WID3008 Image Processing

Assignment Step 3 Report

Title: COVID-19 Detection with Radiography Images

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Dataset Source: https://www.kaggle.com/tawsifurrahman/covid19-radiography-database

Github URL: https://github.com/zhiqin1998/covid19-detection

Objectives:

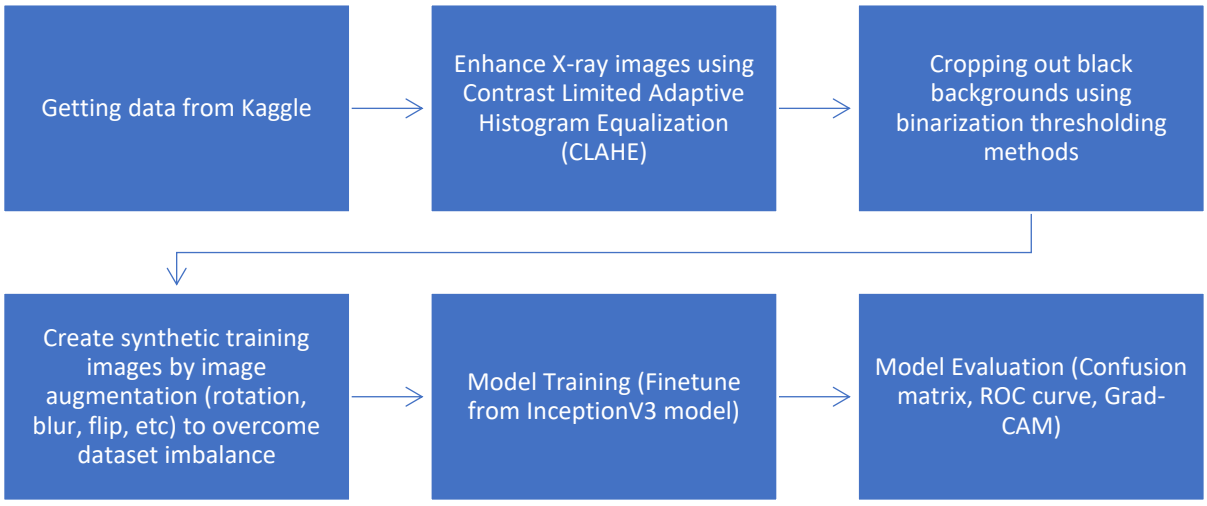
The project aims to:

1. To classify whether a given chest x-ray image is infected by COVID-19 or is a normal chest x-ray image
2. To evaluate the accuracy of COVID-19 classification for chest x-ray images

