applying it to a new but similar problem. This will usually be the core information for the model to function, with new aspects added to the model to solve a specific task.

INCEPTIONV3

InceptionV3 is a convolutional neural network that is 48 layers deep. You can load a pretrained version of the network trained on more than a million images from the ImageNet database. The pretrained network can classify images into 1000 object categories, such as keyboard, mouse, pencil, and many animals. As a result, the network has learned rich feature representations for a wide range of images. The network has an image input size of 299-by-299.

XCEPTION

Xception is a convolutional neural network that is 71 layers deep. We can load a pretrained version of the network trained on more than a million images from the ImageNet database. The pretrained network can classify images into 1000 object categories, such as keyboard, mouse, pencil, and many animals. As a result, the network has learned rich feature representations for a wide range of images. The network has an image input size of 299-by-299.

3.4.5 Hardware and experimental environment

The hardware used for the experiments includes Windows 11 Pro OS, 64-bit operating system, x64-based processor, Intel(R) Core(TM) i5-1155G7 CPU @ 2.50GHz, 8 GB RAM. Experimental environment was prepared by using Python 3.7 programming language.Framework used is keras with tensorFlow as background in the Anaconda environment.Machine learning and deep learning libraries include - NumPy, Pandas, Matplotlib, Sciki,seborn.

Keras

Keras is a deep learning API written in Python, running on top of the machine learning platform TensorFlow. It was developed with a focus on enabling fast experimentation. Keras is:

- Simple: but not simplistic. Keras reduces developer cognitive load to free you to focus on the parts of the problem that really matter.
- Flexible: Keras adopts the principle of progressive disclosure of complexity: simple workflows should be quick and easy, while arbitrarily advanced workflows should be possible via a clear path that builds upon what you've already learned.
- Powerful: Keras provides industry-strength performance and scalability: it is used by organizations and companies including NASA, YouTube, or Waymo.

Tensorflow

TensorFlow is an open source library for numerical computation and large-scale machine learning. TensorFlow bundles together a slew of machine learning and deep learning (aka neural networking) models and algorithms and makes them useful by way of a common metaphor. It uses Python to provide a convenient front-end API for building applications with the framework, while executing those applications in high-performance C++.

TensorFlow can train and run deep neural networks for handwritten digit classification, image recognition, word embeddings, recurrent neural networks, sequence-to-sequence models for machine translation, natural language processing, and PDE (partial differential equation) based simulations. Best of all, TensorFlow supports production prediction at scale, with the same models used for training.

TensorFlow allows developers to create dataflow graphs—structures that describe how data moves through a graph, or a series of processing nodes. Each node in the graph represents a mathematical operation, and each connection or edge between nodes is a multidimensional data array, or tensor. TensorFlow provides all of this for the programmer by way of the Python language. Python is easy to learn and work with, and provides convenient ways to express how high-level abstractions can be coupled together. Nodes and tensors in TensorFlow are Python objects, and TensorFlow applications are themselves Python applications. The actual math operations, however, are not performed in Python. The libraries of transformations that are available through TensorFlow are written as highperformance C++ binaries. Python just directs traffic between the pieces, and provides high-level programming abstractions to hook them together TensorFlow applications can be run on most any target that's convenient: a local machine, a cluster in the cloud, iOS and Android devices, CPUs or GPUs. If you use Google's own cloud, you can run TensorFlow on Google's custom TensorFlow Processing Unit (TPU) silicon for further acceleration. The resulting models created by TensorFlow, though, can be deployed on most any device where they will be used to serve predictions.The single biggest benefit TensorFlow provides for machine learning development is abstraction. Instead of dealing with the nitty-gritty details of implementing algorithms, or figuring out proper ways to hitch the output of one function to the input of another, the developer can focus on the overall logic of the application. TensorFlow takes care of the details behind the scenes.

