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

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Abstract. In India,test for COVID-19 is very expensive and not everybody can afford it.This document provides knowledge and awareness to the reader on COVID-19 screening of a person using radiological chest x-ray images.Here Machine Learning and Deep Learning algorithms like CNN and max-pooling are used .These algorithms identifies different features in the images and help us to distinguish between a COVID-19 and non COVID-19 chest X-ray. This paper also describes the dataset of COVID-19 open image X-rays.It was created by collecting 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.

Keywords: COVID-19 · Corona · Image · Kernel · X-Ray recognition · Pneumonia · Network · Matrix · Convolution.

1 INTRODUCTION

IEEE and concerned authorities have managed to develop datasets related to this disease.One of them is chest X-ray images 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.
This paper is organized in the following order.Firstly,the topic is introduced. Secondly , all the related work is discussed.In the third section various algorithms have been explained.Later after that,the architecture,results and finding of this study are discussed. Finally,this study has been concluded for the readers.

2 Related Work

Deep learning is playing an important role in improving today's generation technology creating next generation technology. In the paper [4] it has been explained thoroughly that deep learning has already made a huge improvement in various areas, such as medical field, automatic vehicles, weather prediction and voice recognition. It also covers various types of deep learning architectures such as DCN, DRN, RNN, reinforcement learning etc.In [5], it elaborates the various types of DNN architectures, training algorithms. There are various shortcomings of the training algorithms discussed. It also describes the necessity of optimization of training algorithms which will increase speed and efficiency of the network. There are few architectures, its corresponding algorithms and its implementations has been explained. In the concluding part the paper also emphasis the importance of deep learning and describes that it is still in its early stage.
Deep learning is a growing field and various approaches have been used to bring it closer to work like biological neural network and to some extent mankind is successful in doing so.One such astonishing example is image processing through Convolutional neural networks [6] and other tools like max pooling.Image processing in turn is acting as a powerful tool for humans to fight COVID-19.Proper screening of patients is major step towards fighting this pandemic.
As in [12] chest radiology gives evidences of Pneumonia and the X-ray of that patient can be distinguished from the uninfected person.So,unlike [12] instead of using COVID-net we have just used convolution and max pooling and still got very high accuracy.As described in [7] CNN can train large amount of data,with millions of parameters.Hence CNN is very useful for detecting features that are not visible with naked eyes.The evolution of image processing or texture recognition is thoroughly explained in [8] and now CNN is accepted widely.Other than image processing CNN can be used in evalution of essays written by students as in [9] and many more infinite applications can be discussed that uses only CNN to achieve its prime result.
As explained in [23],max pooling is also essential for this classification as it boosts convergence rate by selecting higher-grade invariant features which enhances performance.[23]It also suggests use of softmax function for representing probability of each category and selecting the class with highest probability as output.
We got motivated from the need of faster interpretation of radiography images so we planned to train a Deep learning Model[2] based on a CNN network and results have shown to be quite promising in terms of accuracy in detecting pa-

tients infected with COVID-19 via radiography imaging, we have collected data from two different datasets that are widely available from github[11] and kaggle for pnenomina where other were using only from one of them[12].Our model is trained on 224 images based on Covid and Normal images which were greater than other[25] due to which the model gets better training and we achieve a greater accuracy 97.52% in validation accuracy and 98.8% in training accuracy with adam optimizer where other optimizer like DeTraC[26] got lesser accuracy 97.2% . For analysis of results confusion matrix has been implemented.As in [23],Confusion matrix also known as error matrix basically gives the performance analysis of an algorithm in matrix format. As explained in the paper the code matrix allows model to transform a multi class problem into an ensemble of binary classifiers. It has been suggested that a new and un-weighted architecture or framework for extending the code matrix with every iteration and is based on the error/confusion matrix. The confusion matrix stores the information which is important and is extensively used by the suggested architecture or framework. The evaluation of the confusion matrix at every iteration allows to make a decision for the next one with respect to every classifier which will be integrated with the current code matrix.

3 Preliminaries

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.

