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Detection of Pneumonia and COVID Using Machine Learning

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ABSTRACT

During this pandemic we have already lost many lives, and still count is increasing day by day. And WHO still worries that we are no where near to the end of this pandemic and this is highly likely that it will continue in future for may months . Since we know that in case of COVID-19 there is mild to extreme symptoms of pneumonia and these symptoms become life threatening in the end. The aim of this study is to simplify the process of detecting the COVID-19 and pneumonia using the concept called CNN (Convolutional Neural Network).In this we will extract out the features from the images, which will led the foundation for distinguishing between the pneumonia or COVID-19, and then those extracted feature set would pass through the classifier for the prediction . We will propose the highly optimized model , by keeping in mind that we are designing the solution for the mobile and low-end desktop devices with fairly good accuracy, so that everyone can use it , without having hustle of powerful computers to run the model.

Keywords : Convolutional Neural Network , Data Preprocessing, Data Augmentation, Max-Pooling, Dense Neural Network, Deep learning

1. Introduction

Now-a-days deep learning models has developed the accuracy same as human-level and even better in few areas in analyzing and segmenting the image. This is only because of there ability to abstract out the feature set from the images . The medical field is one of most prominent fields which can take the help of this technology to detect the various fazes of the diseases and though the images. Not only this , deep learning can be use in various fields also like, using computer systems for diagnosing , analyzing the health related data of any living organism according to the demo graph. The central part of this state of the art technology is based on it's ability to teach it's neural network to learn high level details from the input raw image data though following the general procedure of learning.

Although, there have been the major advancement to this technology still this technology cannot replace the human counter parts completely like doctors in our case of diagnosing theses lung diseases , but since it has proven it's ability to analyze the raw image data in past , we can use this ability to provide human experts from the medical or non-medical domain in performing the time taking tasks like examining the chest X-Ray for figuring out pneumonia or COVID.

We know that pneumonia and COVID both effects the lungs. Pneumonia is also happen because of inflammation of the lungs, where water start residing inside the lungs and it can be caused by bacteria, viruses and fungi. And this become so common now-a-days that it can occur to anyone , infants ,young people and elder people. And this also found in very early stages of COVID. People having lungs diseases like asthma and those who took cigarettes get to see even worse version of this disease . And people who has hospitalized having symptom of these urgently required ventilator in case of severity. And infants and elder people having above 60 years are even more susceptible from this disease. And COVID has developed the ability to halt the immune system of host and mostly patient have found dead because of the organ failure in the case of COVID . Therefore , there is must our high priority to facilitate the research in this direction to develop new methods with the help of computer-aided systems to detection and diagnosis of there symptoms in very early stages so that preventive measure could be taken against it.

WHO has done the compressive research on the age group of the people who got died due to pneumonia in 2017 in all around world and in that 15% were below 5 years and there numbers were 808,000 . And we know till now over 2.5million people have died because of the COVID19 and the number is still increasing day by day . And it is also found that due to pneumonia more then 90% deaths were in the underdeveloped nations having limited to very few medical resources. Therefore there must be very cheap and reliable solution to be developed for diagnosing these diseases .

In last five years , there have been various reaches has been facilitated by governments of countries for proposing the different artificial intelligence(AI)-based solutions for different medical problems. And Convolutional Neural Networks (CNNs) have given the prominent results to the researchers which attracts more institutions to facilitate research using this technology. Currently this technology have strongly proven itself in medical problems like breast cancer detection, detection of brain tumor and segmentation, diseases that can be classified through X-ray images etc.

Apart from proving it's ability to perform better in image data , CNNs also recognizes and very well known to handling the large dataset to teaching efficiently. However , it is also found that most of the time this approach fails on a small datasets if they are not properly feed to the network. So to meet the network requirements to provide the quality data. We have took an another approach , in that we have generated new data from the previous data , through augmentation. And then feed those data to network so it can be train to form generalize architecture so, that it can work well on any new dataset. So we have worked on this research because we want to propose the novel solution using CNNs , which is not too complex and works fairly well in low-end devices. That's why we went for figuring out the lightweight network architecture which could have accuracy over 95%.