Tools for System Development

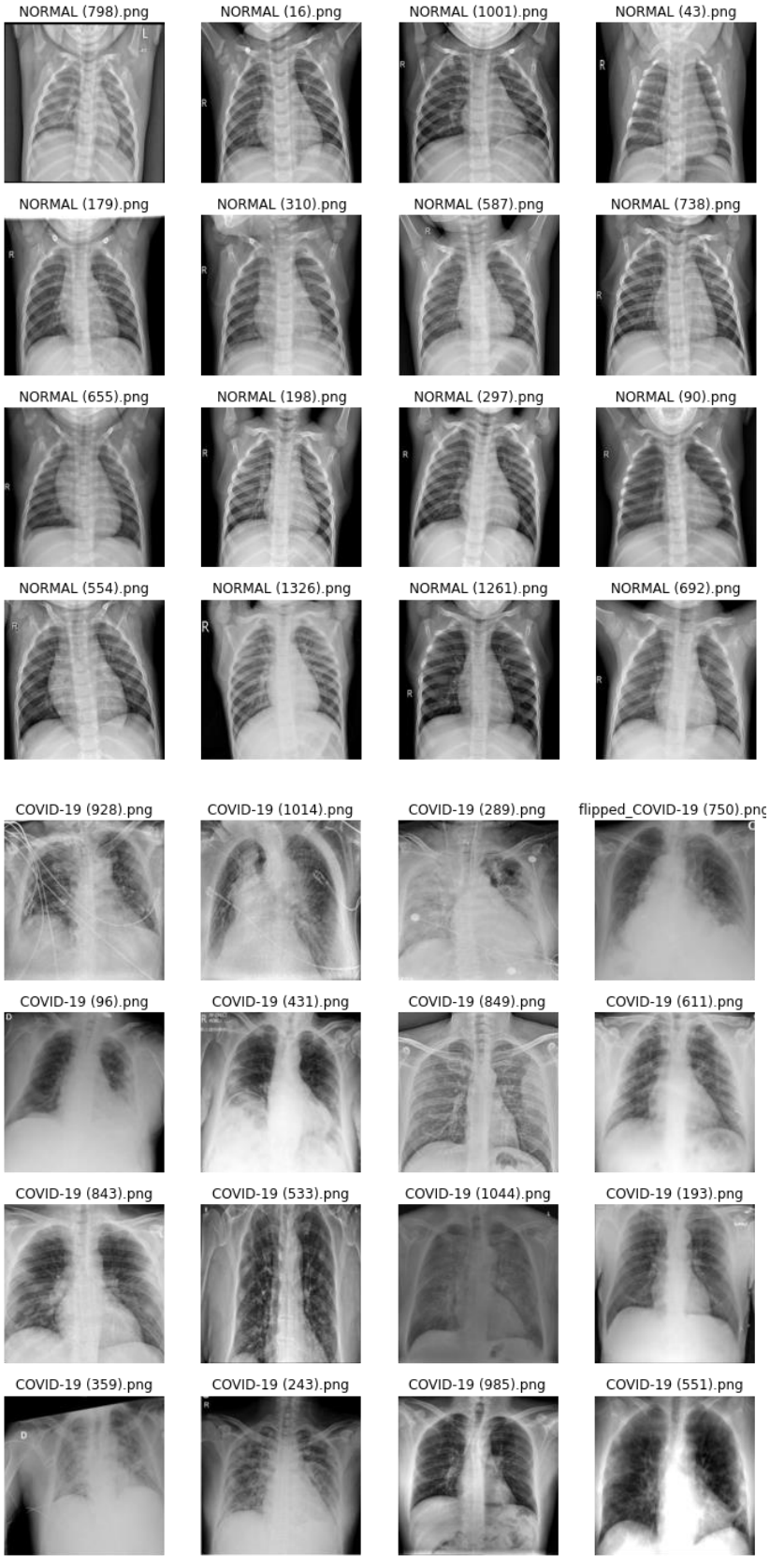
- Python
- Tensorflow 2.4.0 & Keras
- Matplotlib
- Scikit-learn
- OpenCV
- Pillow
- Numpy
- Imageio

