Automated Covid-19 Symptoms Prediction using Machine Learning

A Dissertation

Submitted in Partial Fulfillment of the Requirements for the Award of the Degree of

Masters of Technology

In

Information Technology

BY

TANVEER SINGH 2K20/ISY/21

UNDER THE SUPERVISION OF

Dr. JASRAJ MEENA

Assistant Professor,

Department of Information Technology,

DELHI TECHNOLOGICAL UNIVERSITY, DELHI

DELHI TECHNOLOGICAL UNIVERSITY SHAHBAD DAULTAPUR,

MAIN BAWANA ROAD DELHI, 110042

DELHI TECHNOLOGICAL UNIVERSITY

STUDENT DECLARATION

I, Tanveer Singh of Information Systems department, hereby declare that the thesis titled "Automated Covid-19 symptom prediction using Covid-19" is submitted by me in partial fulfilment of the requirement for the award of degree in Information Systems (Masters) is original and not copied from any source without citation. This work has not previously formed the basis for the award of and Degree, Diploma Associate ship, Fellowship or any other kind of similarity in title or recognition.

DATE- May, 2022

PLACE- New Delhi Tanveer Singh 2K20/ISY/21

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CERTIFICATE

This is to certify that Mr. Tanveer Singh (2K20/ISY/21) has finished the major project titled "Automated Covid-19 symptom prediction using Machine Learning" as a partial fulfillment for the award of Master of Technology degree in Information Systems by Delhi Technological University under my supervision and guidance during the academic session 2020-2022.

Dr. Jasraj Meena

(Project Guide)

Assistant Professor

Department of Information Technology

Delhi Technological University

Bawana Road, Delhi-110042

DELHI TECHNOLOGICAL UNIVERSITY

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Tanveer Singh 2k20/ISY/21

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Abstract:

Covid-19 has been the center of attention of the world since the end of 2019 due to the nature of its effect of the human race as a whole. Not only in the medical field, it has also affected the economic as well as social lives of billions of people around the world and may arguably be the most devastating epidemic in the recent century. Hence, the human race has gotten together in an attempt to prevent the spread of the virus and to find a cure for it as soon as possible. Many scholars and individuals from many fields have been working non-stop to help ease the situation. Similar work is being done in the field of Data Science and Machine Learning. As for this field, various Models and algorithms have been developed and implemented of various different datasets. Some of these models have been implemented using Deep Neural Network. We will try to attempt some of the models and fine tune in a way to achieve maximum efficiency. These will be measured using Recall, Accuracy, Precision and Loss and then the results of these combinations can be useful for custom based situations.

Chapter 1-Introduction:

Ever since the start of 2020, the world has fallen into a mess due the virus that originated in Wuhan and spread its fangs around the world leaving behind no country. Covid-19, as the term indicated is a version of the SARS-Covid virus that originated in the year 2019. It impacted the lives of billions of people, killing around 6.2 million people according to the estimates of the World Health organization. Recent Estimates have shown the daily cases to reach as high as 5000 per million [2] as shown in Fig. 1. It lies in the category of respiratory illness which has other non respiratory symptoms which include fever, loss of taste, fatigue and much more. But the main concern that covid-19 poses is its easy transmissibility that can spread as easily as a simple cough. Due to this reason, governments all over the world imposed heavy lockdown laws and caution an intense isolation strategy. Even after all the efforts by the governments of the world, the virus still continues to persist. The vaccines weren't available to the public for as long as 1.5 years and are still not available in some countries of the world. It has caused the economic imbalance in many countries and destroyed the lives of many. First Vaccine to COVID-19 disease is Sputnik V which was developed by Russia. After which India also developed two vaccines.

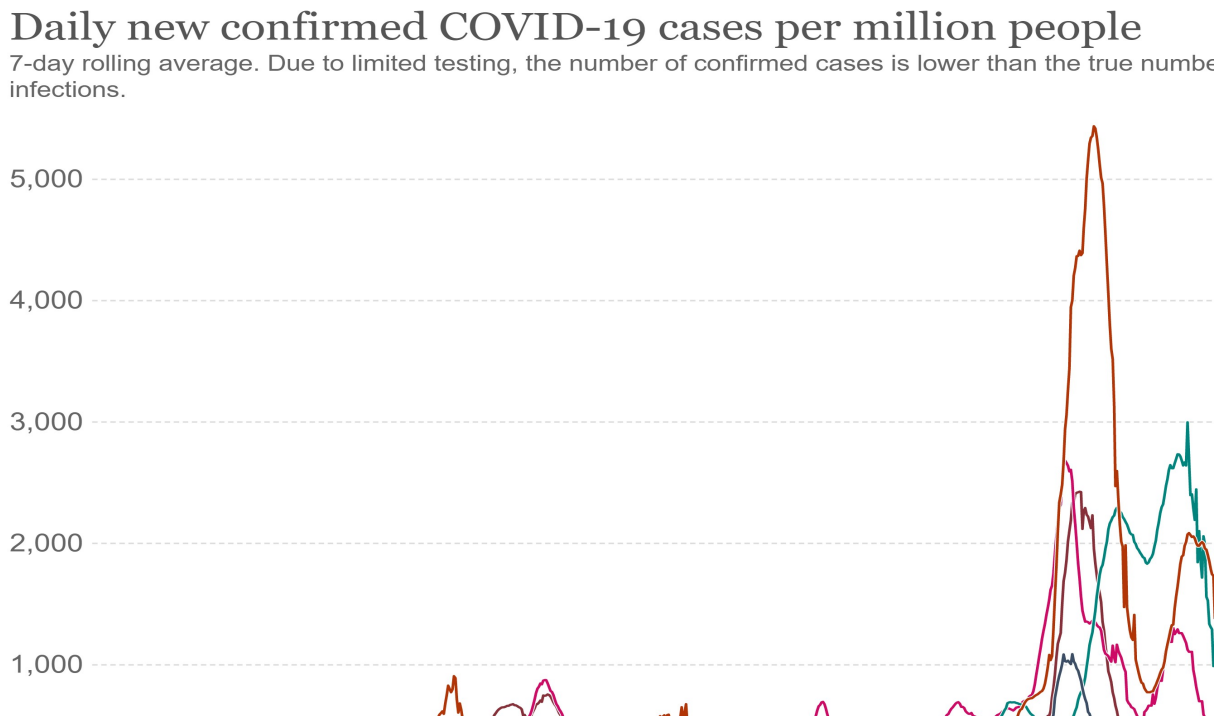


Fig.1 Confirmed daily cases per million people

The major symptom of the COVID-19 is a severe case of pneumonia in the lungs. Thus, the need to quickly test and identify the infection in the host is crucial for the survival of the host. Many tests have been developed in order to quickly identify the virus. One of these methods is "Reverse transcription-Polymerase chain reaction" but, this method has proven to be slow, costly and there were so many instances where it was not that much effective. If the diagnosis part takes ample time then there will be less time for treatment.