And I want to remind that this research was not to replace the human doctor experts , it just designed by keeping in mind that it will do time consuming task for them, so that they can utilize there time on important things.

2. Methodology

2.1 Outline of Methodology

Our proposed methodology is shown in Figure 1. It consist of following stacked layers components : Image Preprocessing , Data Augmentation , Convolutional Neural Network(CNNs) , Classifier. These steps are thoroughly explained in elaborated way in the subsequent sections beneath it.

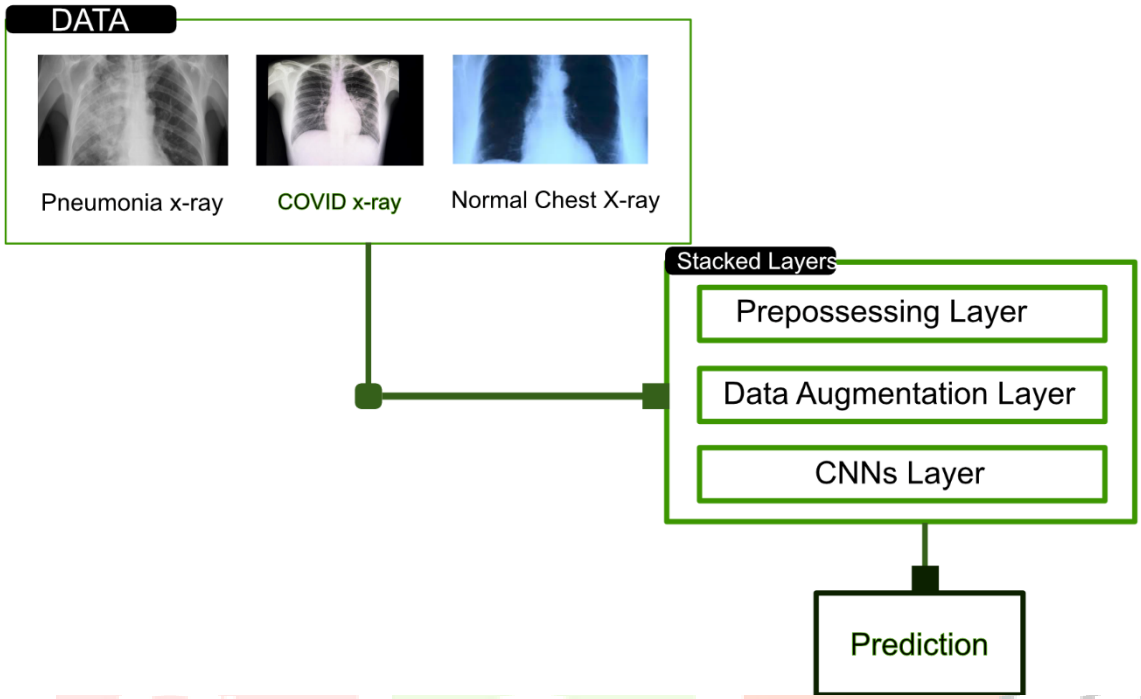

Figure 1. Outline of the Methodology.

2.2 Data Pre-Processing and Augmentation Layer

As we know that to train the more generalized model so that it can perform very well on new data we have to provide very large dataset to the model. Since availability of the data is limited and our goal is to make model more generalized we have introduced the preprocessing and augmentation layer before feeding the data to the model. And since CNNs are very prone to overfitting and this can lead to misleading results to new data, So we have used , Radom Horizontal Flip (so that model could be trained to work well for either side of the X-Ray image),Radom Sized Crop (to make model to understand the information in generalized instead of the information abstracted to only particular are patch of the image) , and in the end we have change the intensity of the image at very different levels randomly (to make model understand data even in case of very abstract intensity). And since our image were fairly large size 256x256 which could be performance intensive for mobile devices, Remember our goal was to create model which is fast and accurate . So we have preprocessed the size of the image and made it 128x128 which made it 4 times faster to process and fairly accurate size to get feature abstracted out by our model without declining the accuracy of the model .

