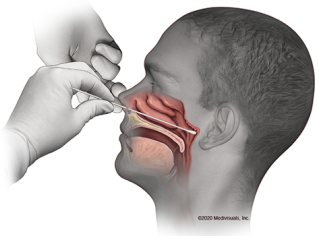
Final project report

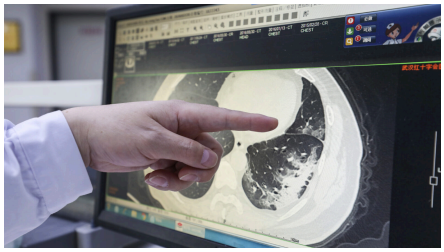
Building a neural network to test COVID-19 virus using CT-Scans

1. Motivations:

A growing number of doctors are calling for use of another method to detect COVID-19, one that would miss fewer cases than molecular testing of swab. Scientist in China reported that chest CT found 97% of COVID-19 infections. In comparison, the study found that 48% of patients who had negative results on the swab test, which detect the coronavirus genome, in fact had the disease.

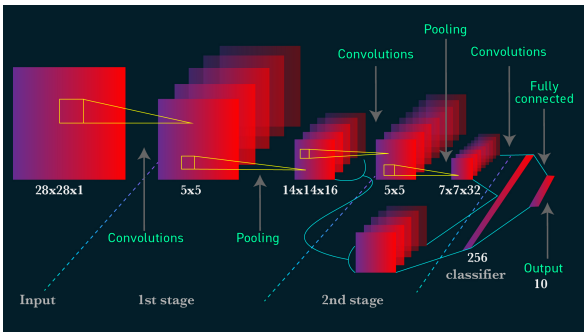


A positive result on the swab tests is usually reliable. But if you get a negative test result, the chance it is wrong is 30%. Which means the traditional method has a high accuracy but a low recall. In fact, low recall, which means a high false negative rate can be a huge problem. If a patient can not be successfully tested, he will spread the virus around him even further unconsciously, which will put people's life in great danger.



Alternatively, scientists have proposed to diagnose the virus using CT Scans of patients lungs. According to researchers, this method can provide 97% accuracy. More importantly, it is very sensitive and has a low false negative rate, which is what we desire.

However, it also has huge disadvantages, one of which is the shortage of radiologists. Analyzing CT-Scans requires high expertise knowledge of radiologists. Unfortunately, not every hospitals have radiologists. Even for those who do, it is impossible to let those radiologists to examine CT-Scans of hundreds and thousands patients.



Fortunately, deep neural network is good at analyzing images. It can automatically extract features and make classification. If we can train a CNN, we can test COVID-19 much more faster and even achieve better accuracy than radiologists. This is what I am going to do

2. Related works:
(1) A group researchers build an end to end network to classify X-ray of lungs to test COVID-19.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7187882/pdf/main.pdf

(2) convidx-net: a novel neutral network for COVID-19 detection.

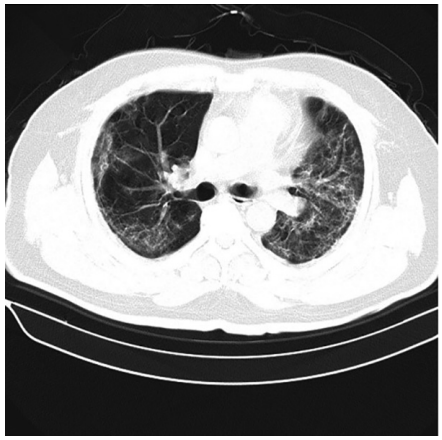
(3) A group of students build a COVID-19 CT scan datasets https://arxiv.org/pdf/2003.13865.pdf

(4)Convid-net:
https://arxiv.org/pdf/2003.09871.pdf

3. Proposal:

(1) I will build a CNN to classify COVID-19 CT scans.