Matplotlib

Matplotlib is a cross-platform, data visualization and graphical plotting library for Python and its numerical extension NumPy. As such, it offers a viable open source alternative to MATLAB. Developers can also use matplotlib's APIs (Application Programming Interfaces) to embed plots in GUI applications. A Python matplotlib script is structured so that a few lines of code are all that is required in most instances to generate a visual data plot. The matplotlib scripting layer overlays two APIs:

- The pyplot API is a hierarchy of Python code objects topped by matplotlib.pyplot
- An OO (Object-Oriented) API collection of objects that can be assembled with greater flexibility than pyplot. This API provides direct access to Matplotlib's backend layers.

Sklearn

Scikit-learn (formerly scikits.learn and also known as sklearn) is a free software machine learning library for the Python programming language. It features various classification, regression and clustering algorithms including supportvector machines, random forests, gradient boosting, k-means and DBSCAN, and is designed to interoperate with the Python numerical and scientific libraries NumPy and SciPy. Scikit-learn is a NumFOCUS fiscally sponsored project.

Seaborn

Seaborn is a library for making statistical graphics in Python. It builds on top of matplotlib and integrates closely with pandas data structures. Seaborn helps you explore and under-

stand your data. Its plotting functions operate on dataframes and arrays containing whole datasets and internally perform the necessary semantic mapping and statistical aggregation to produce informative plots. Its dataset-oriented, declarative API lets you focus on what the different elements of your plots mean, rather than on the details of how to draw them.

Numpy

NumPy (Numerical Python) is a linear algebra library in Python. It is a very important library on which almost every data science or machine learning Python packages such as SciPy (Scientific Python), Matplotlib (plotting library), Scikit-learn, etc depends on to a reasonable extent. NumPy is very useful for performing mathematical and logical operations on Arrays. It provides an abundance of useful features for operations on n-arrays and matrices in Python.

Pandas

Pandas is an open source Python package that is most widely used for data science/data analysis and machine learning tasks. It is built on top of another package named Numpy, which provides support for multi-dimensional arrays. As one of the most popular data wrangling packages, Pandas works well with many other data science modules inside the Python ecosystem, and is typically included in every Python distribution, from those that come with the operating system to commercial vendor distributions like ActiveState's ActivePython.

Chapter 4

Result And Discussion

An automated system for COVID1-9 detection is beneficial for people living in remote areas.Convolutional Neural Network (CNN) have been quite successful in disease identification. Also by using pre trained CNN models on large scale datasets, important features can be learned which can be used in image classification. The efficiency of the model is rated high which in turn can be trusted by the patients. This can further help doctors to ease out their task and will also save their time. After the model is constructed, optimized using Adam optimizer and it's compiled using a categorical cross entropy loss function, batch size is given 32.Different approaches are used for avoiding over fitting. Firstly, the dropout method was used after fully connected layers . Secondly, data augmentation is used for avoiding over fitting.

4.1 Training and validation results

The model is trained for 100 epochs, with a batch size of 32 for the training phase which amounts to 18 steps per epoch for training and a batch size of 32 was employed for the testing phase which contributes towards 18 steps per epoch for testing. Thus, training for 100 such epochs yielded optimized results, with high accuracy of 95% for Xception and 93% for InceptionV3 and corresponding loss of 0.08%, 0.15% respectively for training. The given table 4.1 shows both models training and testing.

Model	**Training accuracy**	**Testing accuracy**
Xception	95%	91%
nceptionV3	93%	88%

Table 4.1: Accuracy of InceptionV3 and Xception

4.2 Performance metrics for validation phase

The below table indicates the performance metrics to calculate accuracy based on the classification results. Performance analysis is done to identify the best model having the highest detection rate. The general evaluation metrics such as Accuracy, Precision, Recall, F1 score and confusion Matrix are used. High accuracy here indicates the enhanced detection rate and reduced false alarm rate. The performance indicators includes: -

- True Positive (TP) is the number of correct classifications of attack category.
- True Negative (TN) is the number of correct classifications of normal category.
- False Positive (FP) is the number of incorrect classifications of attack category i.e., normal category wrongly classified as intrusive.
- False Negative (FN) is the number of incorrect classifications of normal category i.e.,attack category wrongly classified as normal.

