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CNN Based Transfer Learning Framework For Classification Of COVID-19 Disease From Chest X-ray

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***Abstract*—Today SARS-COVID-2 causes Novel Coronavirus diseases throughout in more than 150 countries all over the world. The quicker diagnosis is very crucial to reduce the outbreak of this diseases. The clinic al studies regarding this disease has shown that patients lungs are very much affected after the infection of coronavirus. Chest X-Ray, CT Scan are the most effective imaging approaches for identification of COVID 19 disease. Deep Learning approaches are one of the important approaches of machine learning that gives a critical analysis regarding for study of large amount of image datasets that can make some earlier impact of diseases. in recent years. To analyze the disease 1000 images are used for training and 150 images are used for testing the data from an online available standardized dataset of Kaggle. Here the images are taken as Covid and Non-Covid as the 2 class levels to classify the images using CNN. Here the activation function ReLU provides more than 90 percent of accuracy rates for classification and validation of COVID 19, diseases using CNN based deep learning model. The kernel sizes, other activation functions are varying and accordingly it changes the performance of system. This task concentrates on the approaches of classifying covid-19 infected patients appropriately.**

Keywords—Deep Learning, CT Scan, Convolutional Neural Network(CNN), Medical Image, Magnetic Imaging resonance (MRI), COVID 19, Chest X-ray, Maxpooling, Training Accuracy, Kernal, Pre-processing, RELU.

I. INTRODUCTION

The disease novel Coronavirus 2019 is familier as COVID-19 has been primarily detected in Wuhan, Hubei, China in the year of 2019[1] and after that it becomes a global pandemic that affects more than millions of people life throughout world. Almost more than 15 million people have already affected to this disease and almost a more than millions of people have already passed away due to this disease. As it is a critical disease, faster detection is essential for next level treatments and isolation is become a major way of reducing the spreading of the disease and saving people. Researchers in various areas are actively involved in diagnostic procedures in effective manner and accelerate of providing treatments. So, there are three diagnostic procedures are mainly used: as blood tests, viral tests, and medical imaging.

Computer aided diagnosis has been applied to the biomedical and medical domain from a long period of time. The diagnosis of chest X-Ray[3] is well-known used and user friendly way for identifying chest diseases that are required to create heart, lungs, airways, blood vessels ,bones of spine areas and chest images. Chest X-Ray disease diagnosis is a crucial and very much task for challenges which deals on the basis of expert radiologists' availability. As this is a manual work, the occurrence of error is highly probable. So, there are the requirements of Upgraded methods for improvement of accuracy of diagnosis.

So, computer aided diagnosis has been used as a crucial and urgent domain of research in machine learning. CAD based diagnosis has been used as identifying diseases effectively. So, providing approach of employing machine learning to X-Ray images, those features are very much required to give better quality chest X- Ray images. So, several pathologist and clinical expertise people have suggested in diagnosis of several diseases with the analysis of medical images.

Historically the CAD systems were used by radiologist in diagnosis of various disease through the analysis of medical images [14]. Having huge dependence over the system from a long time sets the milestones in the field of medical imaging, having the widespread presence provided the technology much appreciation. Researcher has mixed review on the technology front, some suggest the methods are efficient enough whereas few questioned the accuracy of it [14]. Deep learning is another field successfully emerged in medical image analysis and widely implemented through its methods and techniques [15].Deep learning has seen tremendous increase in its adaptation and application into the medical informatics domain. Having widespread presence and showing its potential in last two decades, deep learning has been highly researched and widely applied into

the industry. Medical data generated in form of clinical reports, patient charts and diagnosis reports result in exponential surge in medical data. Deep learning having the capability to process huge data and analyze them efficiently proved and edge for its rapid and iterative implementation. Deep Learning has three major methodologies Artificial Neural Network (ANN), Recurrent Neural Network (RNN) and Convolutional Neural Network (CNN). ANN and RNN has been applied majorly in text and number data whereas, CNN is applied for vision or image data [16].

. Deep learning based models have regularly are requited for design and experimental study were done on them with human expertise with a trial-and-error based continuous approaches. The technique needs humongous time, resources etc. To reduce this huge problem, an unusual a very much easier model is created for performing classification tasks in a optimal way with the network of deep learn model automatically. This work creates a convolution neural network model that is basically train for classifying and detecting the appearance of pneumonia of a combination of several X-ray image samples of Chest Images. Without other approaches that are relying based on transfer learning method or traditional handcrafted techniques for getting a very good performance of classification, we constructed a convolution neural network model from scratch for extracting features from the given chest X-ray image and classify it to determine the presence of pneumonia in a human body. This model could help us to mitigate the reliability and interpretability challenges which basically deals with the medical imagery. Unlike those of the deep learning based classification related task of enough image repository, so obtaining a huge amount of pneumonia datasets are required for the particular classification related task. Therefore, we tried to tune several parameters of the model for improving the validation and classification accuracy of CNN based model and getting good validation accuracy.

