Detection of COVID-19 by X-rays using Machine Learning And Deep Learning Models

Achyut Krishna
dept. of Electronics and Communication
Bharati Vidyapeeth's College of Engineering(Aff. to IPU)
New Delhi,India
itsachyutkrishna@gmail.com

Yash Varshney
dept. of Electronics and Communication
Bharati Vidyapeeth's College of Engineering(Aff. to IPU)
New Delhi,India
yash.varshney24@gmail.com

Piyush Anand
dept. of Electronics and Communication
Bharati Vidyapeeth's College of Engineering(Aff. to IPU)
New Delhi,India
piyushanand.1221@gmail.com

***Abstract*—This document provides knowledge and awareness to the reader on how they can test a person COVID-19 positive or negative by using X-rays.Here Machine Learning and Deep Learning algorithms are used .Firstly,the topic is introduced. Secondly , all the Machine Learning and Deep Learning Algorithms which are used in this study are clearly explained. Thirdly,the architecture,results and finding of this study are discussed. Finally,this study has been concluded for the readers. This paper also describes the initial COVID-19 open image data collection.It was created by assembling medical images from websites and publications.Our model accuracy is following a trend of greater than 95% on every runtime.Machine learning models can't have 100% accuracy and hence,this is the best one can get.**

***Index Terms*—component, formatting, style, styling, insert**

I. Introduction

In India,test for COVID-19 is very expensive and not everybody can afford it.So IEEE and concerned authorities have managed to develop datasets related to this disease.One of them is chest X-ray and these datasets with some little cleaning process can easily go through deep learning networks to get trained and predict whether a person is corona positive or not with very high accuracy i.e , above 95% .In order to achieve our predictions, Convolutional Neural Networks for processing X-ray images,max pooling for enhancing the quality and reducing dimensions of the image has been used.In order to understand these two terms one should know about Artificial Neural Networks or simply ANN.Data cleaning operations have been performed as the datasets from IEEE consists data of many other diseases other than COVID-19 and we have compared X-rays in this data with X-rays of pneumonia patients as corona also developes similar symptoms.Corona is more dangerous than pneumonia because in addition to pneumonia symptoms it can also affect affected persons kidneys(damaging them completely)leading to his/her death.This effort is just one step ahead towards finishing this pandemic by which whole world has been affected.

II. Explaination of algorithms

Before computing predictions of the test,one should know how those results were achieved.In this section various algorithms are explained that has been implemented for this purpose.

A. Artificial Neural Networks(ANN)

An ANN is a collection of nodes called artificial neurons, which is similar to the neurons in a biological brain. These connection, like the synapses in a biological brain, can transmit a signal to other neurons. An artificial neuron that receives a signal then processes it and can signal neurons connected to it.In general,there are three layers:input layer,hidden layer and output layer.Each node at input is connected to each node of hidden layer.Similarly each node of hidden layer is connected to each node of output/next hidden layer.The hidden layers' node perform some specific function on the input given to it which is the main task of this process.There can be multiple hidden layers in these networks.Also each node to node connection have some weight.The input coming from the previous layer is summation of input times weight of whole of the previous layer.To decide efficient value of weights we use a technique called Backward Propagation
The *Backpropagation* algorithm uses gradient descent to decide weights that minimize the error function of the given neural network. The weights that minimize the error function is then considered to be a solution to the learning problem.In simple words we perform the following steps:

- First,random value of weights 'W' are initialized and the model is propagated forward.
- If,there is some error. To reduce that error,backward propagation is done and increased the value of 'W'.
- Afterward,if the error has increased. We came to know that, we can't increase the 'W' value.
- So, we again propagated backwards and we decreased 'W' value.