The most important performance matrix is precision. Precision is the fraction of relevant instances among the retrieved instances of classification techniques. The precision value of the proposed Xception is superior to the InceptionV3 model.

Precision = T P/(T P+FP)

Recall is also one of the most common performance metrics to estimate the performance of the classification model. The recall is the fraction of the total amount of relevant instances that were actually the retrieved instance of the classification algorithm.

Recall = T P/(T P+TN)

In statistical analysis of binary classification the f1 score is a measure for testing accuracy. It considers both the precision and the recall of the classification algorithm to compute the f1 score.

F1score = precision Recall/(precision+Recall)

Performance metrics of both InceptionV3 and Xception and models are shown in table 4.2 and table 4.3 respectively.

InceptionV3	**Precision**	**Recall**	**f1-score**	**support**
Non-COVID 19	0.88	0.97	0.93	70
COVID-19	0.97	0.89	0.93	80
accuracy			0.93	150
macro avg	0.93	0.93	0.93	150
weighted avg	0.93	0.93	0.93	150

Table 4.2: Accuracy of InceptionV3

Xception	**Precision**	**Recall**	**f1-score**	**support**
Non-COVID 19	0.92	0.97	0.94	70
COVID-19	0.97	0.93	0.95	80
accuracy			0.95	150
macro avg	0.95	0.95	0.95	150
weighted avg	0.95	0.95	0.95	150

Table 4.3: Accuracy of InceptionV3

4.2.1 Confusion matrix

A confusion matrix is a table that is often used to describe the performance of a classification model(or "classifier") on a set of test data for which the true values are known. It allows the visualization of the performance of an algorithm. It allows easy identification of confusion between classes e.g. one class is commonly mislabeled as the other. Most performance measures are computed from the confusion matrix. The important terms included in confusion matrix are as following:

- True Positive (TP) :Observation is positive, and is predicted to be positive.
- False Negative (FN) : Observation is positive, but is predicted negative.
- True Negative (TN) : Observation is negative, and is predicted to be negative.
- False Positive (FP) : Observation is negative, but is predicted positive.

The confusion matrix of InceptionV3 and Xception is shown in Fig 4.1 and Fig 4.2 with samples of CT images :