3.1 Artificial Neural Networks(ANN)

The elementary unit of Artificial Neural networks is called Artificial neuron, which is similar to the neurons that are in a biological brain. These artificial neurons pass information from one neuron to another neuron. At every node or neuron, signal from the input or the previous neuron is processed and passed to the next node or neuron.In general,there are three types of layers:input layer,hidden layer and output layer.Input nodes are connected to each node of hidden layer in every possible way to one another.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 result of the decided weights gives the minimal value of the error function of the model.In simple words we perform the following steps:

- First,random value of weights are set and the model is propagated forward.
- If,some error is observed so to reduce such error,backward propagation is done and the value of 'W' increased.
- Afterward,if the error increases, the value of weights can't be increased
- So,again propagated to backwards and the value of weights are decreased.
- Now, the error has been reduced. refer to [4],[5],[6]

3.2 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 filter dot products itself with the input and the computed result is 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]

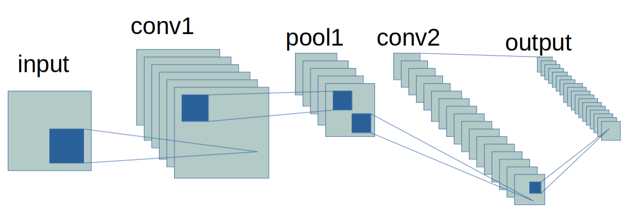

Fig. 1. Convolutional Neural Network.

Convolutional Neural Network comes under Deep Learning that deals with the neural networks for image processing. CNN represents huge break-through in the image recognition in machine and deep learning. It analyzes the visual features in an image and classify images on the basis of these features.In this classification process,we take an Input of images and output a categorical result (like "Covid" or "Normal") or the probability that input is from 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!

$$\underbrace{\begin{matrix} 0 & 1 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 & 0 & 0 & 0 \end{matrix}}_{\mathbf{I}} * \underbrace{\begin{matrix} 1 & 0 & 1 \\ 0 & 1 & 0 \\ 1 & 0 & 1 \end{matrix}}_{\mathbf{K}} = \underbrace{\begin{matrix} 1 & 4 & 3 & 4 & 1 \\ 1 & 2 & 4 & 3 & 3 \\ 1 & 2 & 3 & 4 & 1 \\ 1 & 3 & 3 & 1 & 1 \\ 3 & 3 & 1 & 1 & 0 \end{matrix}}_{\mathbf{I*K}}$$

Fig. 2. Convolution operation on an image.

Following is an example of a CNN architecture:

$INPUT - Convolution - ReLU - Convolution - ReLU - Pooling - Convolution - ReLU - Pooling - Convolution - ReLU - Pooling - OUTPUT$

This clears that CNN is very good network and it seems to be ideal for processing any type of 2D images as also shown in [7],[8] and [9].CNN provides the programmer the advantage of using any kind of filter to detect any kind of features.CNN is used in many applications like face recognition,NLP,recommmender systems,video processing and many more.CNN can also be modified with many other algorithms according to the need of the programmer.It also uses very little preprocessing.

3.3 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]

4 DATASETS

4.1 Chest X-Ray Images (Pneumonia)

What is Pneumonia? pneumonia is a very dangerous disease especially for infants below 2 years and for those who are above 65 years of age.This is because there immune system isn't much active.It causes infection in lungs causing the air

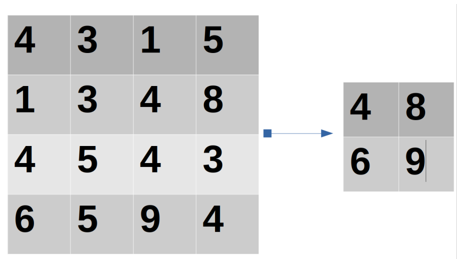

Fig. 3. Max Pooling.

sacs to be filled with puss or fluid.This results in abnormal and difficult breathing.Sometimes the patients don't even get to know that he/she is carrying the disease.This condition is called walking pneumonia by doctors.This situation can affection one or both lungs but the patient suffer similarly in both conditions.We are discussing it because one of the symptoms of COVID-19 is pneumonia.refer to [11]. This data set is divided into 3 folders train,test,validation inside each of these there are 3 folders named categorically into Pneumonia and Normal (X-Ray Images).The total no. of these images are 5,863.