- Now, we noticed that the error has reduced.

for more information on backward propgation visit https://medium.com/datathings/neural-networks-and-backpropagation-explained-in-a-simple-way-f540a3611f5e

B. Convolution operation and Convolutional Neural Networks

We can use general deep neural networks for identification of images which are in gray scale and have white background.For identification of some particular object in images with many things and background we have to adopt to a new technique known as Convolutional Neural Network or simply CNN.Here we decide a filter through which our image is passed which is a small matrix whose dimensions are decided by us.For example,if we have a 3X3 filter then this filter will slide over each 3X3 matrix of pixels in the image.This sliding is refer to as convolving.When the filter first lands on the 3X3 pixels of the input.The dot product of the filter itself with this input will be computed and stored.This is done until we are done with each 3X3 pixels of image.After this process,we'll be left with new representation of our input.This matrix is the output and final result of our convolution operation.We can make this filter as pattern detector and hence can detect objects,shapes etc after passing our image to many of such filters.These filter may be present in one hidden layer of our neural network or in many.Hence,such type of neural network is called CNN.Refer Fig. 1. & Fig. 2.// and [6]

CNN (Convolutional Neural Network) is a class of deep learning of neural networks. CNN represents a huge breakthrough in image recognition in machine and deep learning. It is used to analyze visual imagery and is frequently working behind the image classification. Image classification in CNN is the process in which we take an input (like a picture) and output a class (like "Covid" or "Normal") or a probability that the input is a particular class ("there's a 90% probability that this Person is a Normal"). For radiology it is easier but for fast results we can train our machine with a convolutional neural network! A classic CNN architecture looks something like this: Input -Convolution -ReLU -Convolution -ReLU -Pooling -Convolution -ReLU -Pooling-Convolution -ReLU -Pooling -Output The CNN learned features with input data and used 2D convolutional layers. This means that this type of network is good and ideal for processing 2D images. Compared all to other image classification algorithms, CNN can actually use very little preprocessing. This means that CNN can learn the filters that have to be hand-made with other algorithms. CNN can be used in tons of applications from image and video recognition, image classification, and recommender systems to natural language processing and medical image analysis. In a mammal's eye, individual neurons respond to visual stimuli only in the receptive field, which is a restricted region. The receptive fields of different regions partially overlap so that the entire field of vision is covered. This is the way that a CNN works!

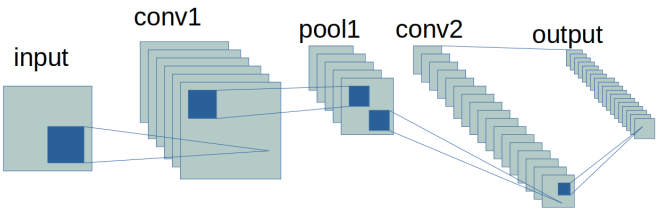

Fig. 1. Convolutional Neural Network.

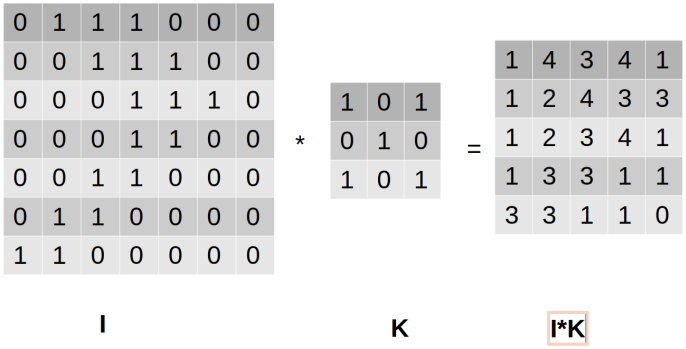

Fig. 2. Convolution operation on an image.

C. Max Pooling

Max pooling is a sample-based discretization process.In this process a filter of desired dimensions is passed over the image.The stride i.e the amount of blocks the filter will move per iteration is also set according to the purpose of implementation.At every iteration on the image at different places selecting different blocks the filter outputs the block with maximum value amongst all blocks that lie within the size of filter.Since high value blocks represents dark pixels therefore,after max pooling the size of image gets reduced and the features are enhanced.It is generally used for extracting low level features like edges points,etc.It is also used to reduce variance and computations.Refer to Fig. 3. and [5]