Although CNN-based deep learning algorithms have become one as a crucial choice for image classifications of medical datasets although the state-of-the-art CNN-based classification techniques gives an almost same fixed architectures as of the trial-and-error system that have an accurate design principle for this system. Medical Image analysis is one of the many application areas of CNN where it is applied for various task such as classification, segmentation, detection and analysis [14]. There are many types of medical images known as image modalities these include Magnetic imaging resonance (MRI)[1], Computed Tomography (CT) [2], X-Ray [3]. Transfer learning can be defined as the transfer of knowledge gained by one architecture transferred to another domain architecture [7].

Objective of the research work is to provide the update and advances in the field of CNN and its architecture application using the transfer learning techniques. Our focus is more on architecture side rather than the type of medical image modality therefore we included all the image types applied with CNN architectures.

In this work, a deep learning-based approach is used for identifying COVID-19 from patient's chest X-ray images has been created. The development of this model based on convolutional neural network model with the use of transfer learning. Here. Adding the classification layer in these model at end part and end to end training is done throughout the network on a dataset consists two classes as of normal or non-covid, covis, and chest X-ray as affected image and also trained with dataset of 2 classes as (COVID and Non-COVID).

II. RELATED WORKS

Application of various CNN architecture is specific to the task it is designed by Stephen et al. [4] discovered classification related work and to identify appearance of pneumonia from chest image dataset of X-ray samples on the basis of ConvNet model which are trained on scratch based datasets[5]. The results getting are training loss = 12.88%, accuracy of training =95.31%, validation loss = 18.35%, and validation accuracy = 93.73%.

In [6], the contributors explained about a faster detection system of Pneumonia based X-ray with Inception , VGG16. Here , a dataset is reported to contain an approximate of 5800 chest X-ray images which was shown by Kermany et al [5] 1600 normal , 4200 up-normal cases of pneumonia in Kermany X-ray dataset. The experimental outcomes have showed that VGG-16 provides well results than X-ception to rate of classification is 87%.

As the COVID-19 disease grew up to be a pandemic , researchers are mainly focusing on creating a vaccine or medicine in hand [8] and COVID-19 detection with PCR and imaging process to other[7]. Here, the studies that are reviewed may be given for radiography images for complementing PCR in diagnosis of COVID-19.

Another Study by [10] describe CNN architectures using transfer learning with ensemble classifier, author claims that ensemble is very efficient method in multi-categorical classification and detection on color fundus images, where images have classified on 16 different species level. Similar method adopted in research by [5] instead of ensemble author integrated two CNN architecture making a pair together namely Inception-ResNet and AlexNet-GoogleNet, ResNet with transfer learning performed best among the rest. Study by [11] applied ResNet and Inception V3 for bird species classification with implementation of two stage training model achieved the accuracy of 55.67 % which one of the best result during the bird species challenge of 2018.

Krizhevky designed a large deep CNN trained on imagenet called Alex Net[9] in 2012. It consists of 8 trainable layers mainly 5 convolutional layers and 3 fully connected layers. Relu is applied after every convolutional layer. First and second fully connected layer is preceded by a Dropout layer. The network has 62.3 million parameters. AlexNet gained its popularity as it uses Rectified Linear Units(ReLU) instead of tanh. It attains multiple GPU training by assigning half of model's neuron on one GPU and other half on another GPU. AlexNet model also introduced overlapped pooling thus making the model harder to overfit. Alex Net used down sampled image of 256*256 pixels. Dropout and data augmentation were used to reduce overfitting.

III. PROBLEM STATEMENT

The approach whatever use for classifying the disease accurately are illustrated below:-

Algorithm Of Classification Of Covid And Non Covid

Step 1: After Taking Input image it is pre-processed i.e. image = M Pre-processing is used (Keras is used for generation of datasets)for this purpose:
i.) Reshape the image (X) to (140, 140, 3) Note: shape = (140, 140, 3) for quicker processing.
shape = (250,250,3) for performance as better
Step 2: Input of the pre trained model is applied on image.
Step 3: Last convolution layer of given model is fetched here.
Step 4: Flatten dimensions are reduced with dimensions to n-1.
Step 5: Next a dense layer is applied.
Step 6: Apply Activation function RELU.
Step 7: Due to inference Dense Layer has been applied.
Step 8: Next use softmax function for classification of data.
Step9: Classify the resultant image as separated as covid and non-covid.
Step10: Measure Several performance parameters.

