Course Project Report

COVID-19 Prediction Using Chest X-rays Images

Submitted By

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National Institute of Technology Karnataka, Surathkal

C E R T I F I C A T E

This is to certify that the Course project Work Report entitled **"COVID-19 Prediction Using Chest X-rays Images"** is submitted by the group mentioned below -

Details of Project Group

Name of the Student	Register No.
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this report is a record of the work carried out by them as part of the course **Computer Vision (IT813)** during the semester **Feb-June 2021**. It is accepted as the Course Project Report submission in the partial fulfillment of the requirements for the award of the degree of **Master of Technology in Information Technology.**

(Name and Signature of Course Instructor)
Dr. Dinesh Naik

DECLARATION

We hereby declare that the project report entitled **"COVID-19 Prediction Using Chest X-rays Images"** submitted by us for the course **Computer Vision (IT813)** during the semester **Feb-June 2021**, as part of the partial course requirements for the award of the degree of Master of Technology in Information Technology at NITK Surathkal is our original work. We declare that the project has not formed the basis for the award of any degree, associateship, fellowship or any other similar titles elsewhere.

Details of Project Group

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Place: NITK, Surathkal
Date: 06-06-2021

COVID-19 Prediction Using Chest X-rays Images

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***Abstract*—Understanding covid-19 became very important since large scale vaccination of this was not possible. Chest X-ray is the first imaging technique that plays an important role in the diagnosis of COVID-19 disease. Till now in various fields, great success has been achieved using convolutional neural networks(CNNs) for image recognition and classification. However, due to the limited availability of annotated medical images, the classification of medical images remains the biggest challenge in medical diagnosis. In our work, we performed transfer learning using deep learning models like Resnet50 and VGG16 and compare their performance with a newly developed CNN based model. Resnet50 and VGG16 are state of the art models and have been used extensively. A comparative analysis with them will give us an idea of how good our model is. We will be developing a CNN model as it is expected to perform really good on image classification related problems. For our research, we have used kaggle radiography dataset for training, validating and testing. Moreover, we have used another x-ray images dataset which we have created from two different sources. The result shows that CNN model developed by us outperforms VGG16 and Resnet50 model.**

***Index Terms*—VGG-16, CNN, Deep learning, Computer vision etc**

I. Introduction

According to World health Organization, covid-19 falls into the family of SARS-CoV-2 virus which was initially outbreak in china in 2003 and end of 2019 due to negligence of chinese government this virus has spread in more than 100 countries and has been declared a global pandemic by WHO. Although COVID-19 affects the entire population, people that have been affected by COVID19 are in most cases either asymptomatic or showcase mild symptoms like cough, headache, fatigue and fever. After this massive outbreak of virus it is very necessary to do the massive testing and break the chain of this virus in order to stop its spread. But the problem is the generic technique that we have is time consuming, not cost effective as well as giving false +ves and false -ves. So it might lead to less testing which results in the more spread of the virus. So much research has already been done to do testing with artificial intelligence. So, keeping these things in mind we came up with a deep CNN model to identify whether a person is diagnosed with covid or not using chest x-ray images.

Convolutional neural networks are extensively been used in image classification, object detection, segmentation task etc and our problem i.e. Covid-19 identification using chest x-ray is also a type of image classification. What this means is that chest x-ray images will be given to CNN models and they have to categorise that image into two classes i.e. either diagnosed with covid or normal. So, for doing this task we have built a deep CNN model from scratch and trained it with two different datasets. There already are various state of the art models like VGG-16, Resnet-50 etc for these kinds of tasks. So we have picked VGG-16 and retrained it also using those two datasets with the help of transfer learning and then we have done a comparative between our model and these state of the art models. Our work shows that our CNN model out performs Vgg16 and Resnet50 models and this has been discussed in details in observation section.

II. Literature survey

The recent development of technology in deep learning and medical image processing in combination with big data repositories for COVID-19 could offer support in the global effort against the new coronavirus. Several studies have investigated the potential of using X-ray and/or CT images identify COVID-19.

COVID-19 Identification from Chest X-Rays : They used retrained models like DenseNet, ResNet, Xception model and classified chest x-ray into 2 classes i.e. diagnosed with covid or not. They were able to achieve 99.90

Classification of COVID-19 in chest X-ray images using DeTraC deep convolutional neural network : Here they created a deep neural network using DeTracC(Decompose,Transfer and Compose for classificaton of chest x-ray). DeTraC can deal with any irregularities in the image dataset by investigating its class boundaries using a class decomposition mechanism. They achieve 93.1% accuracy achieved with 100% sensitivity.

Automated detection of covid-19 cases using deep neural network with x-ray images : A dark CovidNet model has been proposed with YOLO object detection. They achieved 98.03% accuracy. They have implemented a 17 layer CNN model to do this classification task.