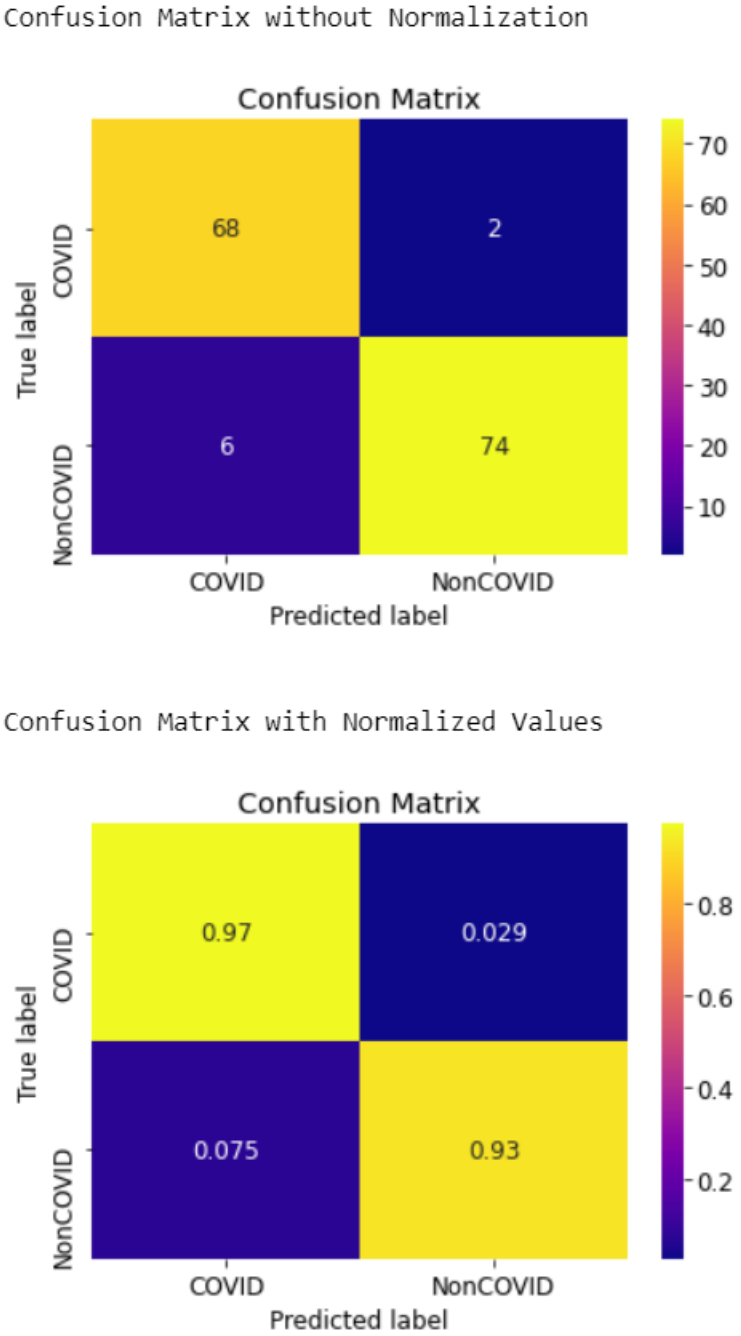

Figure 4.1: Xeption :Confusion Matrix without Normalization and Confusion Matrix with Normalized Values