2.3 Customized Convolutional Neural Network

Currently, most of the computer vision technology uses Convolutional Neural Networks(CNNs) for there analysis of features from raw image or video data . And researchers over the past as shown great trust over this approach instead of traditional Back Propagation Neural Networks , because CNNs has designed in such a way that there explicit assumption of any input data will be in matrix form which is same as the dimension of image data. If we inspect the stack of convolutional layers we would found that in very beginning this network process an raw image data and detect the very low-level features form the image. Low level features in the images are : edges, curves and the separation boundaries .And these networks are very well in detecting the spatial information from the image and since we want that our model to be more generic we did augmentation as explained in section 2.2 , so that our model just not only use those spatial information for particular patch of the image despite it can use those information to generalize any part of the image. AND the CNNs are able to capture the spatial information from the image and combine them to first extract out the low-level features from the image and then use those features to abstract out the more higher level of the features which are major component for distinguishing and predicting the type of image and all these things able to happen because of filters. And unlike normal feed forward network these filters have very less parameters to work upon and also uses technique to share the weights among the filters which make them efficient and reduce the computation efforts. And these filters are the learnable parameters for each layers which convolve in width and height of the image to train itself through the optimizer.

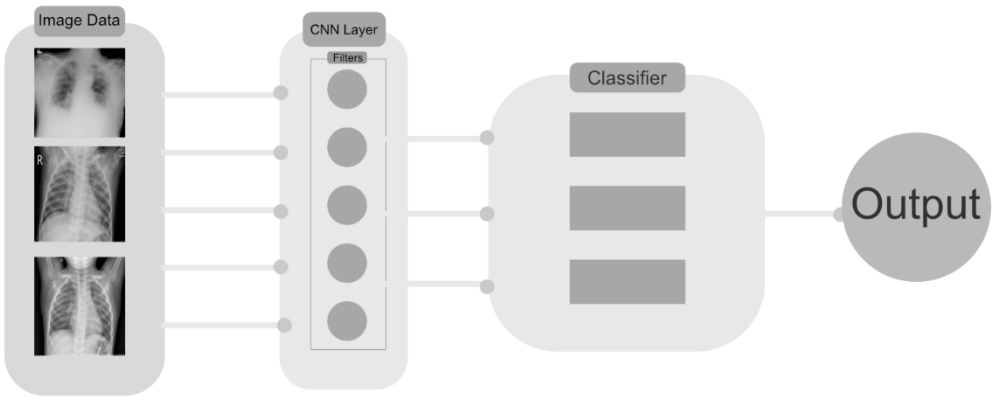

Figure 2. General architecture of image classification using CNN network.

And the another important part of Convolutional Neural Networks (CNNs) are activation layers. These layers are used to map input to output. And it also use to approximate any nonlinear function to it's output.

Pooling layers is also one component of the CNNs , it helps to reduce the size to data volume so that information that is most desirable to make prediction will only pass through it , which not only make our model fast but also less prone to nosy information since they will cornered out by the dominant pixels or the common characteristics of the neighboring pixels.

And it there is common practice to when and where to use pooling layers, we should always use polling layer between two convolutional layers. And the most common polling layer to use is max pooling layers, this pooling layer selects that pixel or data which has highest value in the given window size. And another is average pooling layer ,it will select the average of all data in given window. And since our goal is to design the model which not only accurate in prediction but also less computer expensive so that we can use it in our personal devices easily , without need of high-end computers .

