Covid Prediction from X-ray Images

D.Haritha
Computer Science and Engineering Department
SRK Institute of Technology
Vijayawada, India
harithadasari@rediffmail.com

Ch.Praneeth
Computer Science and Engineering Department
Koneru Lakshmaiah Education Foundation
Vaddeswaram, India
chpraneeth@hotmail.com

M.Krishna Pranathi
Computer Science and Engineering Department
SRK Institute of Technology
Vijayawada, India
Pranathi.meegada@gmail.com

Abstract— **Early detection of COVID 19 is having the significant impact on curtailing the COVID 19 transmission at faster rate and is the need of the hour. An Artificial Intelligence diagnostic using Deep Learning models trained with X ray images of COVID infected and noninfected patients is a new promising method that helps in early prediction and identification of COVID infected persons. This paper 'COVID prediction from X-ray images' acquaints a system to be utilized for automatic identification of corona virus from chest X-ray by machines in less time i.e. less than five minutes. For this we consider dataset of chest x-ray images of pneumonia, COVID 19 disease and normal infected people. We use the concept of Transfer Learning for its advantage of decreasing the training time for a neural network model. Using the VGG model of Transfer Learning we show an accuracy of 99.49% in prediction of the COVID 19 from X ray of the suspected patient.**

Keywords—COVID-19; pneumonia; transfer learning; VGG16

I. INTRODUCTION

COVID-19 is the communicable disease caused by most recently discovered corona virus posing serious threats to the general public health and economies of countries. This cause respiratory infections starting from cold to most severe diseases like Middle East Respiratory Syndrome (MERS) and Severe Acute Respiratory Syndrome (SARS). Its outbreak began in Wuhan, China in December 2019.This spread primarily from person to person and till now there is no vaccination or medicine to prevent or cure the disease. The only way to control the spread of the disease is social distancing and self-isolation. To control its spread early identification is important. The symptoms of the disease include fewer, sore throat, headache, cough, mild respiratory symptoms even leading to pneumonia. It's now pandemic affecting many countries globally. The number of cases around the world has been increasing exponentially. Daily thousands of people are being confirmed with corona positive and the number of deaths is also growing [1]. One of the ways to spot this is Polymerase Chain Reaction (PCR) test. It locates a particular coronavirus gene sequence and creates multiple copies that can then be easily spotted. Along with this PCR test we can use reverse transcription PCR test. This is done by collecting samples of nasal secretions. These test kits are available in very less number that is not sufficient to the current scenario. Since reverse transcription polymerase chain reaction (RT-PCR) test kits also are meagre, there exists a requirement to explore alternative means of identifying and prioritizing suspected cases of COVID-19. Other-wise this virus will spread easily thus increasing the positive cases. So, in addition to these medical tests it is good to aid computer technology like Artificial Intelligence, as it can play a vital role. Artificial Intelligence (AI) is used in cameras to track infected patients with travel history using facial recognition so that we can easily identify other people who are in physical contact with corona effected person., robots to deliver food and medicines for patients, drones to disinfect public places etc. [2]. AI has been used extensively to find new molecules on the way to find aid for COVID-19.

Many researchers are using AI to seek out new drugs and medicines for the cure, along with some computer science researchers focusing on detecting the infectious patients through medical image processing like X-rays and CT Scans [3]. Covid effects lineup of respiratory track, shows preliminary symptoms like pneumonia and as doctors frequently use x-rays to test for pneumonia etc., identification of covid using X-ray can play significant role in corona tests. So, to increase the covid testing rate we can use X-ray test as preliminary test and if AI prediction test results in positive then patient can undergo medical test. In this paper we used transfer learning which is a machine learning technique that focuses on reserving knowledge gained while solving one problem and apply that on other. A dataset consisting of chest x-ray images of Covid-19 patients and normal patients is used for transfer learning.

Section II briefs some of the recent works done in Covid prediction using AI and Deep Learning (DL) techniques. Section III presents our methodology used for application of VGG16 model for Covid prediction and discusses the testing results.

II. Related Work

Starting from the outbreak of the virus many researchers are working on this, discovering many different ways for identifying covid-19 and as well as for its cure. The ide-ology of using x-rays in prediction of covid-19 came from the initial approaches which are used in pneumonia detection from chest x-rays using deep neural net-works [4]. It is also important to have good dataset with chest x-ray images of confirmed covid-19 patients. There are some data repositories available in sources like github and Kaggle [5][6] with x-ray images and even csv file of that data.