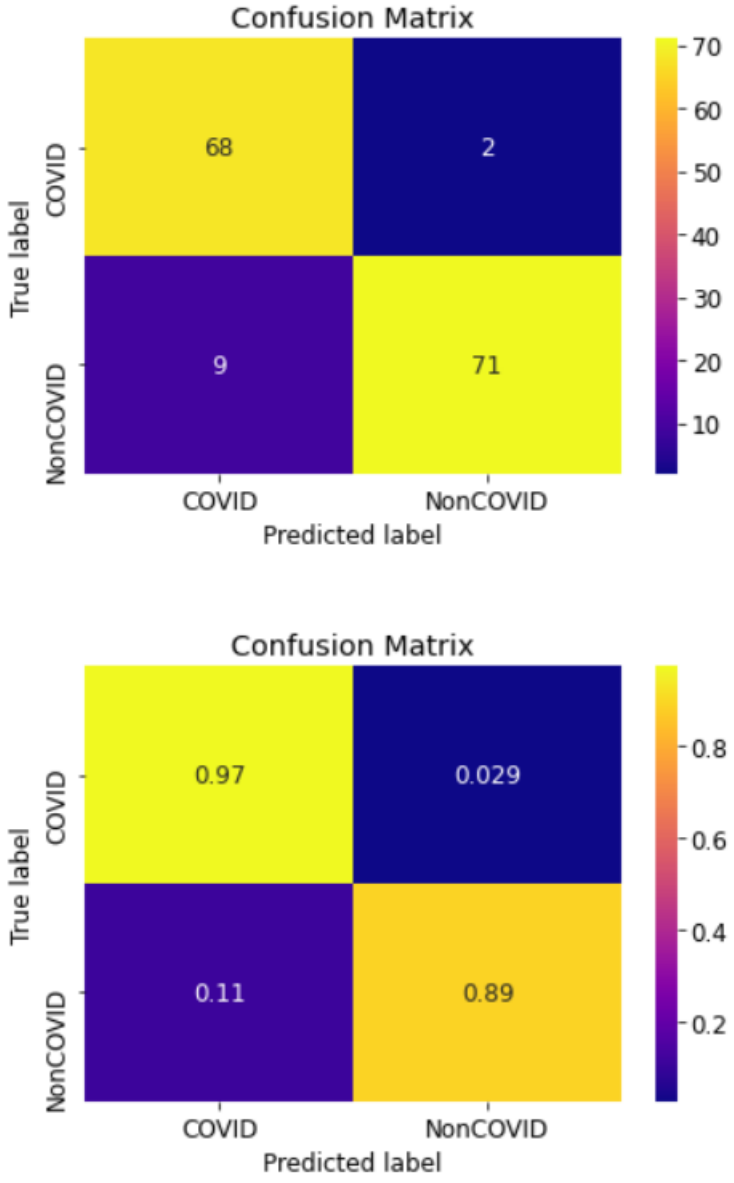

Figure 4.2: InceptionV3 :Confusion Matrix without Normalization and Confusion Matrix with Normalized Values