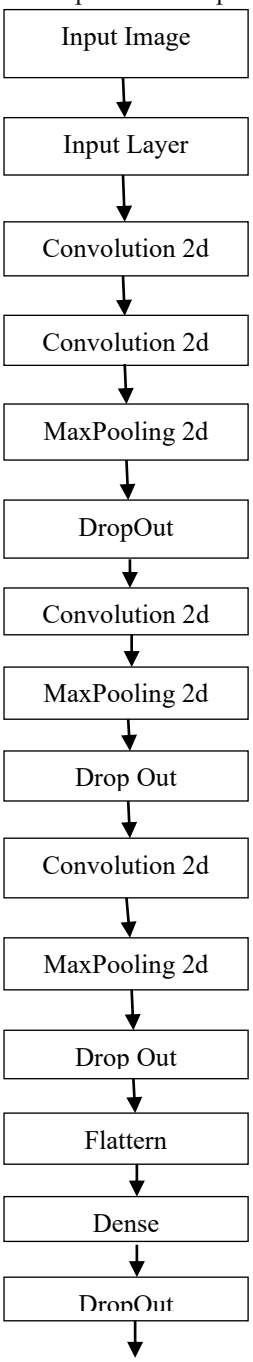

Fig1: Steps Of Proposed CNN Approach

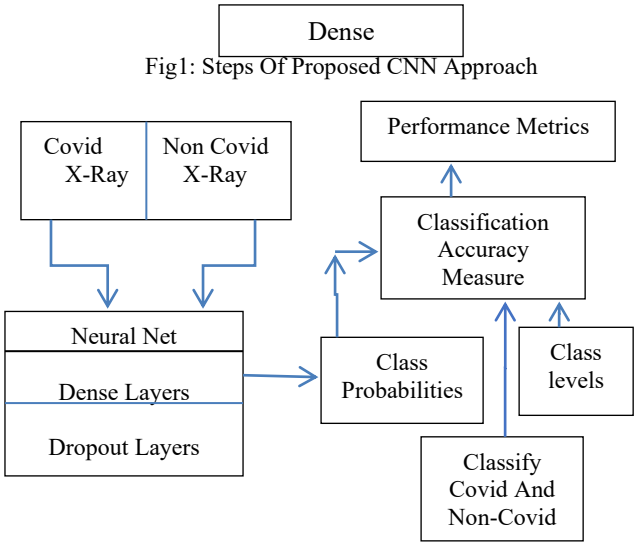

Fig. 2: Proposed Model of Covid Classification Of Chest X-ray

Here the model is used to separate it as 2 classes as covid and non-covid x-ray and use it as class levels and it will be passed to CNN with several layers and finding their class probabilities.

IV. RESULT, ANALYSIS AND DISCUSSION

The result, analysis and some discussions are broadly described as follows: Covid actually originated from the Wuhan city in the Hubai province of China. Thus, the acronym China Originated Virus in December 19 (COVID-19). It was named as Severe Acute Respiratory Syndrome Corona Virus 2 (SARS-CoV-2).The subgroups of the Covid family are alpha-Cov,beta-Cov, gamma-Cov and delta-Cov.

The SARS-CoV-2 is assumed to belong to the beta family of the corona virus or beta. With a significant rise in the number of cases all over the world we can understand that the transfer ability of SARS-Cov-2 is much higher than SRAS-CoV-2. It is estimated that the authentic recombination of 5 protein in the RBD region is the main cause of that.

Deep learning is a subfield of machine learning that is inspired by the techniques of learning of neurons (brain). Nowadays we have seen DL has become popular with research. They use this technique on image and video datasets for better learning of model and better results.

Convolutional neural networks are one of the deep learning techniques that help us classify images. CNN has achieved tremendous success in the medical field of classification of diseases on basis of image dataset. Thus, helping us build accurate models that help us predict and diagnose the disease better. This is the reason why we chose to use the same for our covid-19 dataset.

We have a dataset that contains the x-ray images of lungs. In the dataset we have three categories of images specifically: -

i. Normal or Non Covid

ii. Covid

Here the classification is done of Normal and Abnormal as Covid-19 with 3*3 kernel for filtering and relu activation function is used in CNN model.

So in this algorithm dataset used from Github and kaggle which is initially preprocessed and is divided in three sets accordingly. Actually we had a dataset of covid-19 positive lungs x-ray images from Github, kaggle. But for classification we also need to have x ray images of lungs free from covid-19. Moreover we have also taken into concern that the images are of the front x-ray images.