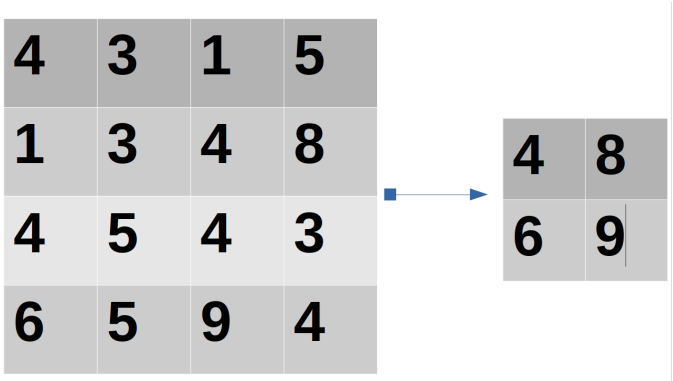

Fig. 3. Max Pooling.

III. DATASETS

A. Chest X-Ray Images (Pneumonia)

What is Pneumonia? Pneumonia is a lung infection that can range from mild to so severe that you have to go to the hospital.It happens when an infection causes the air sacs in your lungs (your doctor will call them alveoli) to fill with fluid or pus. That can make it hard for you to breathe in enough oxygen to reach your bloodstream.Anyone can get this lung infection. But infants younger than age 2 and people over age 65 are at higher risk. That's because their immune systems might not be strong enough to fight it.You can get pneumonia in one or both lungs. You can also have it and not know it. Doctors call this walking pneumonia. Causes include bacteria, viruses, and fungi. If your pneumonia results from bacteria or a virus, you can spread it to someone else.COVID-19 shows similar symptoms. The dataset is organized into 3 folders (train, test, val) and contains subfolders for each image category (Pneumonia/Normal). There are 5,863 X-Ray images (JPEG) and 2 categories (Pneumonia/Normal).

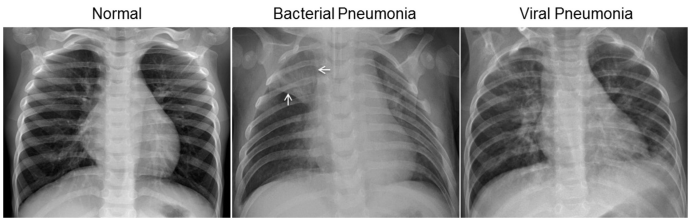

Fig. 4. Convolutional Neural Network.

B. ieee8023/covid-chestxray-dataset

A public open dataset of chest X-ray and CT images of patients which are positive or suspected of COVID-19 or other viral and bacterial pneumonias (MERS, SARS, and ARDS.). Data is being collected from public sources as well as through indirect collection from hospitals and physicians. All images and data is being released publicly in this GitHub repository.

IV. ARCHITECTURE

In this architecture, first it is started by taking an xray rgb image as input. Then we have applied a 3X3 kernal having 32 filters which will extract features from this image. Then no. of filters has been increased from 32 to 64 for better extraction of features. After that for enhancing features, max pooling is done. This pooling will down sample the representation of input image. These steps will be repeated again and again as in [16]. Now, a flatten layer that will make a vector of the all connected layers, for instance, function used here Sequential.add(Flatten()) has been added. Now, added a fully connected layer with Sequential.add(Dense)) function in keras. There has been an addition of dropout layer. Then the output has been generated with the help of prediction.