There are automated methods developed by Asnaoui et al., for detection and classification of pneumonia based on x-ray images [7]. Three types of convolutional neural network-based models (ResNet50, InceptionV3 and Inception-ResNetV2 have been proposed for the coronavirus, pneumonia detection in infected patients using chest X-ray radiographs by Ali Narin, Ceren, Pamuk [8]. They performed these models with 98%, 97% and 87% accuracies respectively. Even Deep Learning showing promising results for this corona prediction, Biraja Ghoshal at el., in their work said that deep learning for disease detection focus specially on improving the accuracy of classification without quantifying uncertainty in a decision. So, there may be diagnostic uncertainty in the work carried out. They investigated how drop weights based BCNN can estimate this uncertainty [9]. Salman, Fatima M., et al., used CNN for covid-19 detection [10]. As an alternate to build a model from scratch, Transfer Learning helps in reducing the computational overhead and is proved to be the most promising technique in many deep learning applications. In this paper we proposed covid-19 prediction from x-rays using VGG, a transfer learning model. There are also previous works done using transfer learning with convolutional neural networks [11]. In this author's used CNN with parameters of transfer learning with networks such as MobileNet v2, Inception and Resnet v2 on 2 datasets. This is one of the available most related paper on our proposed work using VGG16 model. In the next section, a brief explanation of VGG16 model and our methodology of its application for covid prediction from X Rays of covid suspected patients is given.

III. Methedology

A. Dataset of the project

This project needs several chest X-ray images as we are trying to predict covid disease from only the chest x-ray images. Our model is trained on confirmed covid-19 infected and other normal x-rays for covid prediction and also on pneumonia, pneumothorax, TB, so that it differentiates between them well and predicts all 5 differently. There is a collection of these datasets available on internet [5][6]. To train our model we had taken a small dataset consisting of 1824 images comprising of covid and normal x-rays from an available dataset [12]. The following Fig. 1 shows sample chest x-ray images of covid-19 patient and normal patient.

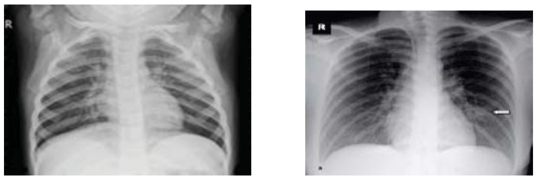


Fig. 1. Sample chest x-ray images of covid and normal patient

Then for multiclass classification and prediction we had build a dataset from different sources [6] which consists of 2476 x-rays of Pneumonia, pneumothorax, TB, covid-19 and normal cases.

B. Transfer Learning

Transfer Learning is a process where we train a model for one problem, and with minor modifications use for few other related problems. One or more layers from the trained model are then utilized in new model. It decreases training time in neural network for optimization of tuning hyper parameters. Generally, when we use pretrained models of transfer learning in our model then we freeze few or no layers of pretrained model. There are 3 popular methods in transfer learning, they are- VGG (VGG 16 or 19), GoogLeNet (Inception v1 or v3), Residual Network (ResNet50). Keras provides access to variety of such pre-trained models. In transfer learning initially Convolution Neural Networks (CNN) are trained on datasets and then they are employed to process new set of images and extract the features. We have taken transfer learning model trained for ImageNet dataset that contains 10 different classes with 70000 images. In medical related tasks we use transfer learning to exploit CNN with these models and evaluate algorithms for image classification and object detection. In this paper we used VGG model of transfer leaning which works as follows. VGG is a Convolutional neural network architecture, it is proposed by Karen simonyan and Andrew of Oxford Robotics Institute in the year 2014. It was submitted to Large Scale Visual Recognition Challenge (2014) as shown in Fig. 2.

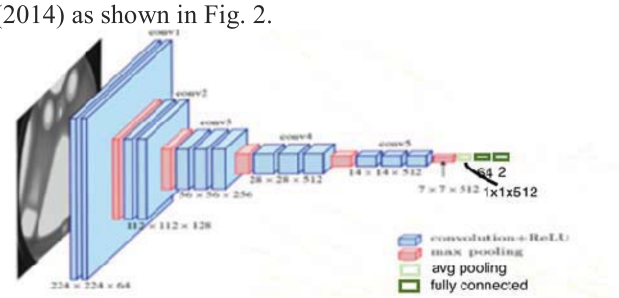


Fig. 2. Architecture of our VGG model

The VGG 16 is deep with 16 weight layers including 13 convolutional layers with filter size of 3 X 3, and fully connected layers. The configurations of fully-connected layers in VGG-16 are equivalent with AlexNet. The stride and padding of all convolutional layers are fixed to 1 pixel. All convolutional layers are divided into 5 groups and every group is followed by a max-pooling layer.