No of epochs	Training Loss (in %)	Training Accuracy (in %)	Val_loss (in %)	VaL_accuracy (in %)
1	77.98	64.06	62.33	81.67
2	49.69	77.59	34.96	91.67
3	31.38	87.55	20.88	95.00
4	20.68	92.12	17.11	98.33
5	22.57	92.58	16.07	98.33
6	16.56	93.36	10.07	98.42
7	14.92	96.89	07.38	98.33
8	15.12	94.14	7.62	98.37
9	10.10	97.35	7.61	98.31
10	19.54	92.97	1.88	98.29

Table1 : Accuracy Measurement Of 3*3 kernel activation Of RELU

Now after screening of the raw dataset some images of the processed dataset have printed and here it have been also splitted the same in train, test and validation. After successful splitting of the dataset, it is found that almost had 1000 images for training the model 150 images for testing or validation data. Here the accuracy is measured as training and validation accuracy after changing the no of iterations in CNN model.

We also had a leftover testing data of 224 images Doing this we finally have three datasets for the training and the picture in this dataset is shown below.

Thus, after experimenting various combinations of kernel size and various activation functions conclusion is drawn to that 3*3 kernal and relu activation function is the best for our proposed model. The results we obtain through this model was satisfactory. The results obtained are provided below. Here the working model is compared with those of the existing ones, i.e of the work done in this field before Loss and accuracy obtained in 3*3 kernel activation relu:

Table 2: Comparative Accuracy Measurement of Several Activation Functions

No of epochs	Kernel used	Function used	Training Accuracy	Testing Accuracy
10	3*3	ReLU	96.87	98.3
10	3*3	sigmoid	51.87	50.00
10	3*3	tanh	52.28	63.3

Thus after experimenting various combinations of kernel size and various activation functions we come to the conclusion that 3*3 kernal and relu activation function is the best for our model.The results we obtain through this model was satisfactory . The results obtained are provided below.

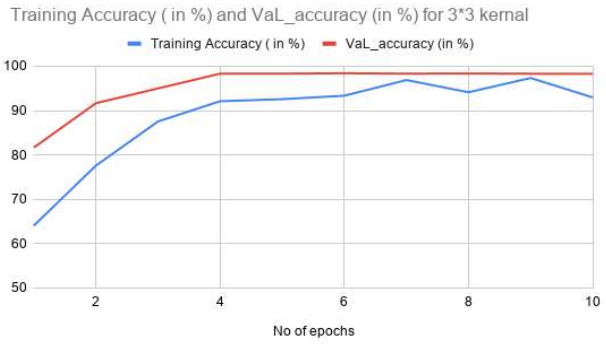

Fig3: Comparison plot for Training and Validation Accuracies for 3*3 kernel

Here the results shows for training and validation accuracy measurement of 5*5 kernel activation function for RELU are given below:-

Table3 : Accuracy Measurement Of 5*5 kernel activation Of RELU

No of epochs	Training Loss (in %)	Accuracy(in %)	Val_loss(in %)	val_accuracy(in %)
1	98.61	50.39	69.32	50.03
2	67.37	57.68	63.65	63.33
3	69.16	76.76	51.69	53.33
4	47.38	85.94	41.20	76.48
5	32.47	92.19	24.68	83.67
6	25.62	91.89	7.43	96.67
7	27.65	91.80	7.28	96.33
8	30.66	92.53	1.42	96.33
9	24.34	91.26	1.64	96.46
10	19.64	91.85	.055	97.5

Here the changing the iteration value will make an impact in training and testing accuracy results that are significantly shows in the table.

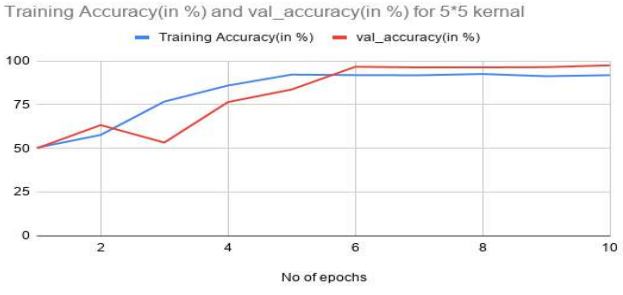

Fig4: Comparison Plot Of Training and Validation Accuracies For 5*5 kernel

Here the resultant training and testing accuracy are continuously increasing according to changes in no of epochs.

Here training and validation accuracy will be increased for changing no of epochs. After epochs 6, 8 and 10 it will near about 97 percent of validation accuracy rates.