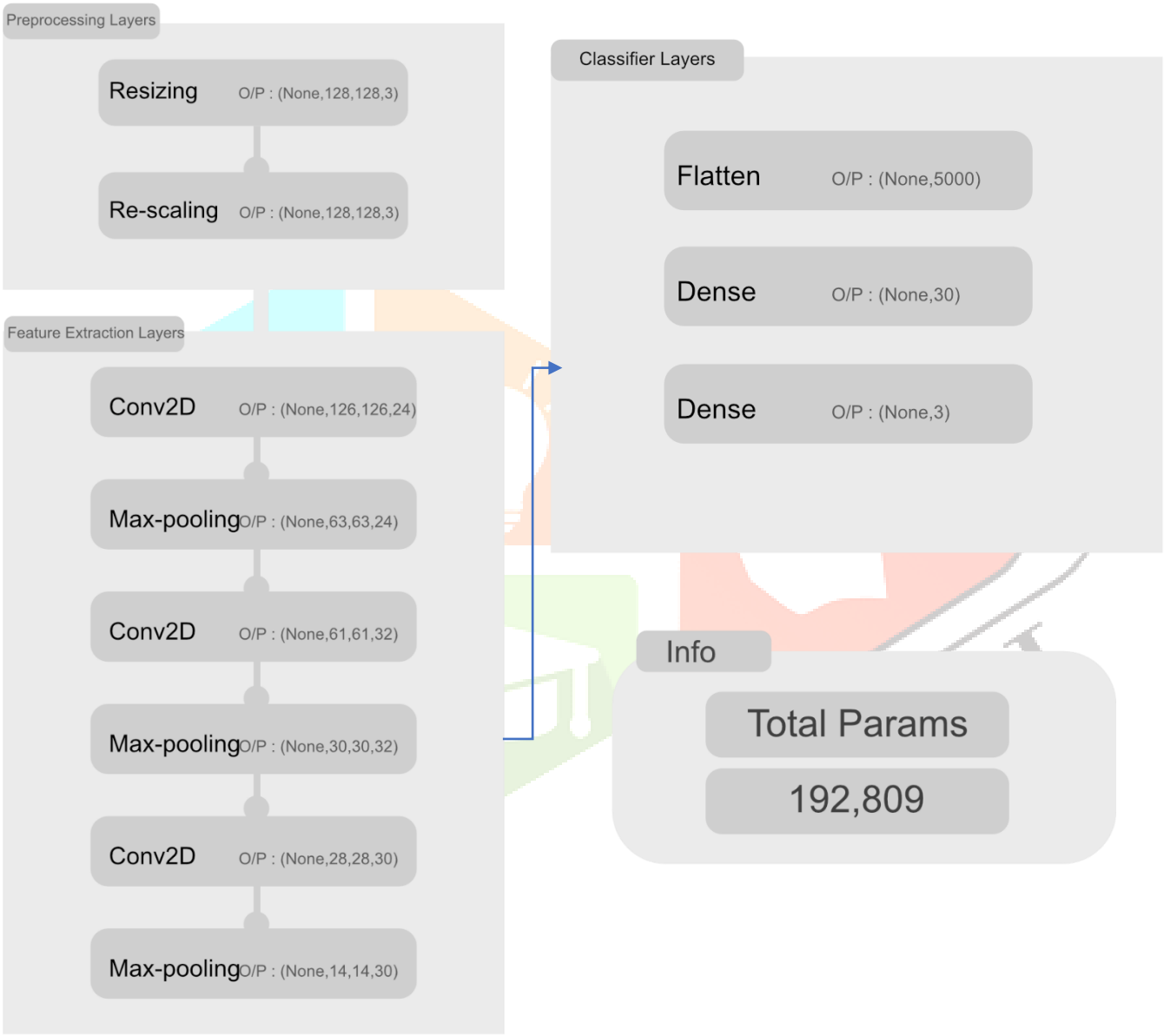

Figure 3. Model Architecture

3. Results

The foremost goal for using the convolutional neural networks approach was to correctly distinguish between the pneumonia and convid19 using the X-ray images. And for this we have implemented various dense networks , but pick the one which has fairly good accuracy and able to run on mobile devices effortlessly. That's why we went with this design .And during training we went with the 30 epoch , and we were able to get the training accuracy around 98.5% and testing accuracy was around 96%.