Convolutional Layers: The convolutional layers in VGG use a very small receptive. There are also 1x1 convolution filters. The convolution stride is fixed to 1 pixel so as that the spatial resolution is preserved after convolution.

Fully-Connected Layers: VGG has three fully-connected layers: the first two have 512 channels each and therefore the third has 2 channels, 1 for each class (covid, normal).

Hidden Layers: All of VGG's hidden layers use ReLU. VGG doesn't generally use Local Response Normalization (LRN).

C. Implementation

In our paper, we have built a VGG16 model for Covid-19 detection from X-rays. First, the baseModel that is pre-trained VGG16 model is considered with 'False' as include_top parameter value. By this, we loaded the VGG16 architecture, leaving off the fully connected layers. Then the output of baseModel is considered as headModel and is now changed according to our model requirements. New FC layers are added to the headModel. The process of whole implementation is given in algorithm below. The deep architecture helped in predicting the result with an accuracy of 99.49% which is greater than the Inception models. The Fig. 3. describes our proposed model implementation.

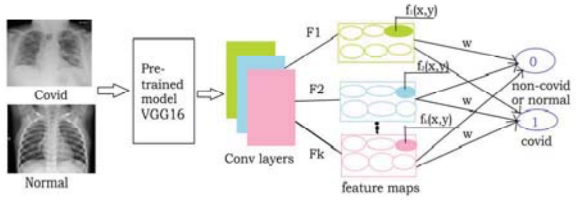


Fig. 3. Schematic representation depicting implementation of our model.

Algorithm

- First, we load the dataset that contains 1824 images with 2 classes and 2476 images with 5 classes.
- As the VGG16 takes input images of size 224 x 224, the images in our dataset are resized to 224 x 224.
- Since we have used the VGG16 network model with weights pre-trained on ImageNet, while leaving off the FC layer head.
- Then a new fully-connected layer head is constructed consisting of POOL => FC =SOFTMAX layers and is appended on top of VGG16.
- Finally, we then freeze the CONV weights of VGG16 such that only the FC layer head will be trained.
- Now, we pass a new X-ray image to detect whether the patient is having covid-19 or not and also if any other diseases like pneumonia, pneumothorax, tb can also be predicted.

D. Experiments and Results

Our VGG model works well and predicts covid-19 without any uncertainty. We have performed different experiments on this. Below sections describe those experiments and the results obtained.

1) Dataset

We had given chest x-ray images as input to our model. This data is divided in 8:2 ratio in our model i.e. 80% for training the model and 20% for model validation. We also tested with other images. All the dataset images are also resized to (224,224) as default image size.

2) Feature Extraction

In VGG the layers from the input layer to the last max pooling layer are considered for feature extraction part. The process of VGG extracting features from images is shown in below Fig. 4.

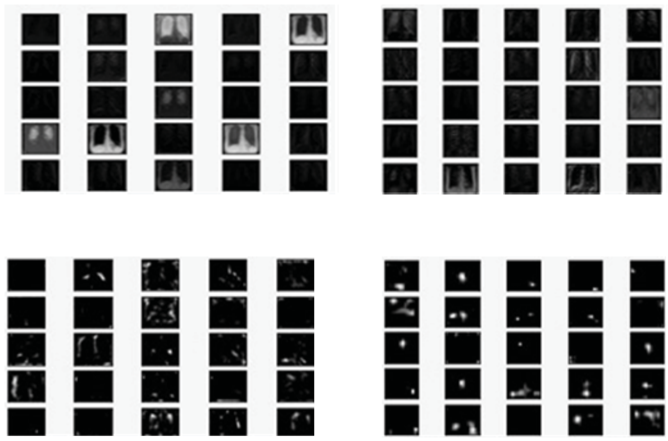


Fig. 4. Feature extraction in VGG16 from x-ray images

3) Hyperparameter tuning

The hyperparameters are tuned in order to obtain a high-performing model. We tuned around 5 different parameters which comprise of adjusting the learning rate, selection of optimizers, loss functions, changing number of epochs, batch size, test size, rotation range etc. Learning rate is given as parameter to the optimizer function. Working on different optimizer and loss function did not affected the working of the model much so we used Adam as optimizer function and binary cross entropy as loss function throughout the model. Batch size is the number of samples that will be propagated through the network and epochs is the number of times the model is implemented on training data. Dropout is a regularization technique where some random neurons are ignored during training. Increasing dropout generally increases accuracy. We can observe in below Table 1. how different values of these parameters affect the performance of model when trained on sample dataset of 66 images.