I will train 3 models
*A simple CNN, designed by myself
*Doing transfer learning using pre-trained DenseNet



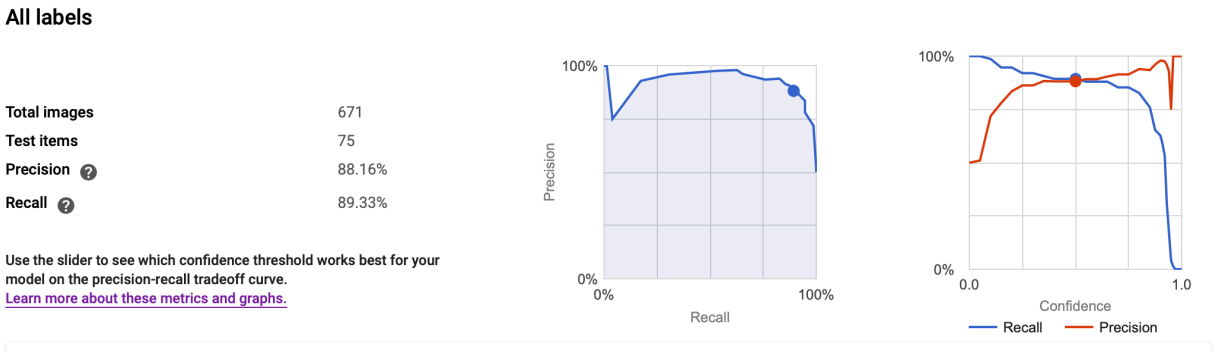
*Training model using GCP auto-ml vision.

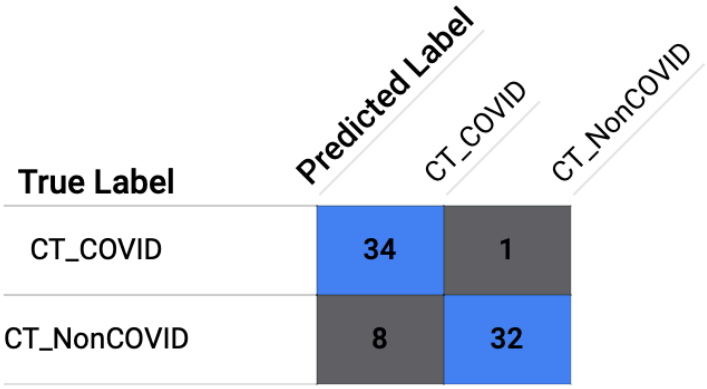
Datasets: COVID-CT datasets built by students from UCSD(756 images in total)
Examples images:
COVID:
Non-COVID:

(2) After comparing the behaviors of different architecture, I will deploy one of them to android plat form using tensorflow lite

4. Results:

(1) For model trained by GCP, the model reaches around 90% of precision and recall, which is pretty good.





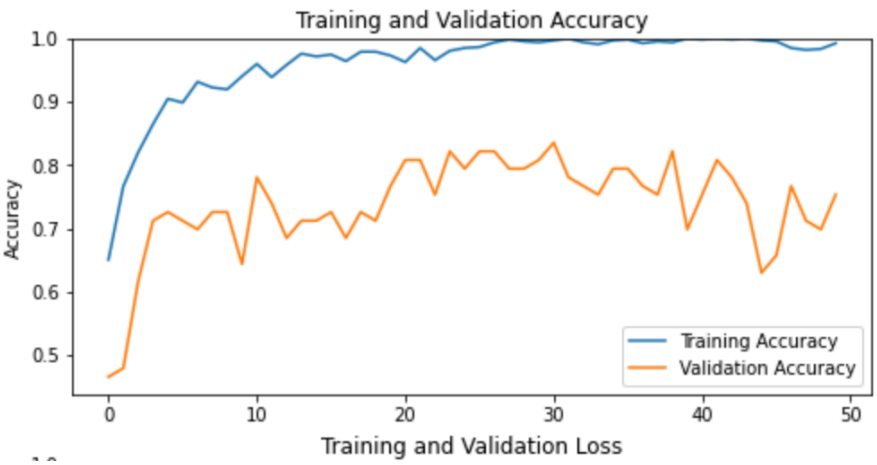
(2) Simple CNN defined by myself.