A capsule-Network based framework for identification of covid-19 cases from x-ray images : The paper presents an alternative framework based upon capsule network known an Covid-Caps. which is capable of handling small dataset which is of significant importance due to sudden and rapid emergence of COVID-19. Coid-Caps has achieved an accuracy of 95% with 90% sensitivity.

III. Detailed Objective

Objectives of this work is to understand VGG-16 and Resnet50 model structure and perform following tasks on both the datasets :

1) perform transfer learning on VGG16 to train the model.
2) perform transfer learning on Resnet50 and train the model.
3) build a Convolutional neural network model and train it.
4) do comparative analysis between the trained models by testing them on a test dataset.

IV. Methodology

Goal at hand was to develop a CNN based neural network model for Covid chest x-ray classification and then perform comparative analysis with Resnet50 and VGG-16 based state-of-the-art models. All our experimentation were done on Google-collaboratory with python as programming language.

Let's look into the concepts involved

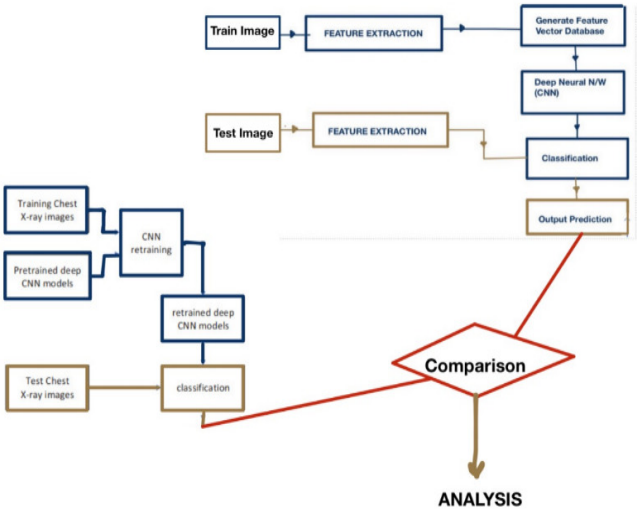

Fig. 1. Flow Diagram

A. Dataset Insight

For training our model we have used two different datasets of chest x-ray images. Sample images of chest x-ray of a person 12 months before getting admitted in hospital for COVID-19, on the day of admission and 10 days after admission is given below.

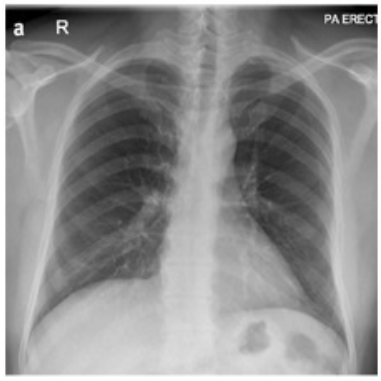

Fig. 2. Chest x-ray of a person 12 months before getting admitted in hospital for COVID-19

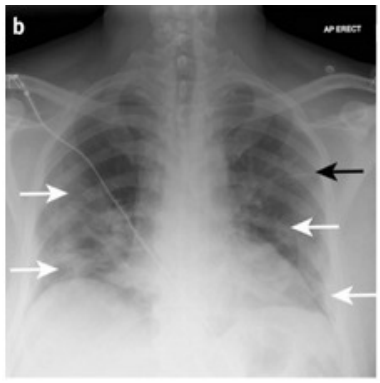

Fig. 3. Chest x-ray of same person on day of admission in hospital for COVID-19

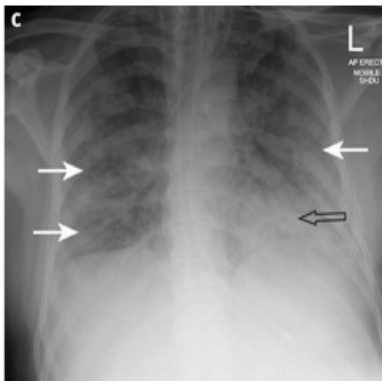

Fig. 4. Chest x-ray of same person 10 days after admission in hospital for COVID-19

1) *Kaggle Radiography Dataset* : It is a publically available chest x-ray image dataset in which total 14000 chest x-ray images belongs to four different classes i.e. Covid, Lung Opacity, Normal and Viral pneumonia. But for our case we have taken 2400 images belonging to two

classes i.e. COVID-19 and Normal for training and 200 images for testing.

2) Own prepared dataset : We have taken Covid diagnosed chest x-ray images from github and Normal chest x-ray images data from Kaggle and by merging these two we prepared another dataset. Here there are 340 chest x-ray images in total which further split as 220 for training and 120 for testing.