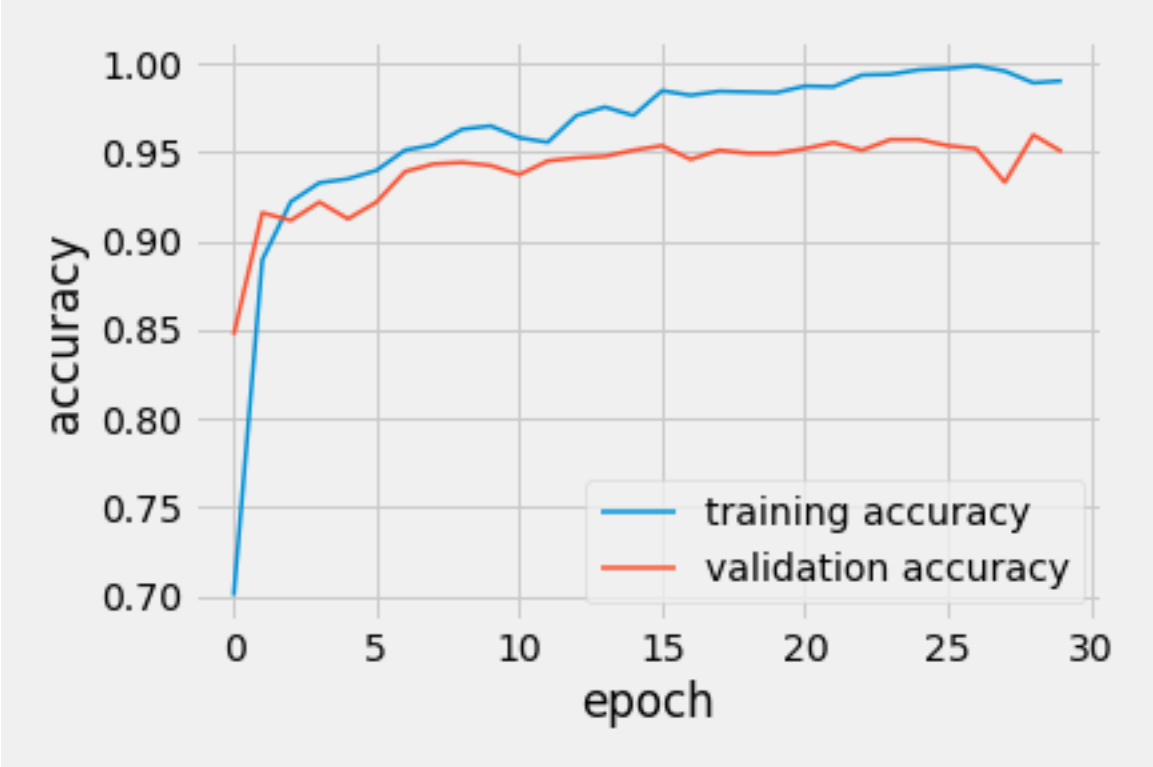

Figure 4 . Accuracy of model as epoch proceeds

From Figure4 we can see that we were able to get the fairly good accuracy, despite of being the model not too complex, that all were possible due to the ability of CNNs to learn the spatial information from the images and then we can pass that information to the classifiers to use that information for predicting the image class. And here we have used the dense network as the classifier, and data being flatten before it passed to the dense network, this is because dense network only accept data in long flat array. That is why they are not good choice for abstracting out the feature from the image, but very good when used in top layers as the classifiers.