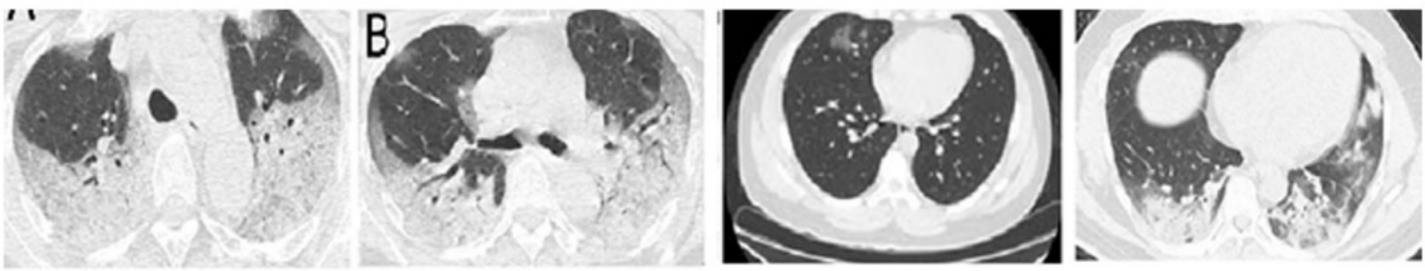

Figure 4.3: Examples of CT COVID-19 images

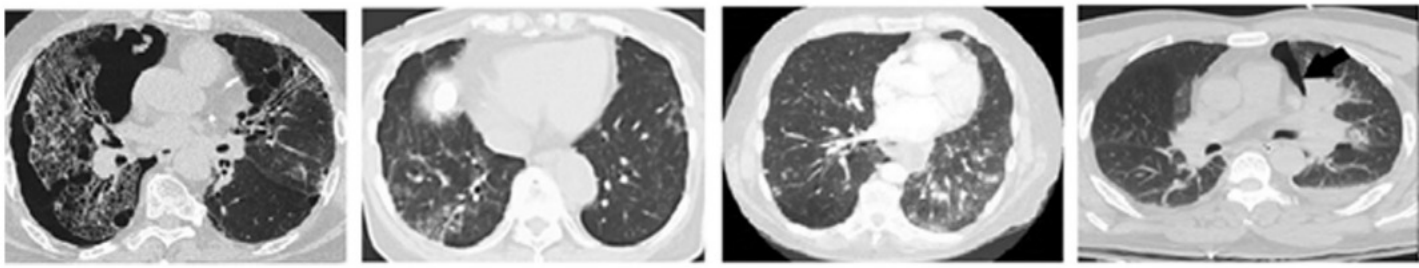

Figure 4.4: Examples of CT Non-COVID 19 images

Chapter 5

CONCLUSION

Therefore, it is concluded that the deep learning model proposed classifies the CT scans for COVID-19 diagnosis in a very accurate manner. The loss of the model is minimized while training and the accuracy simultaneously increases through each epoch stages in order to yield distinct results for classifying the COVID affected and non-affected individuals. The data augmentation and pre-processing stages help to ensure that the performance of convolutional neural networks and deep neural networks is not subjected towards over fitting, thus the results obtained will always remain coherent. With a smaller number of convolutional layers, the proposed model predicts adroitly whether a given sample of CT scans has COVID-19, or is normal. This is immensely helpful in the medical field for early and accurate diagnosis for COVID in patients. Early diagnosis is of paramount importance in saving a person's life, by ensuring effective and timely treatment of the patient.

5.1 Advantages

The main merits of proposed model are:

- No need of an expert knowledge to identify the disease.
- Early diagnosis of disease.
- The system provide more accuracy and efficiency for COVID-19 detection.

5.2 Future Enhancement

This project has an immense scope in the field of medicine and health care and can be continued for other such insightful innovations. Future work will be concentrated on improving the architectures used and other deep learning models moreover,this study can be extended to detect the severity of COVID-19 in patients which has affected many people across the globe.

References

[1] AswathyA.L,AnandHareendran.S,Vinod ChandraS.S, "COVID-19 diagnosis and severity detection from CT-images using transfer learning and back propagation neural network " ,Journal of Infection and Public Health 14 (2021) 1435–1445,Elsevier.

[2] Hemdan EE-D, Shouman MA, Karar ME. " Covidx-net: a framework of deep learning classifiers to diagnose COVID-19 in X-ray images", 2021,IEEE .

[3] Wang L, Wong A. " Covid-net: a tailored deep convolutional neural network design for detection of COVID-19 cases from chest radiography images" , nature research,2021,Scientific Reports,.

[4] N Borakati A, Perera A, Johnson J, Sood T." Diagnostic accuracy of X-ray versus CT in COVID-19: a propensity-matched database study", BMJ Open 2020, IEEE .

[5] He X, Yang X, Zhang S, Zhao J, Zhang Y, Xing E, et al. "Sample-efficient deep learning for COVID-19 diagnosis based on CT scans". MedRxiv ,2020, Yale University, The BMJ, Cold Spring Harbor Laboratory.

[6] Zhao J, Zhang Y, He X, Xie P. "COVID-CT-Dataset: a CT scan dataset about COVID-19", 2020

[7] Loey M, Smarandache F, Khalifa NEM." A deep transfer learning model with classical data augmentation and CGAN to detect COVID-19 from chest CT radiography digital images" 2020. Preprint.

[8] Liu B, Gao X, He M, Liu L, Yin G." A fast online COVID-19 diagnostic system with chest CT scans." Proceedings of KDD 2020, New York 2020.

[9] Wang X, Deng X, Fu Q, et al." A weakly-supervised framework for COVID-19 classification and lesion localization from chest CT." Trans Med Imaging 2020,IEEE.

[10] Pathak Y, Shukla PK, Tiwari A, Stalin S, Singh S, Shukla PK. "Deep transfer learning-based classification model for COVID-19 disease", IRBM 2020.

[11] Han Z, Wei B, Hong Y, et al." Accurate screening of COVID19 using attention-based deep 3D multiple instance learning". Trans Med Imaging 2020,IEEE.

[12] Harmon SA, Sanford TH, Xu S, et al. "Artificial intelligence for the detection of COVID-19 pneumonia on chest CT using multinational datasets".Nat Commun 2020..