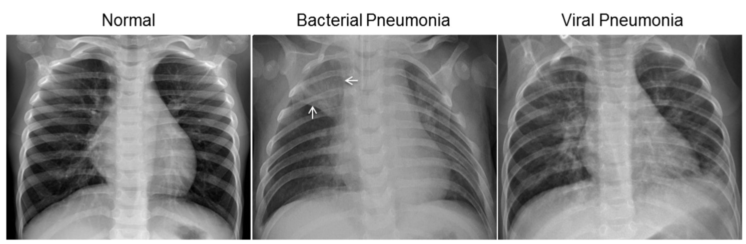

Fig. 4. Convolutional Neural Network.

4.2 ieee8023/covid-chestxray-dataset

This data set is collected from hospitals,doctors and physcians who treat corona virus patients.It consists of X-rays of patients having diseases like SARS,MERS and ARDS or suspected of having them.This data is released on a basis of regular intervals in the Github repository.

5 Architecture

In this architecture, at first this model takes an X-RAY RGB (coloured) image as input. Padding is same here. Padding means the number of pixels integrated

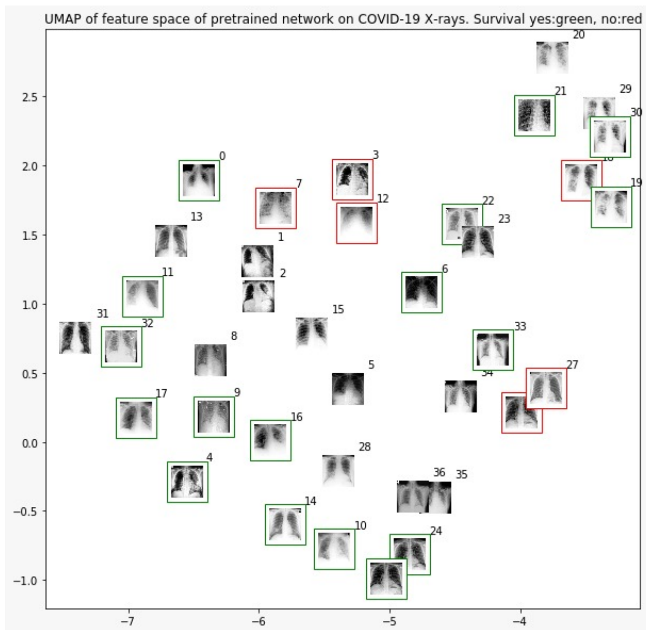

Fig. 5. UMAP of feature space of pretained network on Covid-19 X-rays.Survival yes:green,no:red

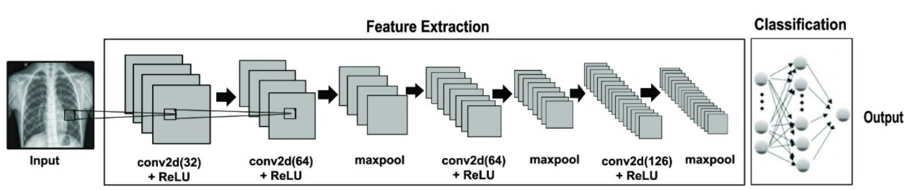

Fig. 6. Architecture of the implemented model

with the image when the kernel of the convolutional neural network processes the image. A 3X3 kernal having 32 filters which will extract the features from this image has been used. Then the no. of filters has been increased from 32 to 64 for better extraction of features of the image. Padding is valid here. After that to discretized, max pooling is done. This pooling will down sample the representation of the input image. There is a dropout (of value p=0.25) layer. In the dropout layer, each neuron generates 1 feature map. Since dropout works with every neuron, dropping a neuron implies that the corresponding feature map has been dropped. The dropout layer is generally added after the pooling layer. At the next 2 steps, the first 2 steps of the model will be repeated again, with a change in no. of filters to 64 128 from 32 64 and the pooling remains the same. Again, there is a dropout (of value p=0.25) layer. Now add a flatten layer that will make a vector of the all the connected layers of the processed image, for instance, function used here for flattening is Sequential.add(Flatten()). Now, add 1 fully connected layer with Sequential.add(Dense)) function in the Keras. There is an addition of dropout (of value p=0.25) layer again. The model is trained now. After all these processes, at last the model produces the output. The output is generated with the help of prediction. The output produced is binary in nature i.e. infected or not infected.