TABLE I.
accuracy, sensitivity, specificity with changing values of parameters

Epochs	Batch size	Test size	Rotation range	Learning Rate	Dropout	Accuracy

10	5	0.2	20	1e-3	0.7	69.23
20	5	0.2	20	1e-3	No	76.92
20	5	0.2	20	1e-3	0.7	69.23
50	5	0.2	20	1e-3	0.7,0.5	69.23
50	32	0.2	20	1e-3	No	38.24
60	10	0.2	20	1e-3	No	69.2
60	5	0.2	20	1e-3	0.7	92.85
60	5	0.2	20	1e-2	No	69.2
200	5	0.3	30	1e-3	0.5	95

Then training on full dataset with parameters values as epochs 30, batchsize 5, learning rate 1e-3, test size 0.2, rotation range 20 has achieved an accuracy of 99.49% for two classes and an accuracy of 98% for multiclass with 5 classes.

4) Performance Metrics

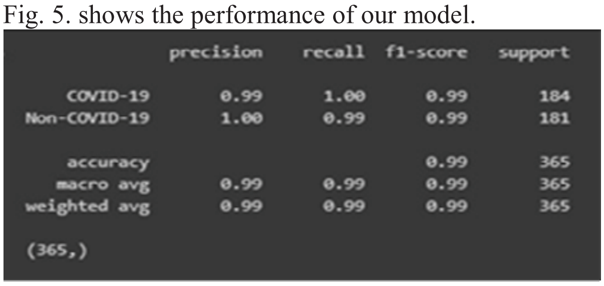
In a model the values like accuracy, precision, recall, f1-score and support are considered as performance metrics since they are used to evaluate the model performance.

Accuracy: It is the measure of total number of predictions that are perfectly classified.

Precision: It is the measure of specific cases expected based on confidence.

Recall: It can be defined as the number of documents retrieved by search in total number of existing relevant documents, which is similar to true positive rate.

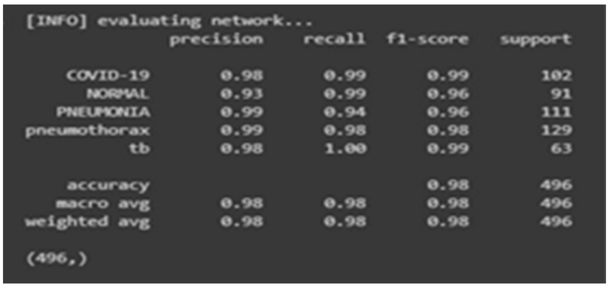
F1-score: It is the weighted average of precision and recall. Fig. 5. shows the performance of our model.



	precision	recall	f1-score	support
COVID-19	0.99	1.00	0.99	184
Non-COVID-19	1.00	0.99	0.99	181
accuracy			0.99	365
macro avg	0.99	0.99	0.99	365
weighted avg	0.99	0.99	0.99	365

(365,)

Fig. 5(a). Performance metric values obtained for binary classification model.



[INFO] evaluating network...

	precision	recall	f1-score	support
COVID-19	0.98	0.99	0.99	102
NORMAL	0.93	0.99	0.96	91
PNEUMONIA	0.99	0.94	0.96	111
pneumothorax	0.99	0.98	0.98	129
tb	0.98	1.00	0.99	63
accuracy			0.98	496
macro avg	0.98	0.98	0.98	496
weighted avg	0.98	0.98	0.98	496

(496,)

Fig. 5(b). Performance metric values obtained for multi-class classification model.

It ends up with a good accuracy of 99.49% and the values for sensitivity, specificity as 1.0000 and 0.9890 respectively for covid and normal classes in covid prediction and accuracy of 98% with sensitivity and specificity values as 1.0000, 1.0000 respectively for multiclass model. Fig. 6. Shows graphs depicting variations in different measures for both binary and multi-class models.