B. VGG-16

It is a CNN based model which was initially developed in the imagenet challenge 2014 and it was the winner of that competition. It is generally used in image classification, object recognition, and image segmentation tasks. VGG has 2 variations, First one is VGG-16 and second one is VGG-19. Here in our case we have retrained VGG-16 using chest x-ray image dataset. It is Known as VGG-16 because it has 13 convolutional layers and 3 dense layers. In this model, at convolutional layers we have used 3*3 filter with same padding and stride equals one and at max pooling layer they have used 2*2 filter with stride as 2. Here in our problem while retraining this model again with the help of transfer learning we have made some changes in the fully connected layer and changed activation function at output layer as "Sigmoid" because we had to do binary class classification.

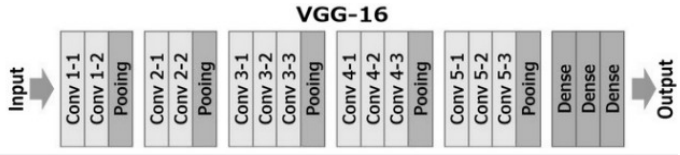

Fig. 5. VGG-16 : Architecture

C. Resnet-50

Resnet (residual network) is broadly used in computer vision tasks like image classification, Object detection, segmentation etc. It was developed in imagenet 2015 challenge and it was a winner of that challenge. The main achievement of this model is that it can allow us to train a very deep neural network with almost greater than 150 layers. Earlier it was not possible due to the vanishing gradient problem. So what the developer did to train such a deep network is that they introduced skip connections which basically resolved the problem of vanishing grading problem while backtracking to find the optimal values of weights.

There are various versions of Resnet-50 as well i.e. Resnet-152 etc. but here we have considered Resnet-50 for our problem which is a shorter version of Resnet-152. We retrained this model on Chest x-ray image dataset with the help of transfer learning and prepared it to do the binary class classification i.e. in our case Covid or Normal.

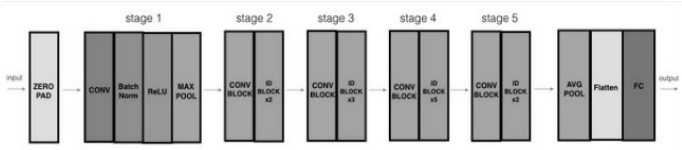

Fig. 6. Resnet-50 : Architecture

D. Transfer Learning

It is a human tendency to learn to solve one task from scratch and when another problem comes with the similar kind of concept then use the knowledge of previous learning to solve the new problem. For instance, Let's remember our learning of first ever object oriented programming language and when we went to learn another object oriented programming language from then it was very easy for us to learn it because we generally used our previous knowledge and correlated almost every concept and learnt it in very less time.

In the same way transfer learning works, it means we don't have to solve a problem from scratch if we have solved almost similar problems in the past. Then we can a Use our past learning and with the help of some modification we can solve our current problem.

So here, for solving our problem using transfer learning we shall keep the conv layer as it is and do some modification in the dense layer like changing activation function etc. and then retrain the model.

E. Our CNN Model

We have created our own CNN model from the scratch in which there are four blocks. In the first block we have two convolution layer with 32 and 64 respectively kernels of size 3*3 and after that we have a max pooling layer with pool size as 2*2 .

```
# CNN Based Model in Keras

model = Sequential()
model.add(Conv2D(32,
                 kernel_size=(3,3),
                 activation='relu',
                 input_shape=(224,224,3)))

model.add(Conv2D(64,(3,3),activation='relu'))
model.add(MaxPooling2D(pool_size=(2,2)))
model.add(Dropout(0.25))

model.add(Conv2D(64,(3,3),activation='relu'))
model.add(MaxPooling2D(pool_size=(2,2)))
model.add(Dropout(0.25))

model.add(Conv2D(128,(3,3),activation='relu'))
model.add(MaxPooling2D(pool_size=(2,2)))
model.add(Dropout(0.25))

model.add(Flatten())
model.add(Dense(64,activation='relu'))
model.add(Dropout(0.5))
model.add(Dense(1,activation='sigmoid'))

model.compile(loss=keras.losses.binary_crossentropy,
              optimizer='adam',metrics=['accuracy'])
```

Fig. 7. CNN : Architecture

Apart from the first block, In all other blocks other than last block, we have a single Convolution layer with 64 ,128 filters and filter size as 3*3 and then a max pooling layer with pool size as 2*2. In the last block we have two dense layers and at the last layer we have sigmoid as activation function because we have to do the binary classification. We also added a dropout layer with value 0.25.