APPENDIX

Screenshots

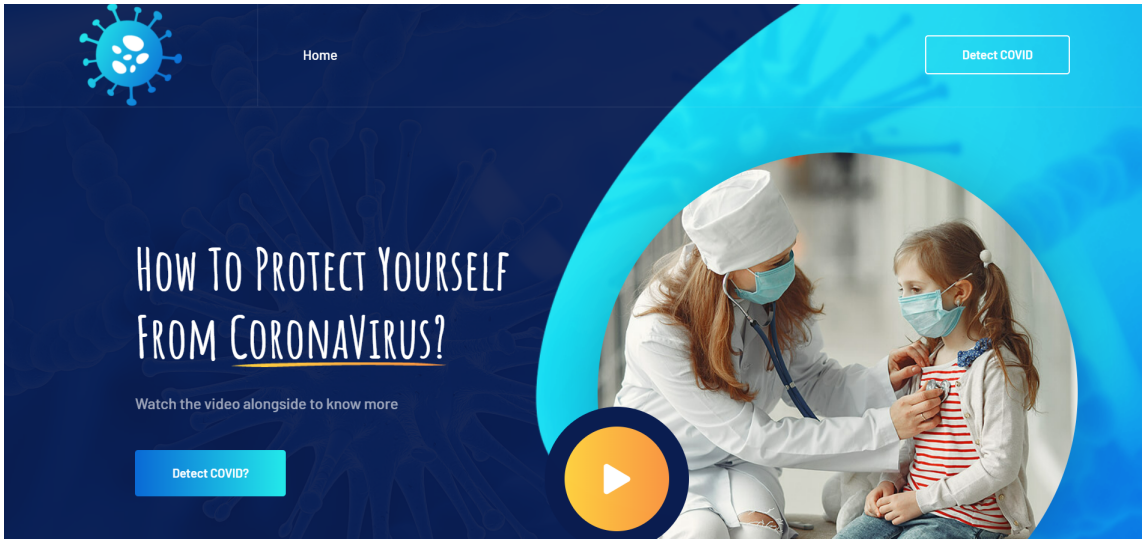

Figure A.1: Home page

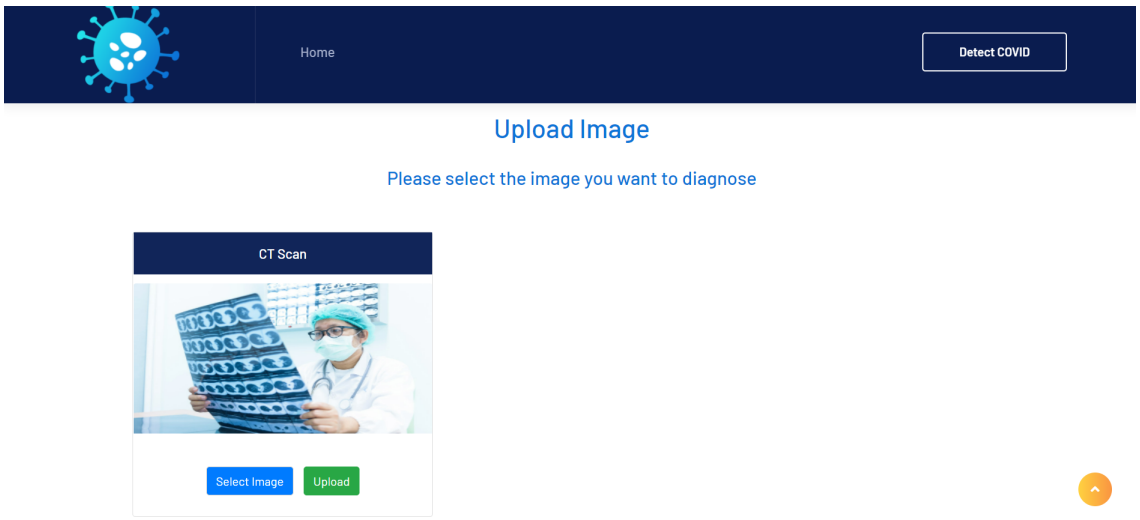

Figure A.2: Upload image