Other methods are X-Ray and "Computed Tomography" scans which are more accurate than the RT-PCR and are less time taking. Using X-Ray we can easily take the images of patient's lungs, which will take less time to diagnose the disease and further process to be started and X-Ray is very economical too. This method is easily available in almost every hospital or clinic.

1.1-Motivation:

The major motivation and objective behind this thesis is to study the already existing methods available and improve upon those methods. It is also important that the methods proposed can be implemented in practical situation efficiently and not just in theory. The country has already seen some of the worst that this virus has to offer and undergone a complete lockdown and several partial lockdowns which have devastated the lives of many and done an irrecoverable damage in many areas. Apart from vaccination, the only measure of defense is a preventive one and for that, proper testing of all the suspected individuals must be done.

Table.1 JHU CSSE COVID-19 DATA

Location	Cases	Deaths
Delhi	19L 19,00,000	26,200
Maharashtra	78.8L 78,80,000	1.48L 1,48,000
Tamil Nadu	34.5L 34,50,000	38,025
Odisha	12.9L 12,90,000	9,126
Telangana	7.93L 7,93,000	4,111

Andhra Pradesh	23.2L 23,20,000	14,731
Karnataka	39.5L 39,50,000	40,106
West Bengal	20.2L 20,20,000	21,203
Madhya Pradesh	10.4L 10,40,000	10,735
Rajasthan	12.9L 12,90,000	9,554
Gujarat	12.2L 12,20,000	10,944
Chhattisgarh	11.5L 11,50,000	14,034
Kerala	65.5L 65,50000	69543
Haryana	10L 10,00,000	10,621
Bihar	8.31L 8,31,000	12,256
Uttar Pradesh	20.8L 20,80,000	23,518
Punjab	7.6L 7,60,000	17,751
Assam	7.24L 7,24,000	7,986
Jammu and Kashmir	4.54L 4,54,000	4,752
Uttarakhand	4.38L 4,38,000	7,693
Jharkhand	4.35L 4,35,000	5,318

Of course, many methods for testing are available but, we need to be smarter, faster and more efficient in order to outmatch a virus of this scale. For that purpose, researchers all around the world have developed many machine learning algorithms and AI solutions to the present situation. Many such datasets have been gathered in order to simplify the task of these researchers. One such dataset is the X-ray Pneumonia dataset containing the X-ray images of unaffected lungs and infected lungs. By using this

dataset, many models have been implemented and these models give their own result depending on their efficiency. The aim of this study will be to implement one such model and see if it can outperform the existing methods to provide a better solution. The reason we chose X-ray of other forms of testing is its easy accessibility in a developing country such as ours. Below are some of the reasons:

- Compared to the other testing methods such as "Reverse transcription polymerase chain reaction" (RT-Pcr), X-ray has an inherent advantage of minimal contact. X-ray can be done in a complete isolation space requiring minimum contact so there is less use of professional PPE kits and minimal contact. This ensures that the front line health workers will not be exposed to the risk of getting infected.
- Chest X-ray, unlike other testing procedures is comparatively faster, especially due to its procedures being done in one place. The testing, checking of the result and printing can all be done in one place hence, minimizing the cost and resources that would otherwise be spent.
- When you look at the whole picture, it is comparatively faster than other methods and also cheaper than any other Covid-19 kit available in the market and with deep learning, it can be reduced even further.

Moving forward, we can see that the X-ray dataset has many uses in the field of DL and ML and if used properly, it can be a boon to the current situation of epidemic. The motivation is to use one such CNN model in a way that we can classify the images into an infected and not infected one. Doing so will further reduce the time needed for proper analyzation. The more accurate result that our model predicts, the better would be in terms of real life applications. Many researchers have already applied a wide variety of ML algorithms. We will be discussing those methods and models in great detail in the further sections. Some of those models are GoogleNet, AlexNet, ResNet, XCeption.

1.2 Thesis Organization:

The whole thesis can be broadly divided into 5 different subsections. Each of these sections will be explained briefly in order to understand the whole thesis:

- The introduction part of the thesis defines the basic summary of what it is that we are trying to achieve through this study. A little bit about the history and statistics of the Covid-19 virus have also been explained. The introduction also talks about the basic motivation behind the study and why it is so important to improve the efficiency and how it will be beneficial to the scientific community.

- The next part talks about the literature review. This is one of the most important parts of the thesis as we have to look through the already existing researches done in the same field, look at their approach towards a particular problem and analyze and assess their result in order to avoid any sort of redundancy in our work and move forward with a better direction in mind. The literature review also explains the types of models used and how they performed.
- Proposed techniques contain the models and parameters proposed by us that have given a significant result in the pursuit of our problem. The models proposed in this thesis are Resnet50, Inceptionv3 and Mobilenetv2.
- Finally, the results have been presented along with a conclusion to the whole thesis and well as the parameters upon which the result has been calculated.

Chapter 2-Literature Review:

We have tried to look at a variety of different research papers in the field of covid-19 and since, the study is fairly recent, the dataset present on the matter are limited, but not to the point that it will impact the research. A large number of these dataset have used the image chest X-ray dataset and applied transfer learning using open source CNN architectures. Along with their hyper parameters, these models and architectures can be found publicly [1].

But some of these researches have outdone themselves and used their own novel approaches in order to achieve desired results. Some of these however, might not be as efficient as the mainstream models but they are useful all the same. We will be discussing some of these approaches and their general structure in the subsequent section in order to achieve an in depth understanding of all the possible variations.

2.1-Classification Task Formulation:

The results are presented upon categorizing the data of the X-ray images into three categories which are test, train and val. These are each further divided into pneumonia i.e. covid infection in the lungs and normal folders. One can easily identify the infected images from the normal ones if one looks at the focal lobar consolidation. The result will be shown in the form of train_loss, valid_loss, accuracy and time. The accuracy factor is expected to be better when compared with other traditional models.

Many researches divided the image dataset into 4 classes which is under multi-class classification. These 4 classes are “Bacterial Pneumonia”, “Viral Pneumonia”, “Healthy”, “Not found”. Similarly, the 3-class classification includes all the above parameters except for the fact that bacterial and viral pneumonia have been superimposed into one single classification that is “Covid-19”.