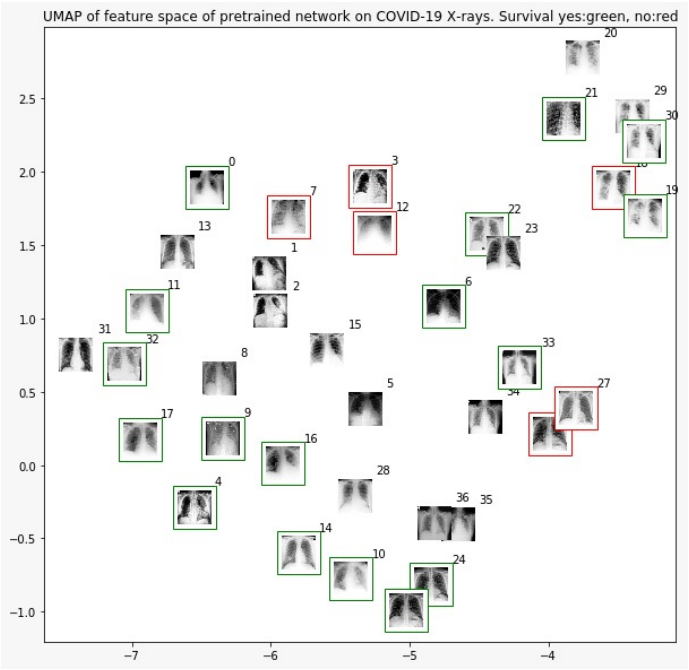

Fig. 5. UMAP of feature space of pretained network on Covid-19 X-rays.Survival yes:green,no:red

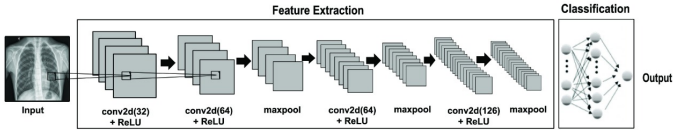

Fig. 6. Architecture of the implemented model

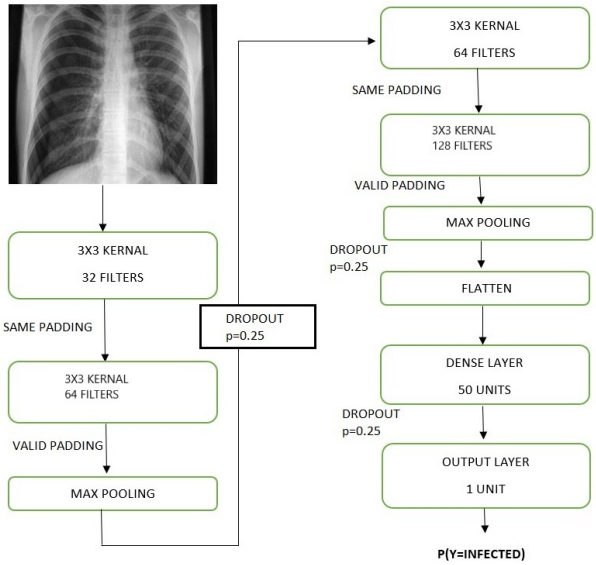

Fig. 7. Flowchart of the implemented model

V. Results and Analysis

A. Accuracy Curve

Accuracy curves is one of the method to study the progress of deep neural networks. For anyone who has some experience in Deep Learning, using accuracy and loss curves is obvious. A more important curve is the one with both training and validation accuracy.The gap between training and validation accuracy is a clear indication of overfitting. The larger the gap, the higher the overfitting.Hence,it's clear that IEEE dataset will show overfitting just after 2 epoch while kaggle dataset after epoches gretater than 8 converges which is a good thing for our model.

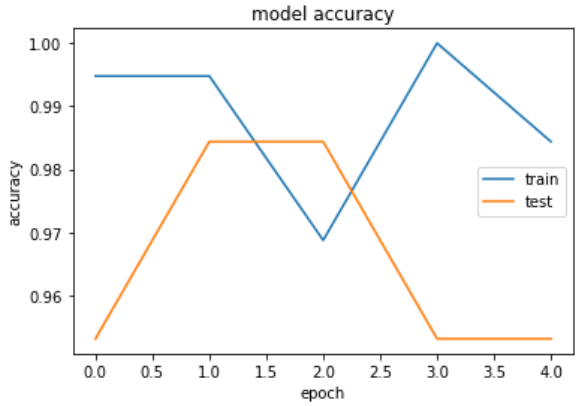

Fig. 8. IEEE model (accuracy- 97.52 %)