Table 4: Accuracy Parameters Measurement

Cardiac Images	Precision	Recall	Accuracy	F1-Score
Covid	0.88	0.98	96.123	0.92
Non-Covid	0.87	0.96	93.31	0.91

Here others statistical parameters are like Precision, Recall, Accuracy, F1-Score etc are measured accordingly these scores are calculating for COVID and Non-COVID both categories of classification. The resultant score are more than 90 percent of prediction of diseases.

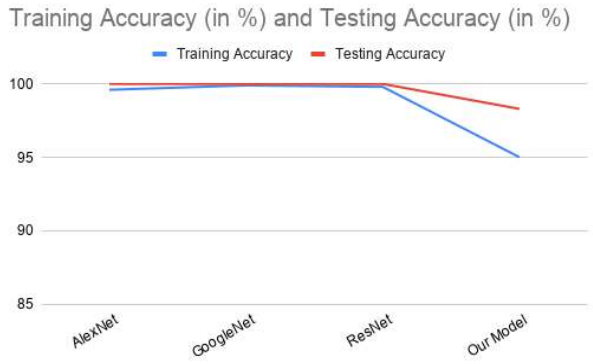

Fig5: Comparing Accuracy Of Several CNN Based Model

The results whatever we have got for the datasets of kaggle and github for COVID and Non-COVID Classification the our RELU Based model gives more than 95 percent of training and testing accuracy and other model these Alexanet, GoogleNet, ResNet also gives more than 99 percent of rates for good classification.

V. CONCLUSION

So, we are able to conclude after experimenting the performances of model that our model can successfully classify X-ray images into covid-19 positive and negative. In the dark times of the pandemic, this study was immensely helpful in knowing the disease and also understanding the effect this virus has our lungs. So Convolutional neural networks (CNN)is based on deep learning feature which is useful for detection of this disease without much human to human contact can play a key role in controlling the rate of spread of this dangerous communicable disease. Clinical test includes collection of swabs which can be highly contagious and infectious. The approach is combined with two types of Xray images, are as COVID-19, and normal. So we are able to conclude after experimenting the performances of model that our model can successfully classify Xray images into covid-19 positive and negative. In the dark times of the pandemic, this study was immensely helpful in knowing the disease and also understanding the effect this virus has our lungs. So Convolutional neural networks (CNN)is based on deep learning feature which is useful for detection of this disease without much human to human contact can play a key role in controlling the rate of spread of this dangerous communicable disease. Clinical test includes collection of swabs which can be highly contagious and infectious. The approach is combined with two types of Xray images, are as COVID-19, normal.

Here we are comparing the several previous works done on COVID 19 based classification on this dataset. So, we compare our algorithm with these methods for identifying the strengths of our approach.

No	Methods/ Approach	Accuracy
1	GLCM+SVM[23]	93.2
2	HOG+SVM[23]	88.5
3	LBP+SVM[23]	93.4
4	Deep learning Methods[20]	89.5
5	TL+CSSL[24]	89.1
6	Transfer learning (TL)[24]	87.1
7	GAN And Deep Transfer Learning[17]	98.5
8	COVID-Net[13]	98.9
9	Deep Learning and Transfer Learning Algorithms [12]	81.8
10	DeTraC[22]	95.12
11	CNN Transfer Learning[18]	94.5
12	Deep Learning and Transfer Learning with Alexanet[25]	100
13	Our Proposed Approach	96.13

Table 5: Comparison of Accuracy Values Of Various Approaches

Here, the L. Wang and A. Wong's approach of COVID-Net[13], Mohamed Loey, Florentin Smarandache of GAN And Deep Transfer Learning[17], H. S. Maghdid, A. T. Asaad, K. Z. Ghafoor of Deep Learning and Transfer Learning with Alexanet[25] algorithms provides more than 98 per cent of accuracy rates for classification and diagnosis of COVID 19 diseases. H. S. Maghdid[12] has proposed a Deep Learning and Transfer Learning methods for Diagnosing COVID-19 and Pneumonia from X-Ray and CT Images with 81.8 percent of accuracy . Our RELU Based Approach provide more than 96 per cent accuracy rates for classifying COVID Disease.

VI. FUTURE STUDY

The work may be extended with some other machine learning based algorithm to compare this CNN based prediction with other model for better accuracy rates. Also, several activation functions can be used and other model as CNN as Alexnet, Densenet, Resnet etc. can be applied on given datasets for finding the accuracy rates. Also, in future we try to illustrate the concepts in a model with detecting both covid and pneumonia with a particular mobile application that can provide better framework for covid classification.

VII. ACKNOWLEDGEMENT

The datasets are taken for Covid 19 prediction is taken from Kaggle, Github open access particularly. These images are very much crucial for working in this area of research.

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