Table.2 Different Datasets pertaining to Covid-19 images

Number	Author Name	Name	Description	Covid-19 samples
1	J.Paul Cohen[3]	“COVID-19 Image Data Collection”	“Public CXR images of COVID-19 that have been collected from numerous online sources with periodic updates”.	>5000
2	A. Narin[7]	“COVID-19 CXR	“CXR images of COVID-19”	

		Dataset Initiative" (COVIDx)		>5000
3	L. WANG[5]	"ActualMed COVID-19 CXR Dataset Initiative"	N/A	>13000
4	M.M. Rahman Khan[20]	"COVID-19 Radiography Database"	"CXR images with COVID-19 positive cases"	>2000
5	X. WANG[9]	"Chest X-ray 8 Chest X-ray14"	"Contains 112,120 frontal-view CXR images of patients also known as the NIH CXR dataset and RSNA Pneumonia Detection Challenge Dataset."	>30000

2.2-Transfer Learning:

Neural network models generally require a large amount of resources and computing time in order to develop on problems. J. Zhang at **[6]** trained the model beforehand to reduce the time it would take overall. Hence, transfer learning comes as a sort of catalyst to the whole process. A pre-trained CNN model might be as good as, or even perform better that a CNN model that has been custom trained. Due to the limited availability of the datasets, Transfer learning has been rigorously used by studies to make use of the available images. If you look at the whole picture, you can categorize these studies into a total of 3 groups **[10]** as shown in Fig. 2. When you look at the 1st one, it pre-trained the CNN model in a similar dataset so that the quantized values of the network can be instantiated. This can significantly reduce the time and resources taken to train on image dataset as used in **[7], [13].**

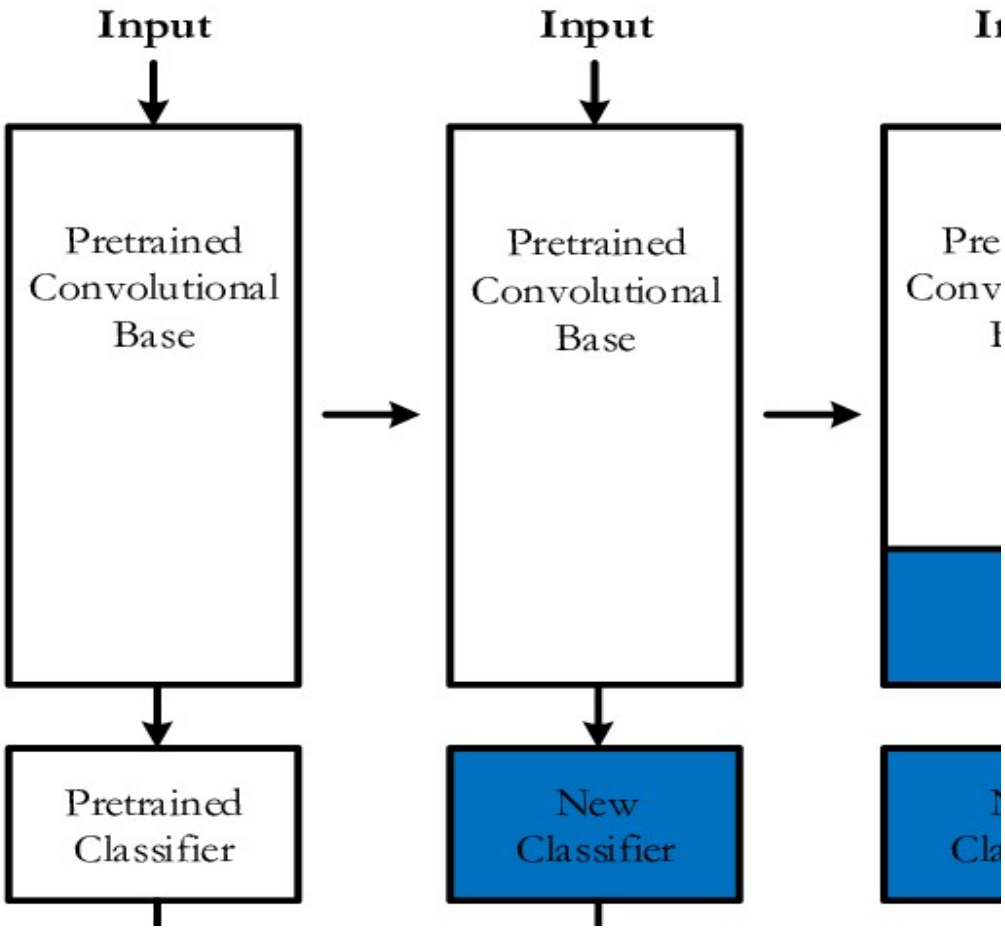


Fig. 2 Transfer learning types used for CNN

The second study was based on the foreknowledge that the early layers of the convolution neural network were not so custom based and could be generally used. So, their weights were kept unchanged and they were kept frozen and the later layers were tuned according to the model.

The third claim was a bit more interesting as it supported the theory that the model could be pre-trained on a similar domain dataset and then can be used on the target dataset. However, these claims are not all favorable as some studies opposed this claim. About half of the studies were in favor and the other half in opposition. So, it could be said that it's a situational based task.

2.3-CNN Architectures:

CNN architectures have come a long way since inception in terms of efficiency and a wide range performance, especially in the field of pathogens and image processing of medical records. 1998 was the year when the first CNN model was successfully executed on handwritten digit recognition. As shown in

R.M. Rawat at **[22],** many CNN architectures were used to find the precision, recall, accuracy and f1 score. MobileNet performed the best. It was termed as LeNet. It wasn't as complex or fast as the current architectures as it had only two fully connected, two average and three convolution layers as shown in **[11]**. Below are some of the architectures described that were used in COVID-19 studies.

