Detecting Covid Cases using CT images

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Abstract

Covid-19 is an infectious virus that has infected more that 4 million people worldwide. The present strategy to fight coronavirus pandemic relies heavily on "testing". There are multiple issues with the presently adopted methods of "testing". The issues ranges from non-availability of test-kits for testing to significant number of False negative cases. This project explores detecting Covid-19 positive cases with CT (Computed Tomography) images. The dataset contains CT images of 349 covid cases and 397 non-covid cases. The model in this project is trained on an augmented dataset, and tested on 72 covid and 78 non-covid original CT images. The model is based upon simple Le-Net architecture and contains three convolution and three fully connected layers. The accuracy reported with this model is 0.78. The result demonstrates the use of deep learning models to detect Covid cases.

1 Introduction

The covid-19 virus has infected more than 4 million and claimed more than 300 thousand lives globally [4]. The virus primarily spreads through human-to-human contact. The scale and transmissibility of this virus has forced the lockdown by the governments all across the world. The market, businesses are closed all across the world on an indefinite basis. The coronavirus pandemic is said to have caused the biggest global economic crisis since the Great Depression[7].

The common symptoms for the disease includes fever, cough, dyspna, and pneumonia, however it is possible that a person infected by covid-19 virus may experience very mild or none of the above mentioned symptoms [8], making it extremely difficult for health professionals to detect covid-19 positive cases. The health professionals presently rely heavily upon RT-PCR tests, which takes around 4-6 hours to give results. Moreover, there is a huge shortage of RT-PCR kits across the world. The other testing method is "rapid diagnostic testing" which can give results very fast as compared to the RT-PCR testing but there are multiple studies showing that the rapid diagnostic testing can have a very large number of False negatives [3].This calls for exploring a testing method that is accurate and accessible.

This project explores detection of Covid positive cases using CT images. Deep learning models has already been successfully used for detecting pneumonia using chest-X rays[11], segmentation of liver tumor using CT-images [10], lung nodule classification using CT images [9]. There are studies[1] which have shown lung involvements ,using CT images, in the coronavirus patients. There are already several works that have utilized the deep learning models to classify covid and non-covid patients based on CT images [2][12][5]. Most of the existing work on Covid classifier using CT images uses dataset that is not available publicly (due to privacy concerns), hence the results are not reproducible. This work explores the detection using Deep learning on a publicly available dataset. The other difference is that this project makes use of a relatively simpler architecture as compared to the architectures used by the other related works.

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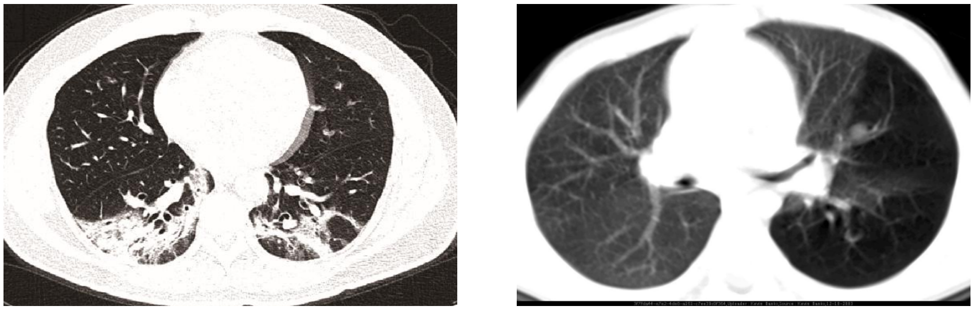


(a) Covid (b) Non Covid

Figure 1: CT scan example for covid and non covid case.

2 DataSet

The Dataset contains CT images of 349 covid patients and 397 non-covid patients. The CT image for covid cases includes clinical findings from 216 patients. Some patient may contribute to multiple CT images in this dataset pertaining to different stages of their illness.The dataset is extracted from 760 medRxiv and bioRxiv preprints about COVID-19 by [13].

The CT images have different sizes. For the purpose of this project, all the CT images have been resized to the height and width of 152 and all the original 3 channel RGB images have been converted to 1 channel grey-scale images.