F. Experimentation Steps

1) We retrained the VGG-16 model on the two dataset(which we already mentioned in the dataset section) and noted down all the results that we got.
2) We retrained the Resnet-50 model on the two dataset(which we already mentioned in the dataset section) and noted down all the results that we got.
3) We build our own CNN model from the scratch and train it on the two datasets and noted down the results.
4) Finally, we did a comparative study of all these model and find out that which

V. Observation and Results

We did our experiments on VGG-16, Resnet-50 and our CNN model using 2 datasets mentioned above. VGG-16 and Resnet-50 are widely used for image classification and have been used here for the same to classify data into two classes : covid or normal. Here are the results obtained through the experiments :

DATABASE 1			
Algorithm	Training Accuracy	Validation Accuracy	Testing Accuracy
VGG-16	51	48	50
Resnet-50	95.4	64.06	64.25
Our CNN	78.29	73	69.82

Maximum testing accuracy that we got for database 1 was in case of our CNN model. What we also observed in case of database 1 was that quality of images were not so good. And also since there is very thin line of difference between x-ray of lungs when a patient gets newly affected by covid vs a healthy lung x-ray, it is hard for models to distinguish between these features in case of blurry images.

DATABASE 2			
Algorithm	Training Accuracy	Validation Accuracy	Testing Accuracy
VGG-16	94	93	87.5
Resnet-50	94.99	99	93.7
Our CNN	96.3	96.8	96.67

Database 2 was specially created to test our models and consisted of good quality chest x-ray images. This resulted in better results for all the three models. Test, train and validation accuracies for all 3 models were better for database 2 when compared to database 1. Among these, our CNN model still out-performed

VI. Conclusion

In our work, we worked on binary classification of chest x-ray of patients into COVID-19 affected or normal classes. For this we worked on two datasets. Dataset 1 was a Radiography dataset taken directly from Kaggle and dataset 2 was a mixture of multiple datasets. We trained two state-of-the-art CNN based models, i.e. VGG-16 and Resnet-50. We also developed another CNN based model to do its comparative analysis with VGG-16 and Resnet-50 models. In case of Dataset 1, We achieved the highest test accuracies in case of our CNN model. For VGG-16 accuracy was 50% and in case of Resnet-50 it was 64.25% which shows that our model out-performed these two.

In case of dataset 2, we achieved better accuracies than database 1 for all three models. The reason for this was that dataset 2 consisted of good quality images. We achieved the highest accuracy of 96.67% for our CNN model and 87.5% for VGG-16 and 93.7% for Resnet-50 model. This shows that our CNN model outperforms both of these models too.

VII. Future Work

A lot of new strain of viruses are coming out. COVID-19 virus is evolving and this is resulting in vaccines made for older virus become not useful for these. Also, a recent study showed that we might get an evolved version of coronavirus around 2025. This makes it very important to only increase research in this field. Our work can be expanded to classify these viruses into other classes too like pneumonia, etc. Moreover, good quality dataset creation should be of high focus as if now as higher the availability of these datasets, better will be performance of our neural network models.

References

[1] Iosif Mporas - Prasitthichai Naronglerdrit [*COVID-19 Identification from Chest X-Rays*].

[2] Asmaa Abbas - Mohammed M. Abdelsamea - Mohamed Medhat Gaber [*Classification of COVID-19 in chest X-ray images using DeTraC deep convolutional neural network*].

[3] TulinOzturk - MuhammedTalo - Eylul AzraYildirim - Ulas BaranBaloglu - OzalYildirim - U.Rajendra Acharyafgh [*Automated detection of COVID-19 cases using deep neural networks with X-ray images*].

[4] Parnian Afshara - Shahin Heidarianb - Farnoosh Naderkhania - Anastasia Oikonomouc - Konstantinos N. Plataniotisd - Arash Mohammadia [*A Capsule Network-based Framework for Identification of COVID-19 cases from X-ray Images*].

[5] Hussin A.Rothan and Siddappa N.Byrareddy, [*The epidemiology and pathogenesis of coronavirus disease (COVID-19) outbreak*].

[6] Kai Liu, Ying Chen, Ruzheng Lin, Kunyuan Han [*Clinical features of COVID-19 in elderly patients: A comparison with young and middle-aged patients*].

[7] Yi-Wei Tang, Jonathan E. Schmitz, David H. Persing, Charles W. Stratton [*The Laboratory Diagnosis of COVID-19 Infection: Current Issues and Challenges*].

[8] Abbas A , Abdelsamea M M, Medhat Gaber M [*Classification of COVID-19 in chest X-ray images using DeTraC deep convolutional neural network*].

[9] [*Dataset 1*].
https://github.com/ieee8023/covid-chestxray-dataset
[10] [*Dataset 2*].
https://www.kaggle.com/tawsifurrahman/covid19-radiography-database