Flowchart



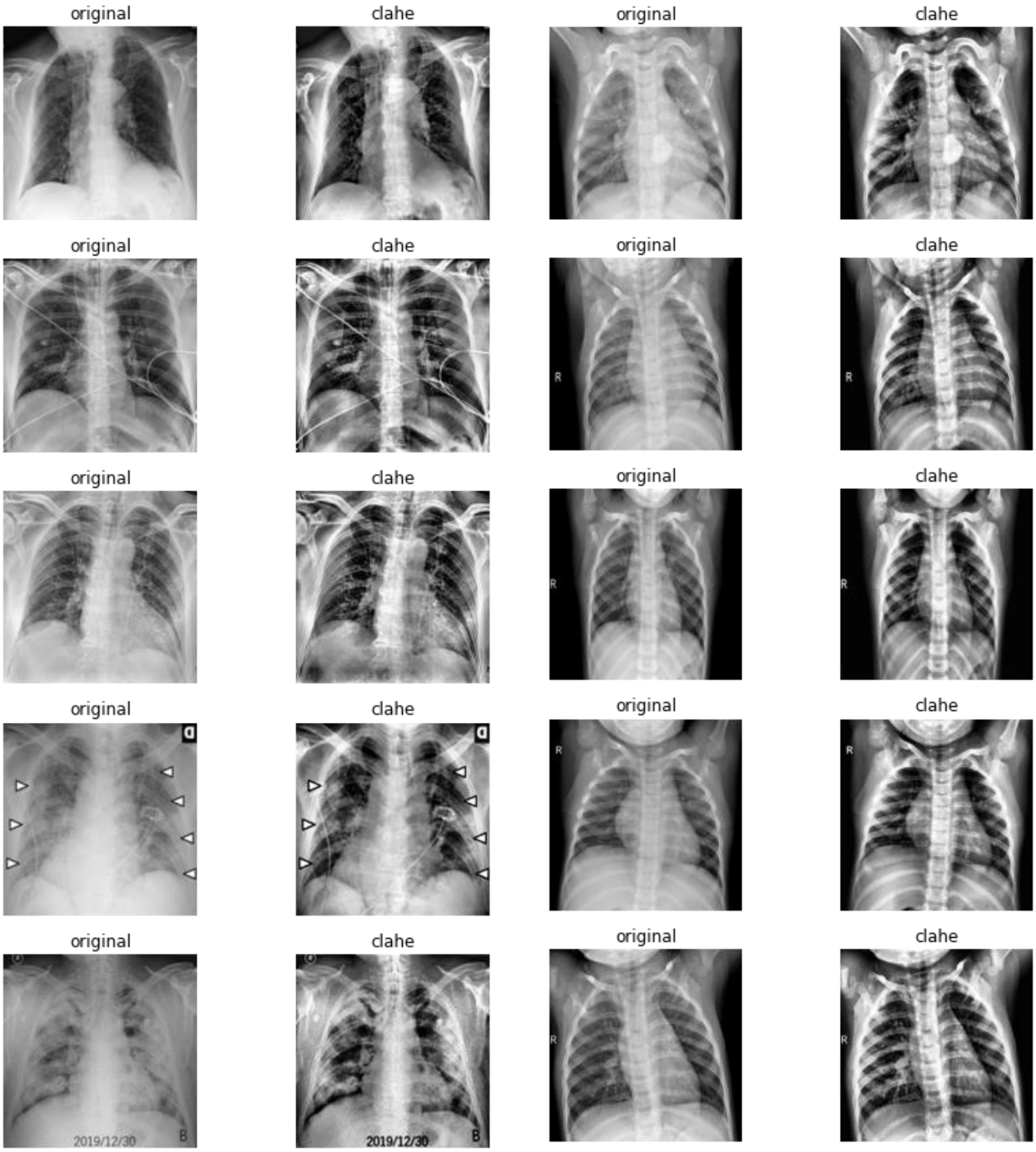
Sample Inputs

Datasets are obtained from Kaggle https://www.kaggle.com/tawsifurrahman/covid19-radiography-database. Below are a few training images examples



Pre-processing

The most important pre-processing steps here is to enhance the image using Contrast Limited Adaptive Histogram Equalization (CLAHE). CLAHE is an algorithm which is a variant of adaptive histogram equalization in which the contrast amplification is limited to reduce noise amplification. It operates on small regions in images, called tiles. The neighbouring tiles are then combined using bilinear interpolation to remove the artificial boundaries. This algorithm is applied to improve the contrast of images. Below are the results of CLAHE:



Sample Outputs

Below are a few prediction results from the final model:

Probability: 0.9990883
Predicted Class: COVID-19

Probability: 0.99826497
Predicted Class: COVID-19

Probability: 0.999762
Predicted Class: COVID-19

Probability: 0.00044270308
Predicted Class: NORMAL

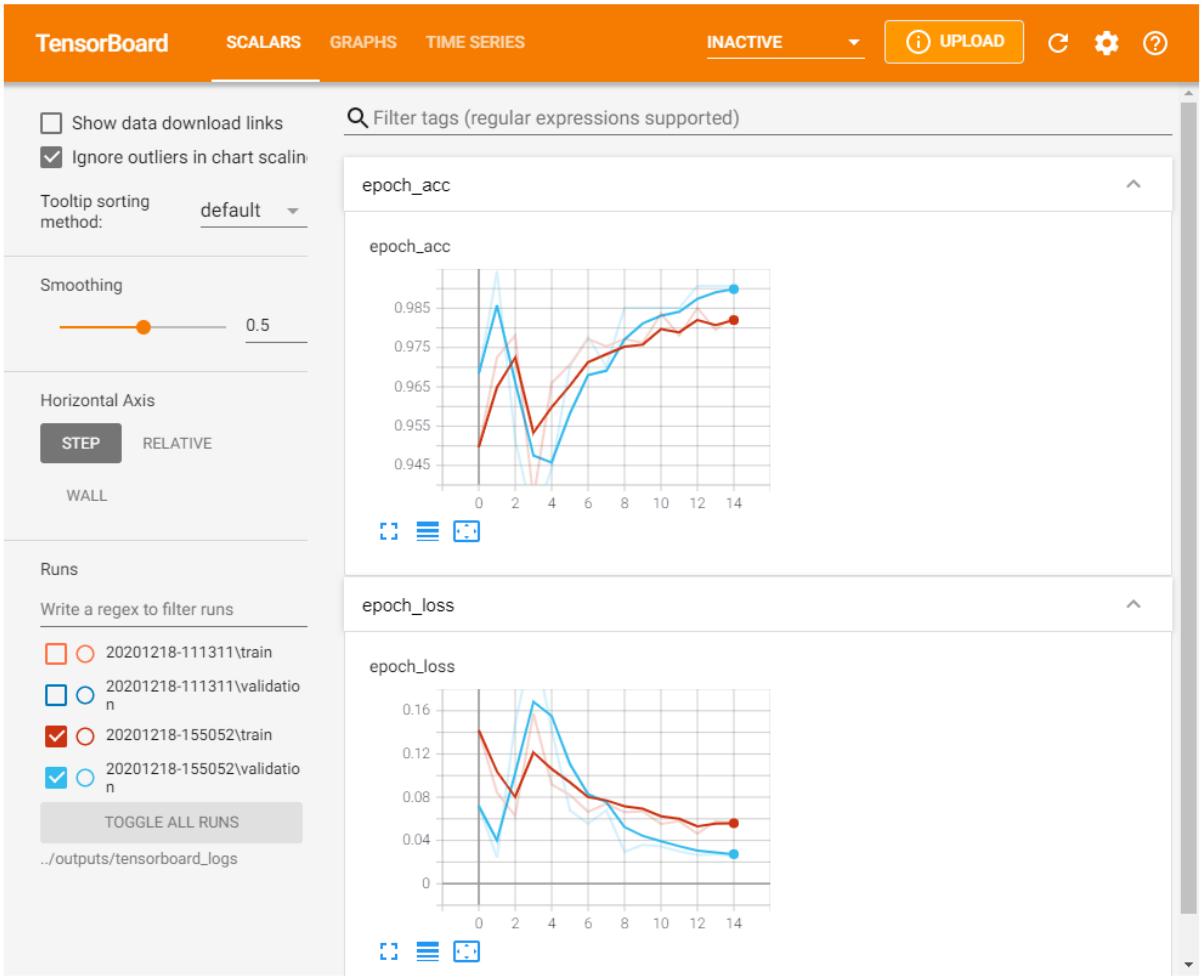
Probability: 0.00016045429
Predicted Class: NORMAL