The dataset is split into two parts (0.2 test split), the training dataset and the testing dataset. Due to the small size of the dataset, testing and validation data-sets are taken to be same. The train dataset contains 277 covid CT images and 319 non covid CT images, whereas the test dataset contains 72 covid CT images and 78 non-covid CT images.

For the training of the model, the train dataset is further augmented with the color jitter, affine, horizontal and vertical flip transformations. The final data, after transformation, on which model is trained consisted of 1595 non-covid images and 1382 covid images.

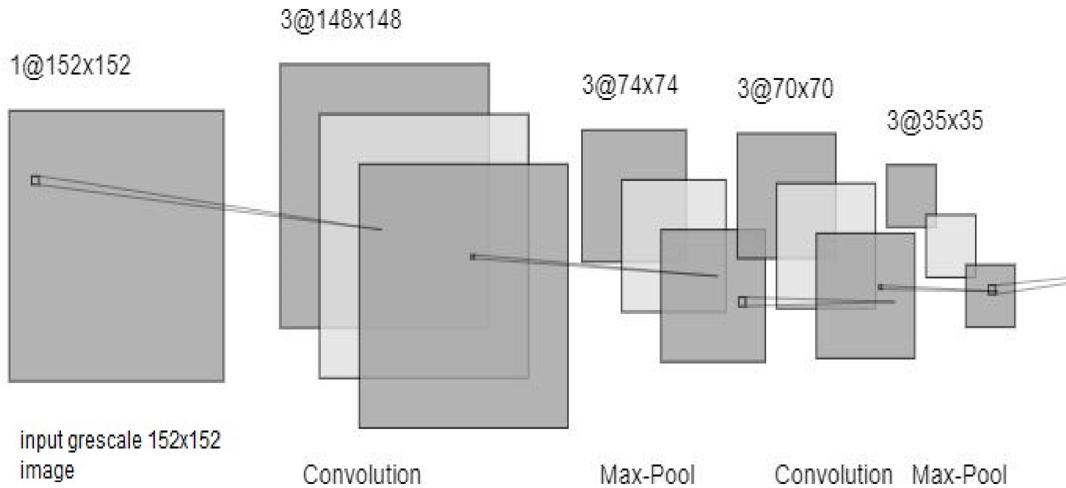
3 Model Architecture and Training

The model architecture used for this project is motivated from Le-Net. The model consists of 3 convolution layers, 3 max-pool layers in between convolution layers and 3 fully connected layers at the end. The neural network architecture also has one drop-out layer between the first and second fully connected layer with p = 0.5. The drop-out layer has been added so as to tackle the over-fitting problem faced in the alternate architectures. The model is trained using the cross-entropy loss. The architecture for the model is summarized in Table 1. Please note that the design decisions for this architecture has been decided after experimenting with multiple values. These design parameters have performed best for this architecture and on this dataset.