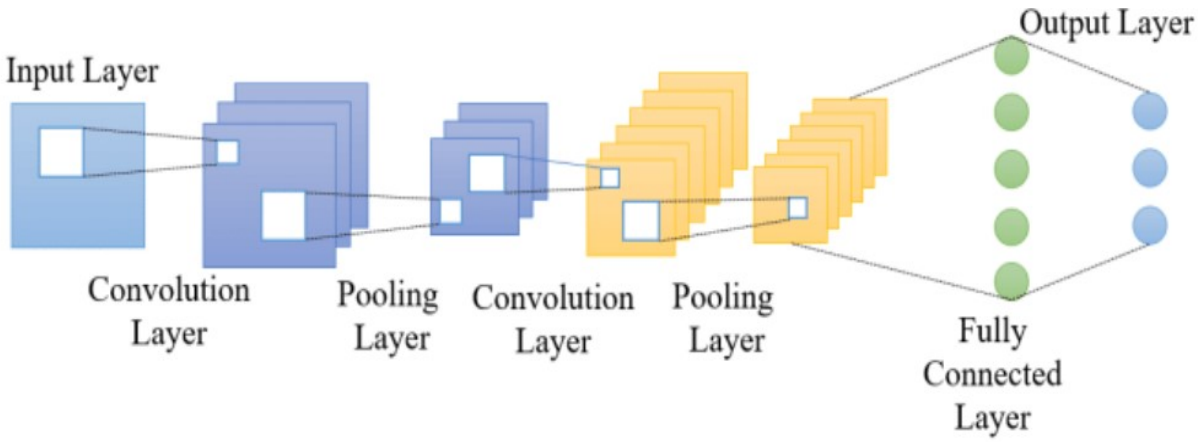


Fig. 3 Convolution Neural Network Layers

2.4-AlexNet:

Consisting of a total of 5 layers in which 5 are convolution layers, this architecture has been made up of a total of five layers. AlexNet was used in different scenarios with different types of pooling layers in *Shadman Q. Salih at* **[21].** *Tao Wang at* **[22]** 8 layer model of AlexNet was built and the result was measured in accuracy and recall. The accuracy came out to be **90%.** Some of the interesting features that make AlexNet really special are

1) **Multiple GPUs:**

   The days when around 2Gb of GPU memory was considered a big deal is now gone and dataset containing millions of image have appeared that have outmatched the GPU functionality of today. AlexNet provides a simple solution in a way that it divides the model's neurons into multiple GPUs which helps a lot with reducing the training time and also reducing the load on GPUs.

2) **ReLU Nonlinearity:**

Instead of using the standard tanh function, it used Rectified Linear Units (ReLU). A CNN that uses Relu was 6 times faster than the CNN using tanh on the CIFAR-10 dataset. So, it is definitely better in terms of speed.

2.5-Xception:

The full form of Xception is the Extreme version of Inception and is a modified form of the depthwise separable convolution. This model far outperformed Inception-V3 in every aspect when it was executed on image classification comprising of 17,000 classes and 350 million images. In this, a special layer replaces the IM which is call the depth-wise separable convolution. The main benefit of using this type of architecture is that the computational cost would be drastically reduced, accuracy is severely enhanced and you even need less parameter on the ImageNet dataset. When comparing with the original, there are quite a few differences, 2 of which are listed below:

- Xception performs a channel-wise spatial convolution before the 1x1 convolution which is the complete opposite of the original depth-wise separable convolution which implements the former first and then the latter.
- The second difference occurs in the ReLU non-linearity where the original Inception module shows non linearity whereas Xception does not[13] as shown in Fig. 4.

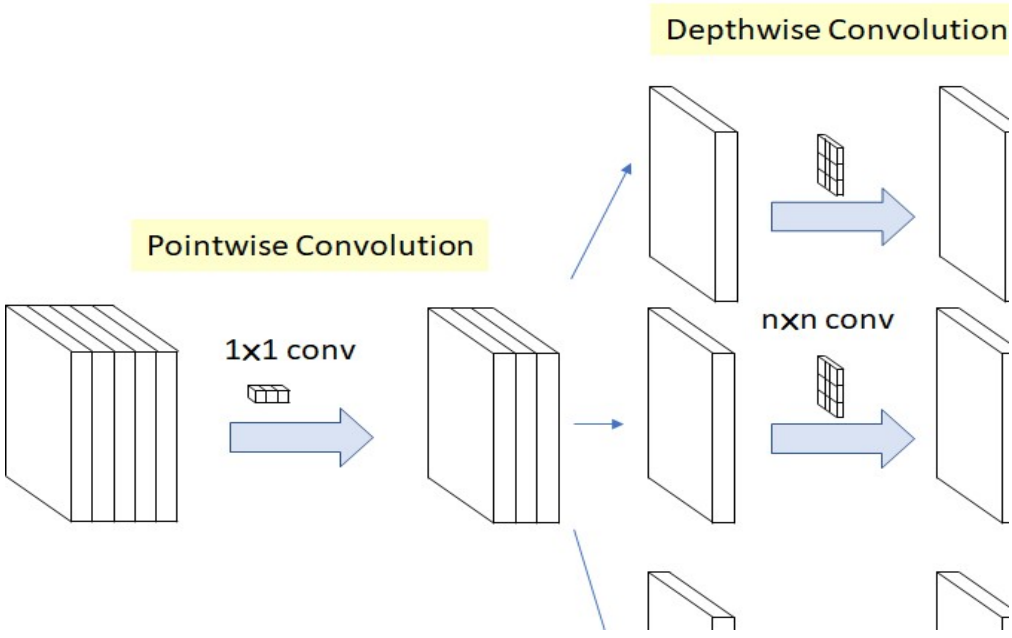


Fig.4 Modified depth-wise convolution used as inception model in Xception

2.6-Fast.ai:

Fastai model was developed under apache 2.0 license along with 676 contributors. This model was developed in Jupyter Notebook using the languages Python, CSS, HTML, JavaScript and Makefile. In the domain of deep learning domains, fastai is a library that can provide optimal results to practitioners having a comparatively high level of components and provide the low level components to researcher so that they can be mixed and matched accordingly. A block diagram at [12] is shown below:

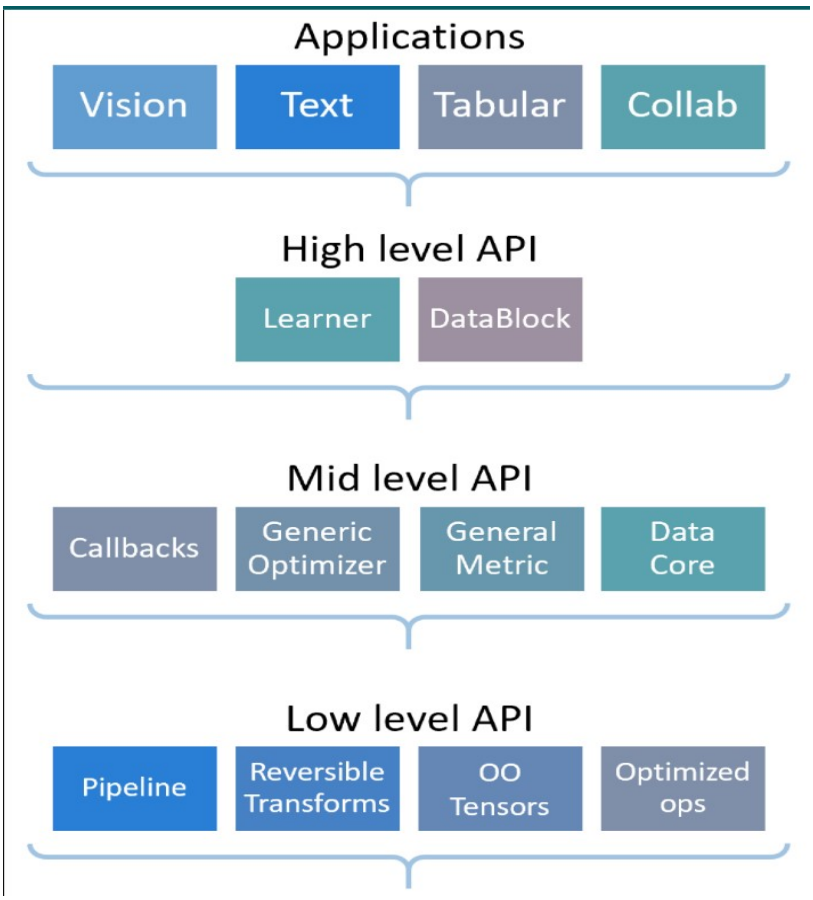


Fig.5 Process flow diagram of FASTAI model

The goal here is to achieve a perfect balance between the performance, flexibility and ease of use for the researcher. Along with this, a new type of semantic hierarchy is provided for tensors in python along with a new type of dispatch system.

Some of the features of fastai are:

- It also contains a computer vision library which is specifically GPU optimized and can also be extended for pure python.
- Now, a completely novel system based on the 2-way call back that can optimize or access any random part of the data and alter it without any timing, the new optimization algorithms can be written in 5-6 lines of actual code and a lot of other things can be done using fastai.
- Data block API is fairly new.

2.7-Residual Networks (ResNet):

This design first proposed the idea of a residual network in order to address the issue of the vanishing or expanding gradient of AlexNet. Within this particular network, we can make use of a method known as skip connections. The skip connection links straight to the output rather than going through the training for the first few layers.

In lieu of the layers learning the rudimentary depiction, this network can be made to fit to the remaining mapping. This is the technique that lies behind this network.

The CNN architecture received an addition in the form of a lingering learning constituent thanks to ResNet [43]. The residual unit, often known as the RU, is made up of a standard layer and a skip connection. The ResNet algorithm may also be implemented with 34, 50, or 101 layers.

2.8-VGG-16:

The ILSVRC ImageNet Competition, often known as the ILSVRC, is a competition that takes place annually in the field of computer vision. Two challenges are set for competitors to tackle every year. The first step is termed "object localization," and it involves locating items inside an image that belong to one of 200 different classifications. The second step is to identify each image with one of a total of one thousand different image classifications. K. Simonyan along with A. Zisserman at Oxford University published their idea for VGG16 in the study "VERY DEEP CONVOLUTIONAL NETWORKS FOR LARGE-SCALE IMAGE RECOGNITION" in 2014. During the ILSVRC challenge, this model became the winner and runner-up in each of the aforesaid categories.

$$E = 1/\mathrm{n}\ \Sigma_k\ min_i\ d(c_i, G_k)$$

Where d = 0 if $c_i = G_k$

The picture in its dimensions is what the network receives as its input. The starting 2 layers each include sixty four channels with a sieve size 3 by 3, each use the identical padding. Then two convolution layers of 256 and filter size follow a max pool layer with a stride of (2, 2) afterwards (3, 3). After it, there was a layer with a maximum pooling stride of two and two, which was identical to the layer that came before it. After that, there are two convolution layers with filter sizes of two hundred and fifty six and 3 for a total of two hundred and fifty six. After that comes a max pool layer, which is followed by two sets of three convolution layers. In these convolution and max pooling layers, the filters that we utilize have a size of 3*3, but in AlexNet and ZF-Net, those sizes are 11*11 and 7*7 respectively. This is done in some of the layers. To avoid the spatial features of the picture from being affected, a padding of one pixel is added after each convolution layer. This padding is the same each time.

Table.3 Methodologies implemented in different studies

Research Study	**Dataset(s)**	**Contributions**
[6]	[3],[9]	In order to classify COVID-19 images, the author used anomaly detection and generated a scalar anomaly score. The benefit of this is that it will provide a large classification score to the images.
DeTraC	[3], [14]	Using the k-nearest neighbor model, the classes were further decomposed into sub-categories and then the author applied transfer learning on these classes and error correction criteria was used in order to further refine them.
COVID-DA[15]	[3],[9],[8]	In this study, domain knowledge was transferred from well labeled domain (source) to a partially labeled domain (destination).
CoroNet[17]	[3], [9]	Feature extraction was done using Autoencoders

[18]	[16]	Class imbalance problem was solved using SMOTE

Chapter 3-Proposed Approach:

The problem we are trying to solve is a classification one in which we are categorizing Chest-X-ray input depending upon the presence of pneumonia infection. Many deep learning models have developed to the point that they can accurately predict up to some point in some very complex problems using only raw dataset and can also deduce the information hierarchy on all levels. We have applied a total of 3 models and based on those models, we have calculated the accuracy, precision, recall and loss.

The basic architecture of MobileNetV2 is different from the traditional residual model that uses expanded depiction in output and input. MobilenetV2 follows inverted residual model in which residual blocks of input and output are thin bottleneck layers.

In MobileNetV2, while filtering intermediary expansion layer features, it makes use of lightweight convolutions in the depth wise direction. Eliminating non linearity in thin layers is necessary requirement for keeping the emblematic power they provide of MobileNetV2. An insight was provided that led to the development of this design and provide evidence that demonstrates that this enhances performance. Finally, it enables the input and output domains to be decoupled from the expressiveness of the transformation, which provides a practical foundation for more research. VOC picture segmentation, COCO object Identification and Image-net classification are benchmarks that we use to evaluate our performance. Specifically, we focus on the number of multiply-adds (MAdd) and the number of parameters.

3.1-Model Architecture:

The model architecture is quite simple, yet uses a pretty complicated combination in order to achieve the best results. A total of three models have been used in this study which are resnet50, mobilenetv2 and inceptionv3. These will be further implemented on either imagenet weights or None. The blockwise tuning will also be done either true or false making the whole combination multiplied by 2. So, when we look at the total combinations that have to be run, it'll be around 3 x 4 = 12 combinations. Each of these combinations will give a score of accuracy, precision, recall and loss. The study will find the best result out of these 12 in order to optimize the solution.