Probability: 0.00042440512
Predicted Class: NORMAL

Discussion

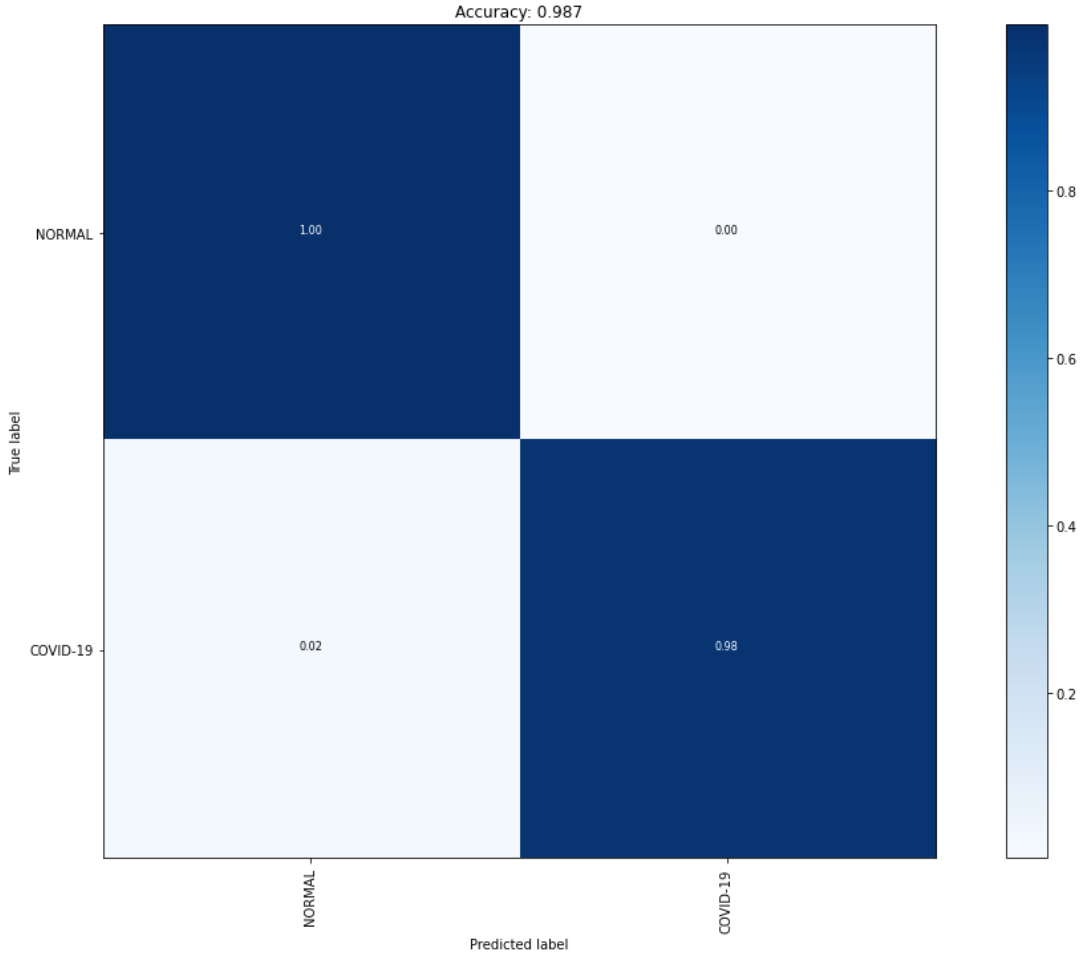
Epoch Plots

The loss and accuracy epoch plot are made with TensorBoard. The head of model is trained for 3 epochs then train the last few inception block until 15 epochs. Overall, the epoch plot looks good with a good fit. (No underfit or overfit). The small spike at epoch 3 is because we unfreeze the last few inception block and the parameters are retrained. The final validation loss is 0.0258 and the final validation accuracy is 0.9907.



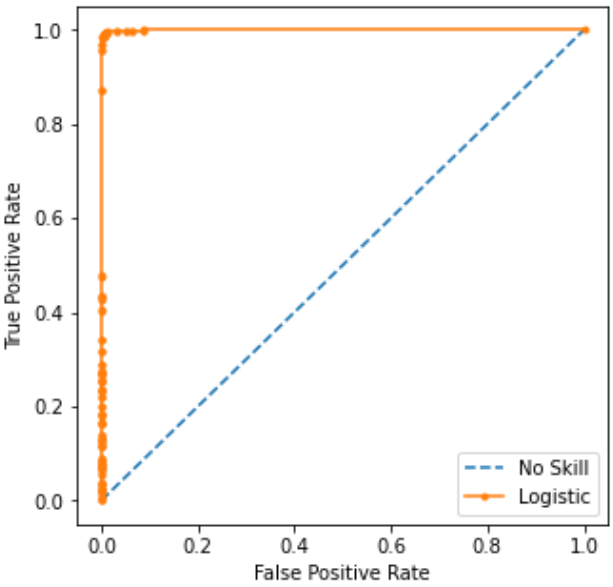
Confusion Matrix

From the confusion matrix, we can see that only 2% of the time when our model predicts NORMAL class, it is a wrong prediction.