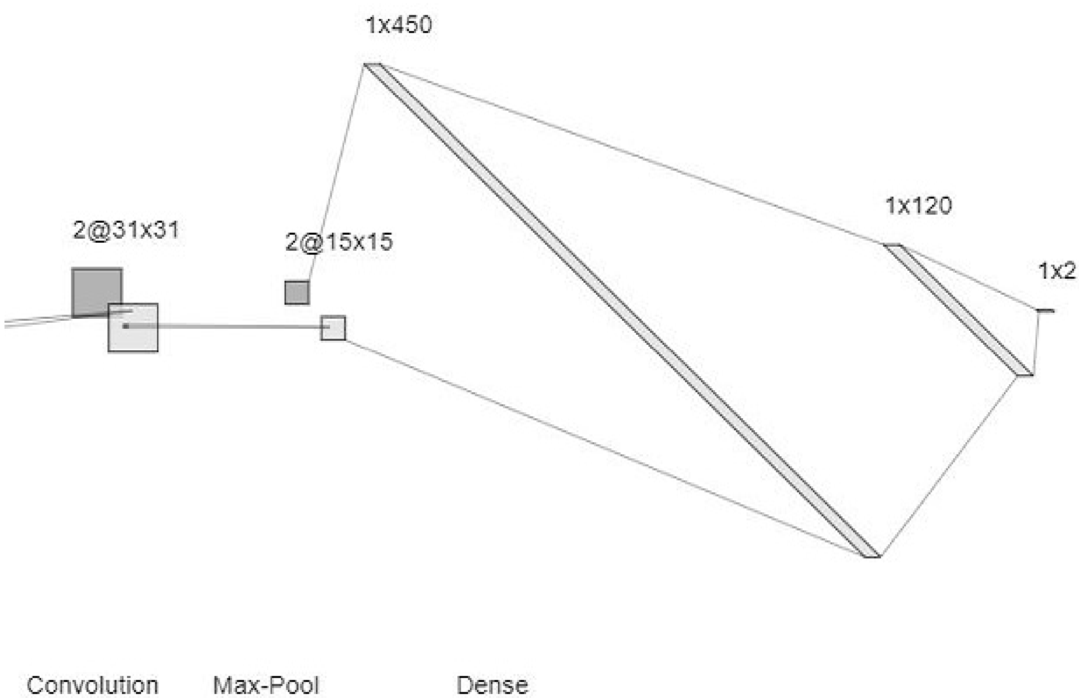
The weight parameters in the networks were optimized using Gradient Descent. The model is trained for 1000 epochs with a learning rate of 0.005, momentum value = 0.9. L2 regularization is also incorporated into the model to deal with the over-fitting problem. The alpha value used for the L2 regularization is 0.1. The model also underwent training for longer period of epochs, but that most of the times resulted in over-fitting. The hyperparameters are tuned on the test dataset as well.

4 Results

The best results achieved in this project using the above-mentioned architecture is listed in table2 along with the results obtained by [13]. The results by [13] are achieved by using DenseNet [6] pretrained on ChestX-ray14 [11] dataset.



(a) Conv part

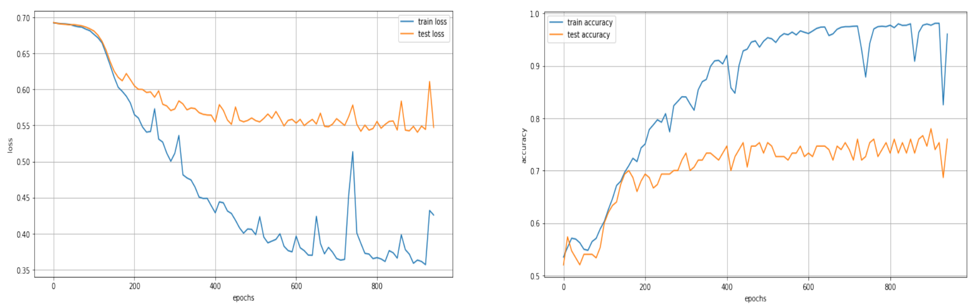


(b) FC part

Figure 2: Model Architecture

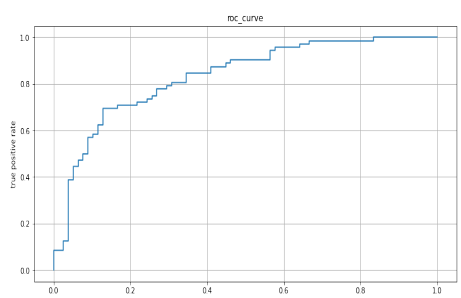
Table 1: Model Architecture Summary

Name	Description
input	152 x 152 x 1
convolution1	5x5 @ 3 filters
pooling1	2x2 stride = 2
convolution2	5x5 @ 3 filters
pooling2	2x2 stride = 2
convolution3	5x5 @2filters
pooling3	2x2 stride = 2
fully-connected1	450
drop-out1	p = 0.5
fully-connected2	120
fully-connected3	2



(a) Loss (b) Accuracy

Figure 3: Loss and Accuracy, epoch = 950, lr = 0.005, momentum = 0.9, alpha = 0.1



(a) Loss

Figure 4: ROC Curve

Table 2: Result Summary

Performance metrics	Project Model	Dense-Net Model
Accuracy	78	84.7
Precision	82	97
Recall	70	76.2
F1 score	75	85.3
AUC score	83	82.4

The project model is not able to beat the accuracy achieved by the pre-trained dense net model. The dense-net performs better on almost all of the performance metrics except for the AUC score. This can be attributed to the lack of pre-training in the project model.