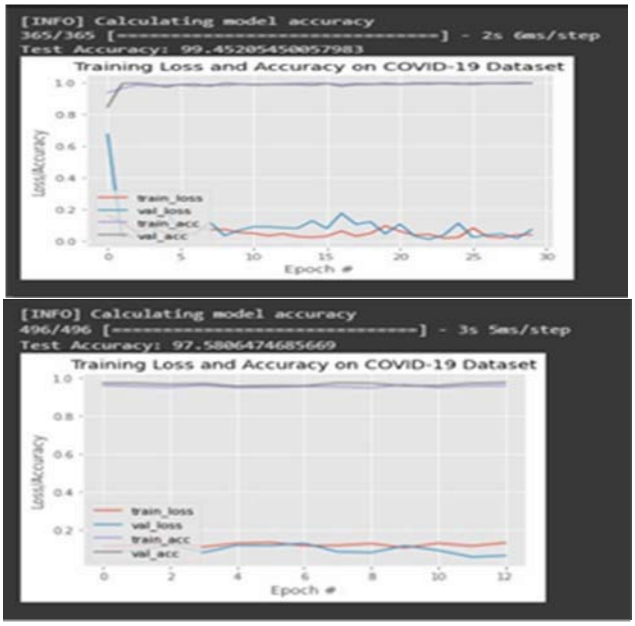


Fig. 6. Graphs showing variations in different measures i.e. train_loss, val_loss, train_acc and val_acc for binary and multi-classes.

IV. Conclusion and Future Work

In this paper we trained the CNN with VGG model using x-ray images to predict the novel covid-19 disease. We obtained an accuracy of 99% in detecting covid-19 virus and also 98% for other different classes that included pneumonia along with covid from chest x-rays. This paper supports the significant use of Artificial Intelligence and in particular Transfer Learning in disease prediction. This idea can further be implemented and extended in real-time scenarios with use of Internet of Things to get instantaneous Xrays of suspected patients of covid-19 and do prediction in very less time. We worked on VGG model and this can also be extended to other transfer learning methods.

Our main future goal is to train this model on a larger dataset so that we can train the model well and thus increasing accuracy, because in machine learning training with more data makes the model to perform much better on unseen data. This can also be further developed to predict the possibility of that affected person to survive. We are also working on this. However, it's our hope that this project will still improve and potentially offer insight which will contribute toward medical research regarding COVID-19.

References

[1] Source of data about daily confirmed covid-19 cases,deaths.https://github.com/owid/covid-19-data/tree/master/public/data.

[2] M.A. Ruiz Estrada. The uses of drones in case of massive Epidemics contagious diseases relief humanitarian aid: Wuhan-COVID-19 crisisSSRN Electron J (2020), 10.2139/ssrn.3546547(February)Google Scholar

[3] T.T. Nguyen, G. Waurn, P. CampusArtificial intelligence in the battle against coronavirus (COVID-19): A survey and further research and directions (2020), 10.13140/RG.2.2.36491.23846Google Scholar

[4] Wu, Huaiguang, et al. "Predict pneumonia with chest X-ray images based on convolutional deep neural learning networks." Journal of Intelligent & Fuzzy Systems Preprint (2020): 1-15.

[5] J. Cohen, “COVID-19 image data collection”, GitHub, 2020. [Online]. Available: https://github.com/ieee8023/covid-chestxray-dataset. [Accessed: 17- Mar- 2020].

[6] “RSNA Pneumonia Detection Challenge”, Kaggle, 2020. [Online]. Available: https://www.kaggle.com/c/rsna-pneumonia-detection-challenge. [Accessed: 22- Mar- 2020].

Sources of x-ray images of pneumonia, pneumothorax and tb

URL:https://www.kaggle.com/paultimothymooney/chest-xray-pneumonia URL:https://www.kaggle.com/iafoss/siimacr-pneumothorax-segmentation-data-256/kernels

URL:https://www.kaggle.com/kmader/pulmonary-chest-xray-abnormalities

[7] Asnaoui, Khalid El, YounessChawki, and Ali Idri. "Automated methods for detection and classification pneumonia based on x-ray images using deep learning." arXiv preprint arXiv:2003.14363 (2020).

[8] Narin, Ali, Ceren Kaya, and Ziynet Pamuk. "Automatic detection of coronavirus disease (covid-19) using x-ray images and deep convolutional neural networks." arXiv preprint arXiv:2003.10849 (2020).

[9] Ghoshal, Biraja, and Allan Tucker. "Estimating uncertainty and interpretability in deep learning for coronavirus (COVID-19) detection." arXiv preprint arXiv:2003.10769 (2020).

[10] Salman, Fatima M., et al. "Covid-19 detection using artificial intelligence." (2020).

[11] Apostolopoulos, Ioannis D., and Tzani A. Mpesiana. "Covid-19: automatic detection from x-ray images utilizing transfer learning with convolutional neural networks." Physical and Engineering Sciences in Medicine (2020):

[12] http://md-datasets-public-files-prod.s3.eu-west-1.amazonaws.com/bc9f750d-b663-48a7-844e-4e8246751706.