Chapter 4-The Experimental Approach:

Now that we have made our approach clear, it is important to look at the approach with which we will move forward. First of all, the specifications of the system that will be used for running these models are:

- Inter core I5 9th Generation Processor
- The RAM of the system is 8GB
- The System has a Hard disk capacity of 512GB
- The code is run on Colab with the GPU setting ON and took around 2-3hours to run for the whole program

Since data analysis is the final step in the process of evaluating, cleaning, converting, and modelling data with the purpose of locating valuable data, reporting conclusions, and providing support for decision making, it is the critical stage with the objective of preserving the best from the waste produced by the process.
The intricacy of the data and the way it is presented is one of the key reasons for performing an analysis on it, along with ensuring that the data is accurate and has all of the necessary variables.

4.1-Dataset:

Chest-X-Ray images (Pneumonia) dataset from Kaggle which has two categories which includes one without any sort of opacification in the X-Ray image. For viral pneumonia i.e. the case of SARS-Covid, both lungs exhibit a pattern of interstitial diffusion of the infection. The dataset has a total of 2 GB image data which can be subcategorized into 3 folders namely train, test and val (validation). These are each subdivided into “Pneumonia” and “Normal” subfolders. These images are a group of anterior-posterior images collected from pediatric patients that were taken as a part of their usual care routine. In order to provide an unhindered and high efficiency analysis, all the low quality images were removed and these radiographs were screened.

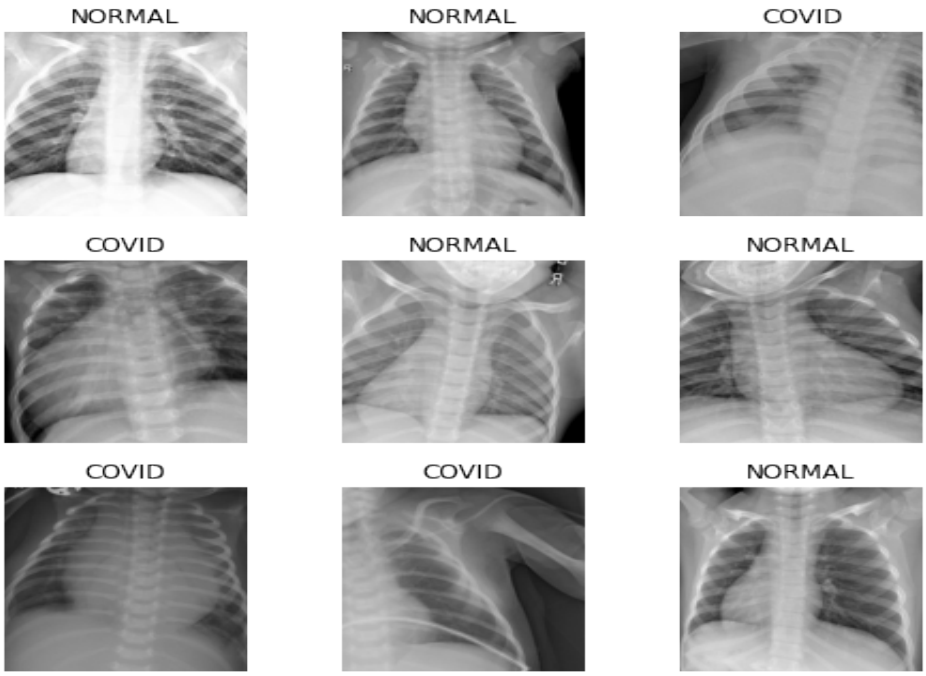


Fig. 6 Chest X-Ray dataset from Kaggle

4.2-Model Results:

Accuracy metric is utilized to quantify the efficacy of an algorithm in a manner that is understandable. The accuracy of a model is often estimated in the form of a percentage once the model parameters have been determined. This process typically comes after the model has been validated. It is the degree to which your model's forecast corresponds to the actual data when compared to those data.

4.3-Loss:

A flawed forecast leads to an undesirable outcome. Loss refers to inaccuracy in the model forecast when applied to a data point.

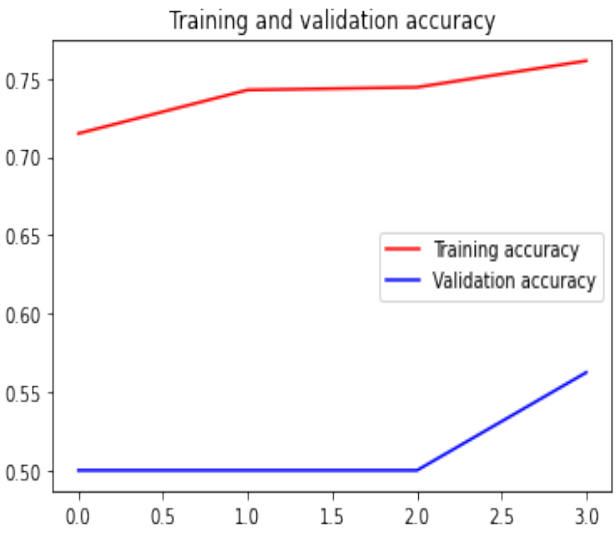
In the event that the model's forecast is spot on, there will be no loss; in all other scenarios, the loss will be bigger. Finding a set of biases and weights for a model having small loss value on average, among all the training instances is the purpose of the training process. Any model will perform poorly (provide an inaccurate prediction) if it has a higher loss.

The interpretation of the loss depends on how well the model is doing for training data and validation data. Loss is estimated based on both sets. A loss, in contrast to accuracy, is not expressed as a percentage. It represents the total number of mistakes that were committed across all of the examples in the validation or training sets.

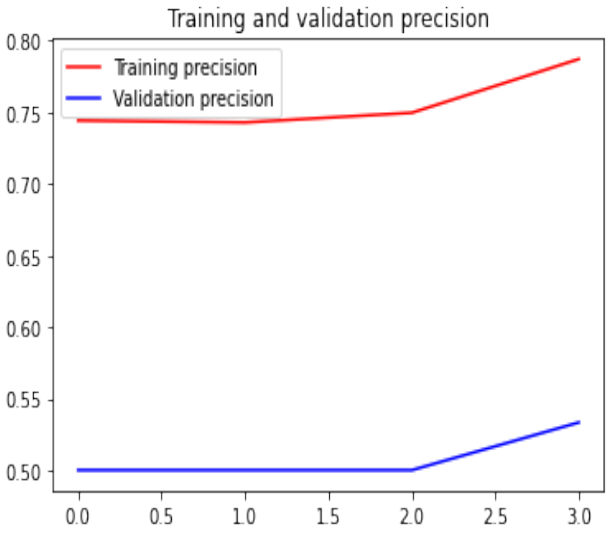
4.4-Recall:

The recall is determined by the ratio of true positive samples to the total number of samples. This ratio is then multiplied by 100. The model's capacity to recognize positive samples is evaluated using the recall metric. The recall is directly proportional to the number of samples which are positive.
The one below uses ResNet50 model. A total of 4 combinations were tried on this model and the best results were obtained with None weights and block-wise tuning as False

1) **Resnet50 Model:** The one below uses ResNet50 model. A total of 4 combinations were tried on this model and the best results were obtained with None weights and block-wise tuning as False



(a)



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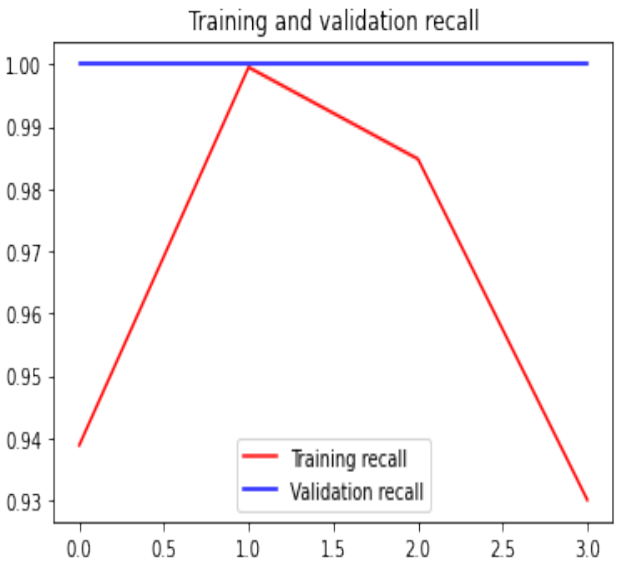

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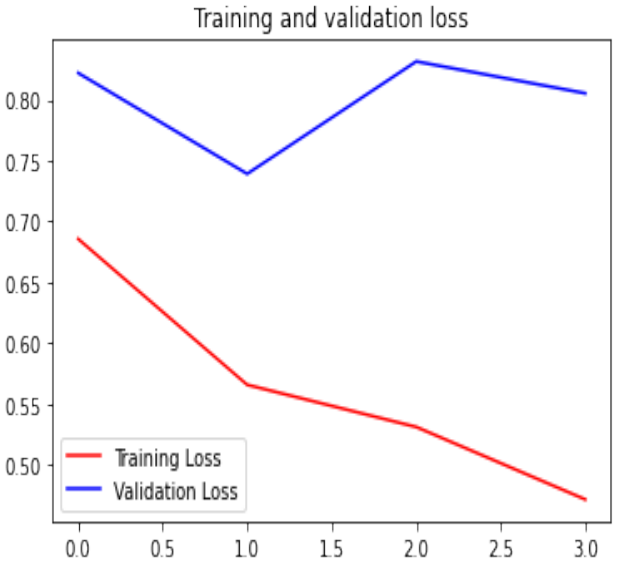
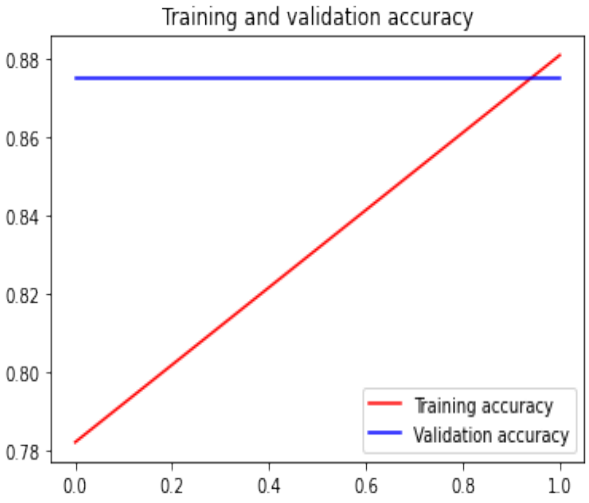


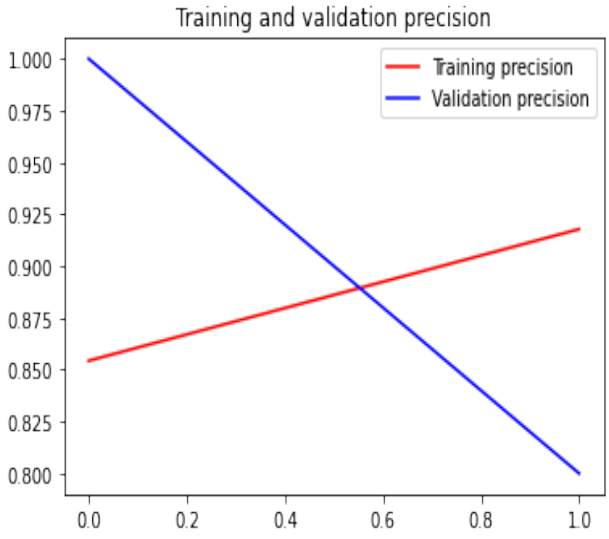
(d)

Table 4 Training and Validation parameters of Resnet50

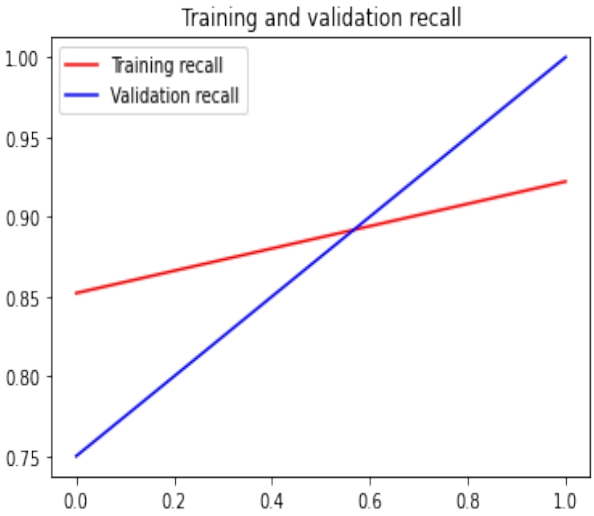
(a)	**Training and Validation Accuracy**	**0.625**
(b)	**Training and Validation Recall**	**1.0**
(c)	**Training and Validation Precision**	**0.625**
(d)	**Training and Validation Loss**	**0.6352907419204712**

2) **MobileNetV2 Model:** The one below uses mobilenetv2 model. A total of 4 combinations were tried on this model and the best results were obtained with ImageNet weights and block-wise tuning as True.