The attached loss and accuracy plots reveals that the overfitting problem. This can be attributed to the small dataset size. The model performs reasonably well with the amount of data it is trained on, and in the absence of any pre-training. The model can be expected to perform better when trained on a greater amount of data.

5 Conclusion and Future Works

The performance metrics observed using the project model demonstrated the ability of deep learning to build effective covid classifiers that can aid the medical professionals in the fight against the pandemic; the model used here is simplistic and is still able to achieve reasonable performance.With sufficient data, a very effective classifier can surely be built.

The future work for this project involves pre-training the project model with Chest-Xray14 dataset and the fine tune on Covid Dataset. The transfer learning may help to boost the performance metrics of the project model.

6 presentation link

`https://docs.google.com/presentation/d/1uaTnc2nJ8NvvdanY7VKpjeKsvxx1FA92X7zOEfxLjbU/edit#slide=id.g84f5634740_180_0`

References

[1] Adam Bernheim, Xueyan Mei, Mingqian Huang, Yang Yang, Zahi A Fayad, Ning Zhang, Kaiyue Diao, Bin Lin, Xiqi Zhu, Kunwei Li, et al. Chest ct findings in coronavirus disease-19 (covid-19): relationship to duration of infection. *Radiology*, page 200463, 2020.

[2] Charmaine Butt, Jagpal Gill, David Chun, and Benson A Babu. Deep learning system to screen coronavirus disease 2019 pneumonia. *Applied Intelligence*, page 1, 2020.

[3] CNBC. Fda issues warning on accuracy of abbott's rapid coronavirus test after study finds false negatives.

[4] John Hopkins University CSSE. Covid-19 dashboard.

[5] Xuehai He, Xingyi Yang, Shanghang Zhang, Jinyu Zhao, Yichen Zhang, Eric Xing, and Pengtao Xie. Sample-efficient deep learning for covid-19 diagnosis based on ct scans. *medRxiv*, 2020.

[6] Forrest Iandola, Matt Moskewicz, Sergey Karayev, Ross Girshick, Trevor Darrell, and Kurt Keutzer. Densenet: Implementing efficient convnet descriptor pyramids. *arXiv preprint arXiv:1404.1869*, 2014.

[7] IMF. The great lockdown: Worst economic downturn since the great depression.

[8] Anne Kimball. Asymptomatic and presymptomatic sars-cov-2 infections in residents of a long-term care skilled nursing facility—king county, washington, march 2020. *MMWR. Morbidity and mortality weekly report*, 69, 2020.

[9] Devinder Kumar, Alexander Wong, and David A Clausi. Lung nodule classification using deep features in ct images. In *2015 12th Conference on Computer and Robot Vision*, pages 133–138. IEEE, 2015.

[10] Wen Li et al. Automatic segmentation of liver tumor in ct images with deep convolutional neural networks. *Journal of Computer and Communications*, 3(11):146, 2015.

[11] Pranav Rajpurkar, Jeremy Irvin, Kaylie Zhu, Brandon Yang, Hershel Mehta, Tony Duan, Daisy Ding, Aarti Bagul, Curtis Langlotz, Katie Shpanskaya, et al. Chexnet: Radiologist-level pneumonia detection on chest x-rays with deep learning. *arXiv preprint arXiv:1711.05225*, 2017.

[12] Bo Xu and Xiangfei Meng. A deep learning algorithm using ct images to screen for corona virus disease (covid-19).

[13] Jinyu Zhao, Yichen Zhang, Xuehai He, and Pengtao Xie. Covid-ct-dataset: a ct scan dataset about covid-19. *arXiv preprint arXiv:2003.13865*, 2020.