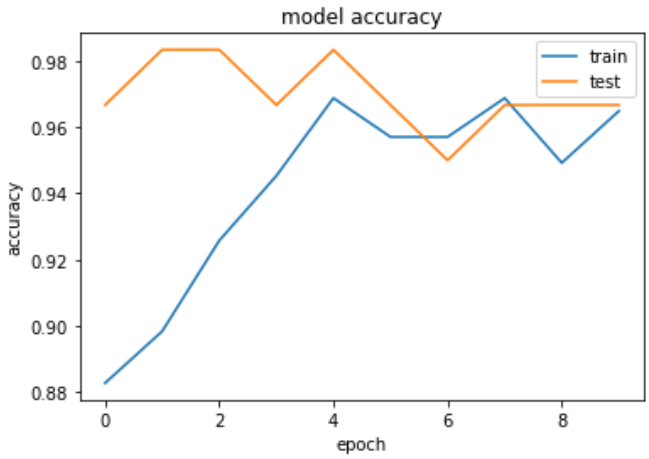

Fig. 9. Kaggle Model (accuracy-96.66%)

B. Confusion Matrix

Here in Fig. 7. and in Fig. 8. two confusion matrix are shown one representing dataset of IEEE and other representing that of Kaggle respectively.Here 0 represents Corona positive while 1 represents normal patient.The top left box (0,0).Here on X axis represents actual data while Y axis represents predicted data.The (0,0) box represents people that actually have corona and our model also detected them while (1,1) box represents people who in real don't have corona and also our model predicted about them correctly.Hence, the no. written in these two box represents the no. of people and therefore this no. should be high.Similarly the blue box represents the reverse of this situation and hence no. labelled on it should be low.Our confusion matrix follow these principles and hence our model is working good!

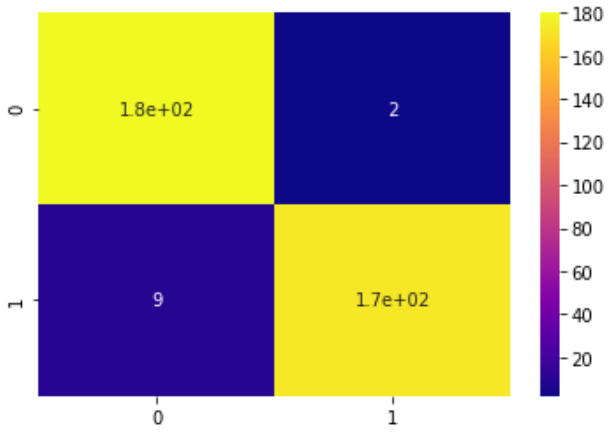

Fig. 10. IEEE Confusion matrix

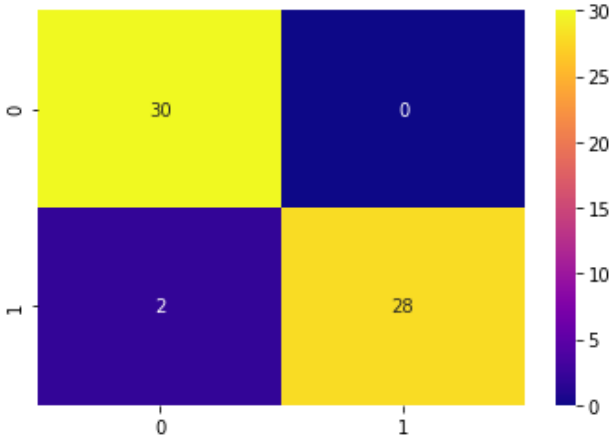

Fig. 11. Kaggle Confusion matrix

VI. Conclusion

It can be concluded that Deep learning technology is acting as a boon for the humanity in this pandemic situation .As a programmer who don't know about biology can also predict by just processing X-rays through these type of neural networks. This project must encourage others to implement there knowledge somehow, to improve this situation. Since normal blood

tests are expensive,this type of tests are very reliable.But there is a drawback also.As 100% accurate model can't be made so there is chance that positive patients go undetected and hence they can spread the virus.For eg in X-rays of 100 people and with accuracy say,97% implies a chance of leaving 3 people undetected and hence they can become the virus spreading agents if not quarantined.

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