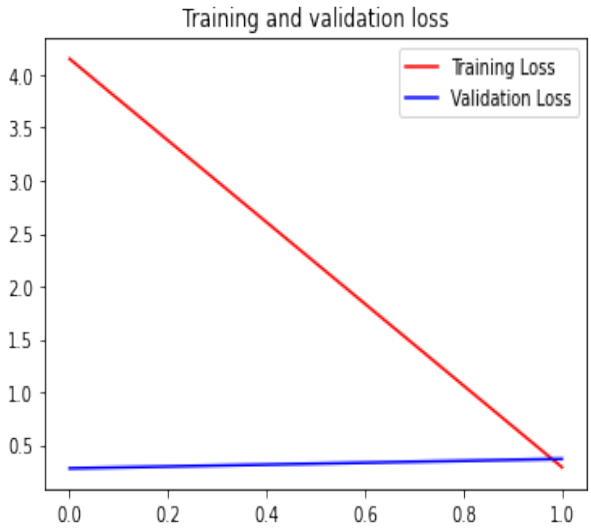


(a)



(b)

(c)

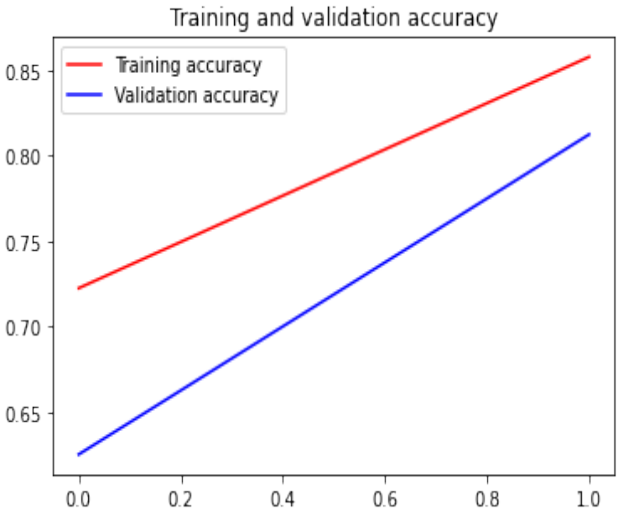


(d)

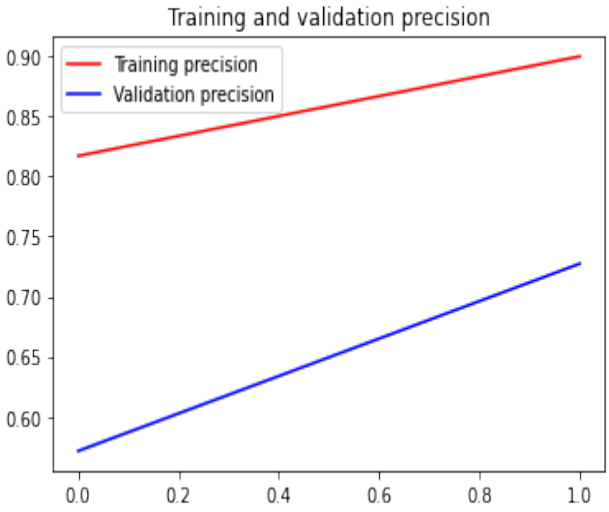
Table 5 Training and Validation parameters of MobileNetV2

(a)	**Training and Validation Accuracy**	**0.8685897588729858**
(b)	**Training and Validation Recall**	**0.9410256147384644**
(c)	**Training and Validation Precision**	**0.8615023493766785**
(d)	**Training and Validation Loss**	**0.33740630745887756**

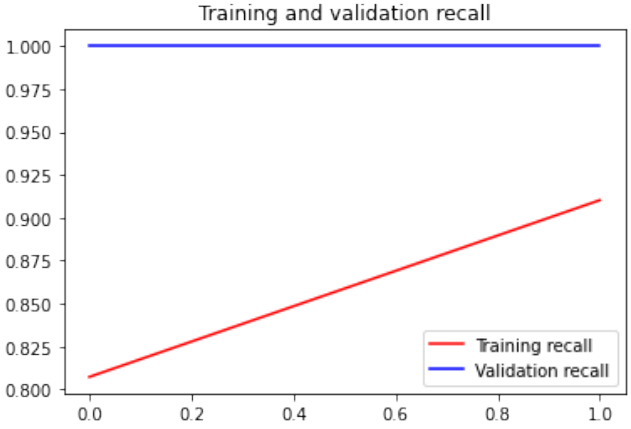
3) **InceptionV3 Model Output:** The one below uses inceptionv3 model. A total of 4 combinations were tried on this model and the best results were obtained with ImageNet weights and block-wise tuning as True



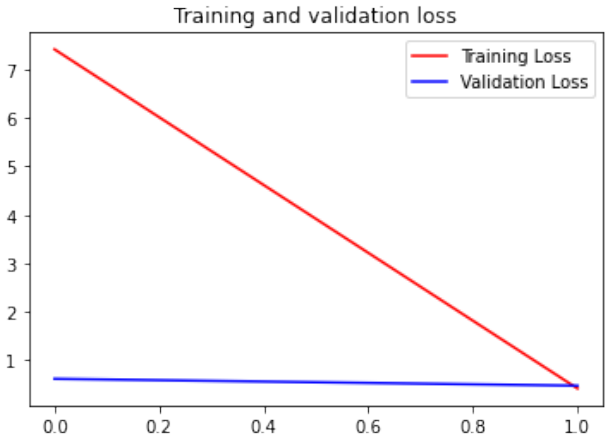
(a)



(c)



(b)



(d)

Table 5 Training and Validation parameters of InceptionV3

(a)	**Training and Validation Accuracy**	**0.7644230723381042**
(b)	**Training and Validation Recall**	**0.9512820243835449**
(c)	**Training and Validation Precision**	**0.7434870004653931**
(d)	**Training and Validation Loss**	**0.447445809841156**

Chapter 5-Conclusion:

Covid-19 has done an insurmountable damage to life and property. A lot of research has been done on the subject of covid-19 in order to lessen the impact of its destruction. Many models in the field of ML have been implemented in the real world and all of these models have different measures of output depending on different situations. We have done some research in order to improve upon the output measures of some of these studies.

The best accuracy turned out to be 0.8685897588729858, the best precision 0.8615023493766785 and the best Recall is 1.0. The results have been obtained by taking the dataset form Kaggle and we expect to improve upon our results in the future by taking an even larger dataset. With time, the virus evolves and so does the people. And so, we may look forward to solving some tougher challenges of this virus such as the long term effects or different variant.

Past researches have found an accuracy of 87%, and a recall of 98% using ResNet50 and VGG-19. Our accuracy was not as good as 87% but the recall was 100%. This can be very useful in the case when false negatives can be more damaging than False Positives. So, our result can be very helpful in those cases.

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