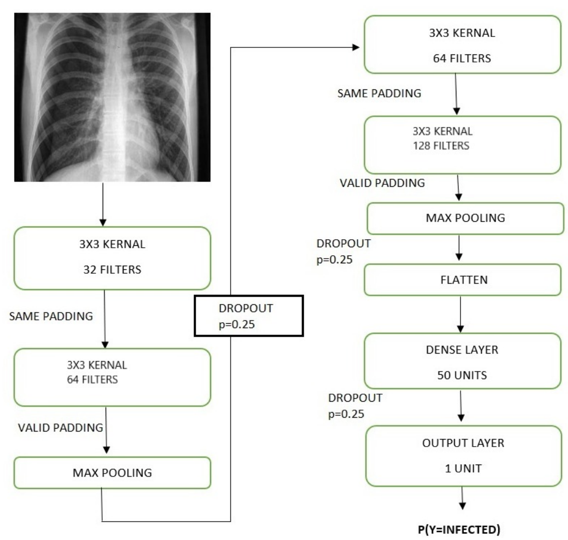

Fig. 7. Flowchart of the implemented model

6 Results and Analysis

6.1 Accuracy Curve

Referencing to [22],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.

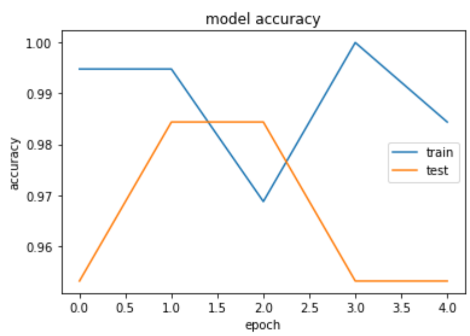

Fig. 8. IEEE model (accuracy- 97.52 %)

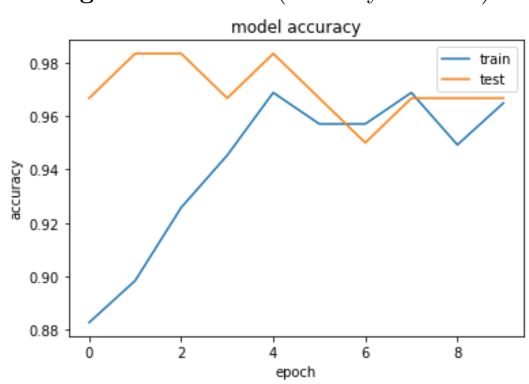

Fig. 9. Kaggle Model (accuracy-96.66%)

6.2 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 the 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!.refer to [23].

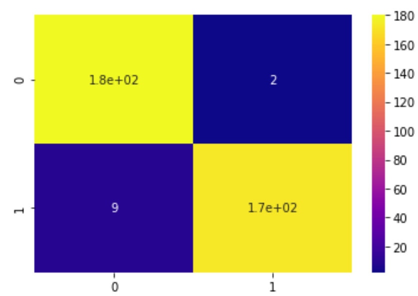

Fig. 10. IEEE Confusion matrix

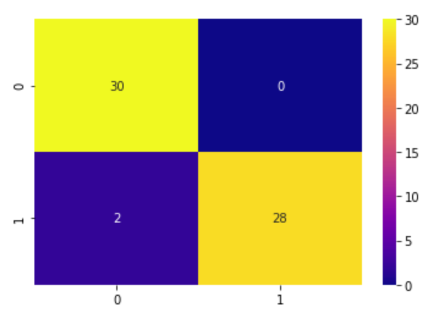

Fig. 11. Kaggle Confusion matrix

7 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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