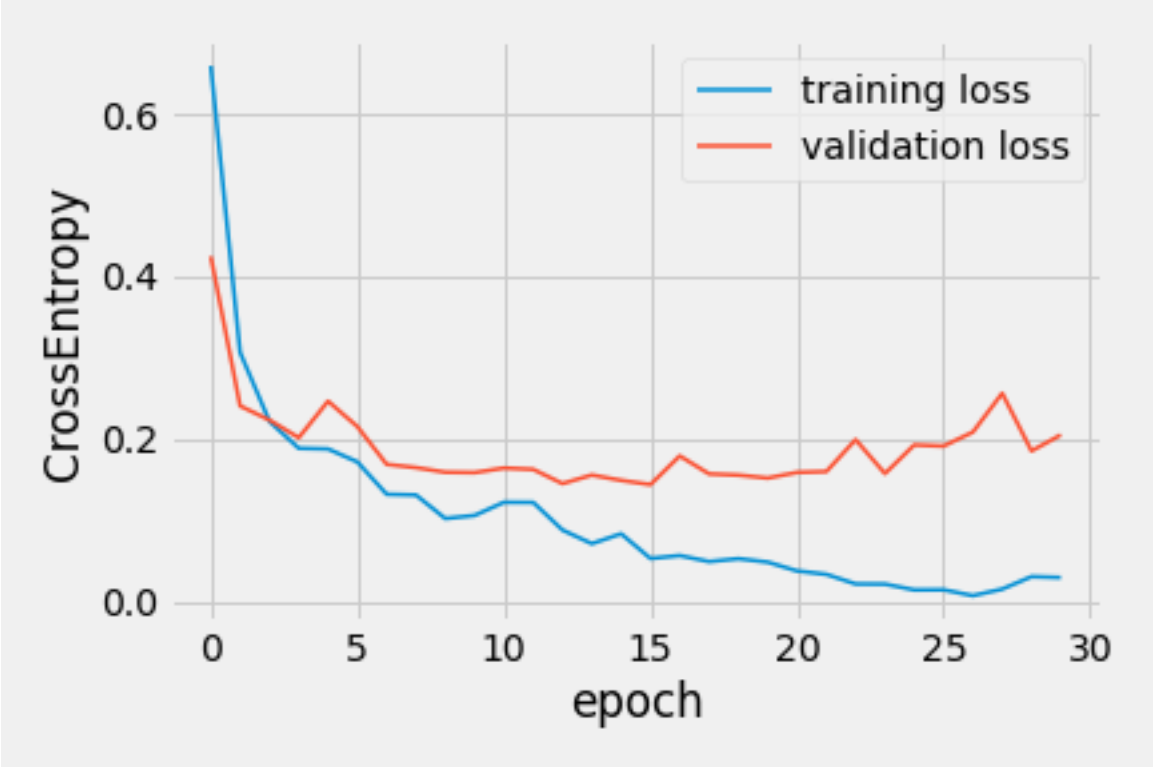

Figure 5 . Training and Validation loss in respect to Epoch

4. Conclusions

In this paper , our main aim is to provide the solution for detection of pneumonia and COVID19 using the chest X-ray images by using the deep learning based approach. We have especially opt for the convolutional neural network approach to extract the special features from the image and pass that to the classifier and then output is collected as the classification probabilities of belongness .And while training the model we have learned that performance of this model can be further improved by increasing the amount of data to be provided for training and custom data can also be generated by the approach called as data augmentation.

Our research was based on the notion of using technology to simplify the process of diagnostic and improve the in general disease management .But it does not mean that it has been designed to completely replace the doctor out of equation. We know that pneumonia or covid19 diagnoses are commonly confirmed by a single or group of doctors. But this also increase the chances of human error. But think this proposed methodology as two-way process in which first system see the chest-x ray images and provides it's result then those to be passed in the hand of attending physician, which drastically minimizes the both the errors computer as well as the human.

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