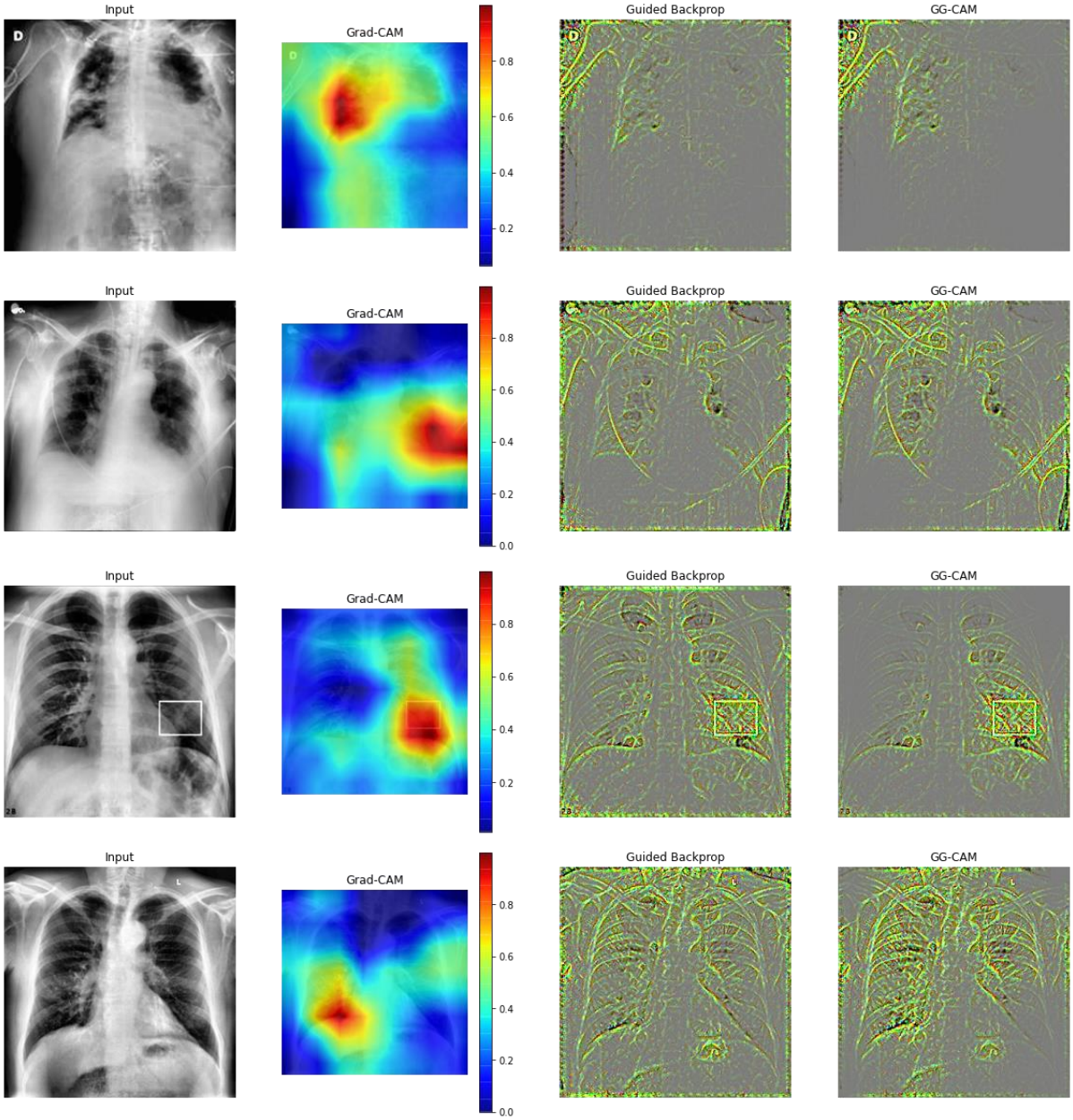
ROC Curve

To interpret a ROC curve, the curve closer to the top-left corner indicate a better performance, while closer to the diagonal means less accurate model. The graph is expected given the high precision and recall rate of our model.



Guided GradCAM

Guided gradient-weighted class activation mapping is a method to visualize region of inputs that are "important" for getting the final class predictions. GradCAM produces a heatmap that indicates important regions while Guided GradCAM combines the heatmap with a saliency map produced by guided backprop.



We can observe that some of the COVID-19 images has boxes that indicates the effects of COVID-19 disease (fluid, debris, pneumonia) and our model successfully learnt how to identify those effects.

Limitations

Overall, the image classification task is considered not hard as there are only 2 class to predict. However, there are one limitation of the model from the project which is that most of the normal chest radiography images are very similar (refer to sample images from page 4). In my experiments, although all training images is augmented with random rotation, zoom, shear, etc., the model might still learn to predict normal images based on the "similar" features instead of looking at the correct features. Since, deep learning models are a black-box model, there is no easy way to tell whether the model is predicting based on the correct features. We can easily overcome this limitation by getting more training images from various sources.