*Model architecture:

Layer (type)	Output Shape	Param #
conv2d (Conv2D)	(None, 224, 224, 32)	896
batch_normalization (BatchNo	(None, 224, 224, 32)	128
conv2d_1 (Conv2D)	(None, 224, 224, 32)	9248
batch_normalization_1 (Batch	(None, 224, 224, 32)	128
max_pooling2d (MaxPooling2D)	(None, 112, 112, 32)	0
dropout (Dropout)	(None, 112, 112, 32)	0
conv2d_2 (Conv2D)	(None, 112, 112, 128)	36992
batch_normalization_2 (Batch	(None, 112, 112, 128)	512
conv2d_3 (Conv2D)	(None, 112, 112, 128)	147584
batch_normalization_3 (Batch	(None, 112, 112, 128)	512
max_pooling2d_1 (MaxPooling2	(None, 56, 56, 128)	0
dropout_1 (Dropout)	(None, 56, 56, 128)	0
flatten (Flatten)	(None, 401408)	0
dense (Dense)	(None, 2)	802818

Total params: 998,818
Trainable params: 998,178
Non-trainable params: 640

*Training result:
The model can achieve an average of 75% validation accuracy.



(3) Doing transfer learning on DenseNet:

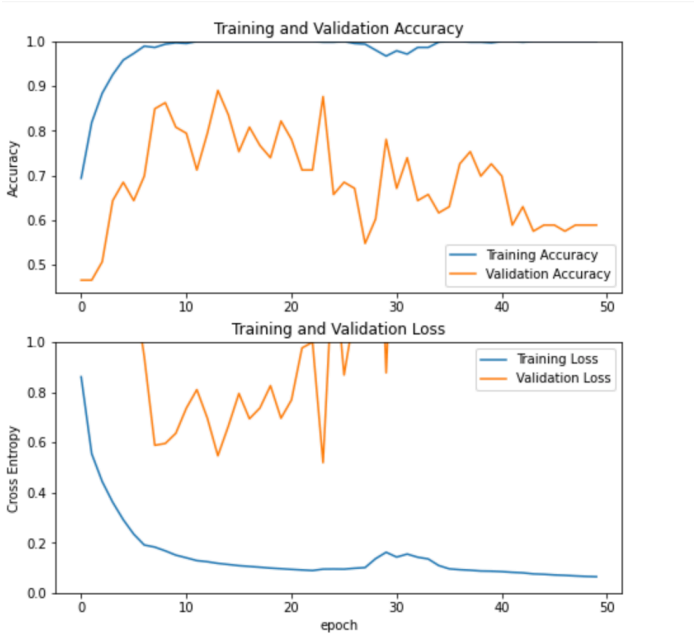
*Model architecture:
Adding two convolutional layer and one dense layer on top of the DesneNet.

Layer (type)	Output Shape	Param #
densenet121 (Model)	(None, 7, 7, 1024)	7037504
conv2d_4 (Conv2D)	(None, 5, 5, 64)	589888
batch_normalization_4 (Batch	(None, 5, 5, 64)	256
conv2d_5 (Conv2D)	(None, 3, 3, 64)	36928
batch_normalization_5 (Batch	(None, 3, 3, 64)	256
max_pooling2d_2 (MaxPooling2	(None, 1, 1, 64)	0
dropout_2 (Dropout)	(None, 1, 1, 64)	0
global_average_pooling2d (Gl	(None, 64)	0
dense_1 (Dense)	(None, 2)	130

Total params: 7,664,962
Trainable params: 627,202
Non-trainable params: 7,037,760

*Training results:

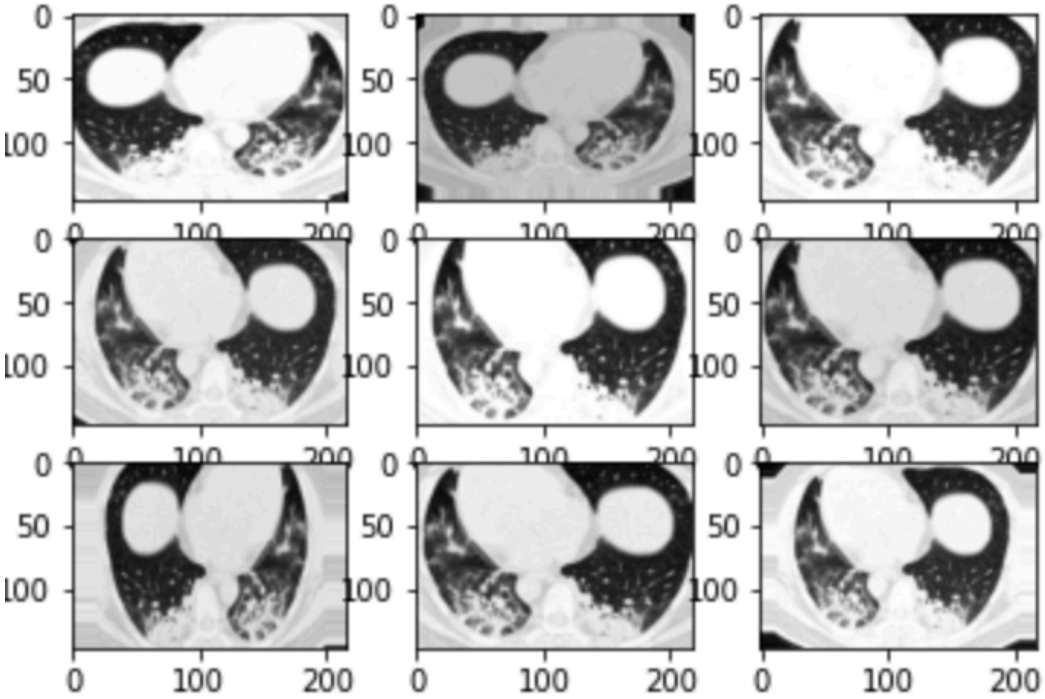
The model can achieve more than 80% validation accuracy, but overfitting happens, which may be caused by the complicated DenseNet model structure.



To solve the overfitting problem,
I choose to do data augmentation on every batch of training data. For each images, I randomly adjust their brightness, scale and flip them horizontally.

Here is a example of augmentation:

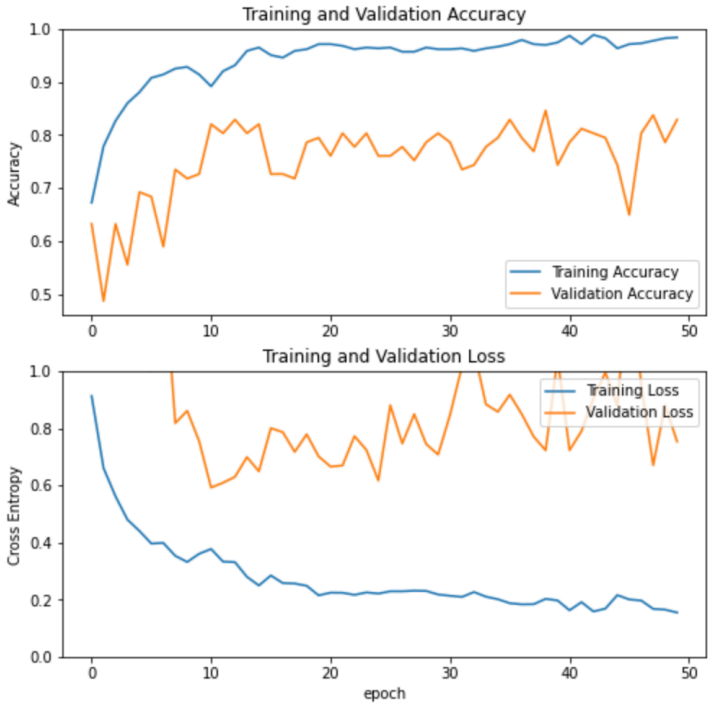
All the nine images below originates form the same training image.



*Training results:

By doing data augmentation, the model can achieve a stable 80% training accuracy, which is good.

I choose this one to deploy to the android platform



5. Conclusion and future work:

The model trained by myself can get an average of 80% accuracy based on only 756 training images. It is clear that convolutional neural networks can be used to benefit health care system. Currently the datasets is small due to privacy and social morality. I am hoping in the future, deep learning can be widely adapted in the heath care system so that we can face the crisis better.

Reference:

1.https://www.statnews.com/2020/04/16/ct-scans-alternative-to-inaccurate-coronavirus-tests/

2.https://pulmccm.org/uncategorized/an-illustrated-guide-to-the-chest-ct-in-covid-19/

3. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7187882/pdf/main.pdf

4.https://arxiv.org/pdf/2003.09871.pdf