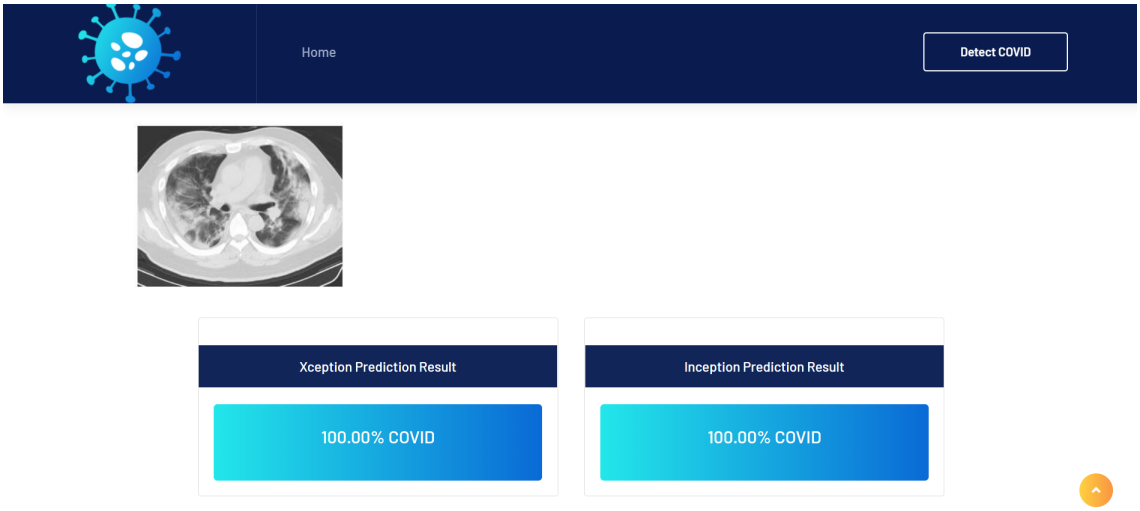

Figure A.3: Predicted as Covid-19 Image

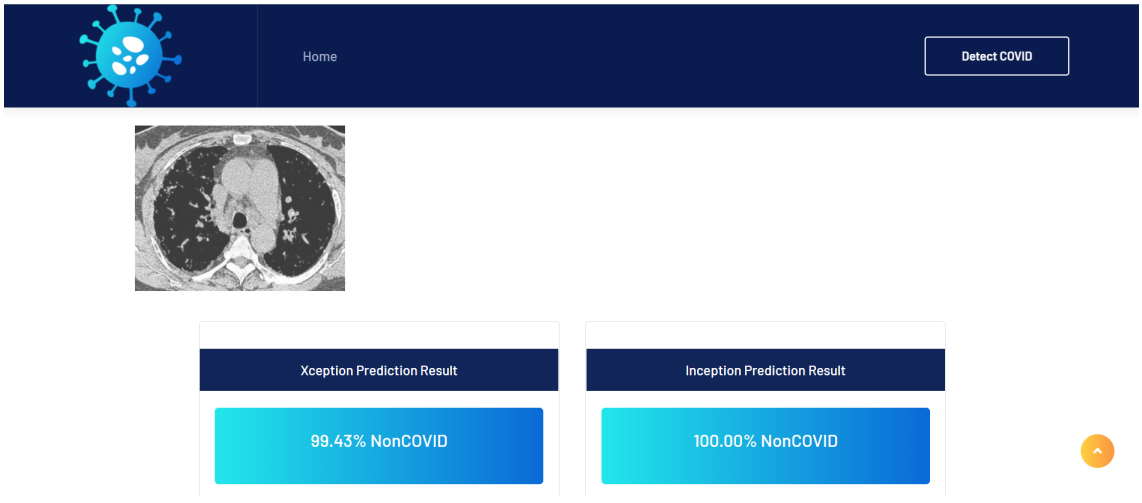

Figure A.4: Predicted as Non-Covid-19 Image