

# COVID Triage with CNN

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## Problem statement:

- Scarcity/delay of COVID tests
- Triage solely on symptoms
- Many false positives/negatives
- Clogging of healthcare system

## Solution

Test COVID positives with other methods: X-ray and Deep Learning

- immediate results classifiable
- no need for .99 accuracy
- prioritize severe cases and ID false positives

9,544 lung X-ray images:

- 5,500 negatives
- 4,044 positives

Augmentation techniques such as blurring, rotating, shearing, etc. to expand number of examples.

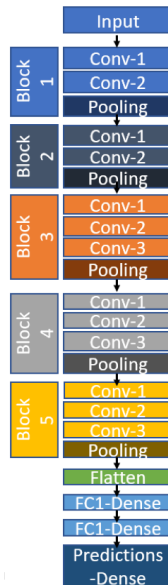
We can see a Positive example (above) and a Negative one (below).



## CNN - VGG16

TensorFlow.Keras

Transfer learning from Imagenet



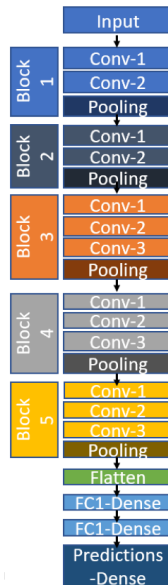
# NN Architecture

The George Washington University

CNN - VGG16

TensorFlow.Keras

Transfer learning from Imagenet

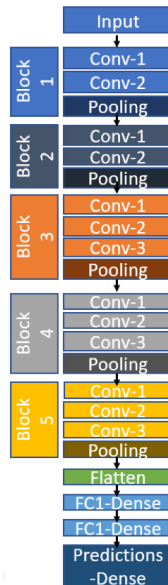


# NN Architecture

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Layer (type)	Output Shape	Param #
input_6 (InputLayer)	[(None, 224, 224, 3)]	0
block1_conv1 (Conv2D)	(None, 224, 224, 64)	1792
block1_conv2 (Conv2D)	(None, 224, 224, 64)	36928
block1_pool (MaxPooling2D)	(None, 112, 112, 64)	0
block2_conv1 (Conv2D)	(None, 112, 112, 128)	73856
block2_conv2 (Conv2D)	(None, 112, 112, 128)	147584
block2_pool (MaxPooling2D)	(None, 56, 56, 128)	0
block3_conv1 (Conv2D)	(None, 56, 56, 256)	295168
block3_conv2 (Conv2D)	(None, 56, 56, 256)	590080
block3_conv3 (Conv2D)	(None, 56, 56, 256)	590080
block3_pool (MaxPooling2D)	(None, 28, 28, 256)	0
block4_conv1 (Conv2D)	(None, 28, 28, 512)	1180160
block4_conv2 (Conv2D)	(None, 28, 28, 512)	2359808
block4_conv3 (Conv2D)	(None, 28, 28, 512)	2359808
block4_pool (MaxPooling2D)	(None, 14, 14, 512)	0
block5_conv1 (Conv2D)	(None, 14, 14, 512)	2359808
block5_conv2 (Conv2D)	(None, 14, 14, 512)	2359808
block5_conv3 (Conv2D)	(None, 14, 14, 512)	2359808
block5_pool (MaxPooling2D)	(None, 7, 7, 512)	0
average_pooling2d_5 (Average)	(None, 1, 1, 512)	0
flatten_5 (Flatten)	(None, 512)	0
dense_10 (Dense)	(None, 64)	32832
dropout_5 (Dropout)	(None, 64)	0
dense_11 (Dense)	(None, 2)	130
Total params: 14,747,650		
Trainable params: 32,962		
Non-trainable params: 14,714,688		

We used 2 callbacks for training:

- Early Stopping (patience=5)
- Reduce Learning Rate on Plateau (patience=5)

```
reduce_lr = ReduceLRonPlateau(monitor = 'val_loss',  
                               factor = 0.2,  
                               patience = 5,  
                               verbose = 1,  
                               min_delta = 0.001)  
  
earlystop = EarlyStopping(monitor = 'val_loss',  
                           min_delta = 0,  
                           patience = 5,  
                           verbose = 1,  
                           restore_best_weights = True)
```



## Hyper-parameters fine-tuning

- Epochs = 100
- Batch size = 128
- Optimizer = Adam
- Loss Function = BCE

Using 1000 epochs, the training stopped at 88th epoch.

Learning rate was reduced at:

- 1 59th epoch
- 2 70th epoch
- 3 77th epoch
- 4 82nd epoch
- 5 87th epoch

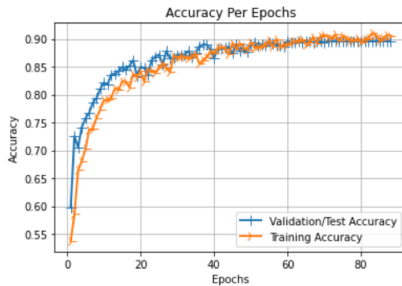
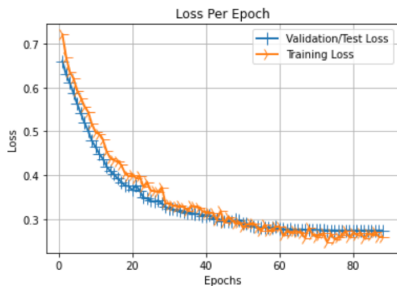
We used the following metrics to train our VGG:

- Binary CrossEntropy for loss
- Accuracy for performance

We ended up with solid results given our task.

	precision	recall	f1-score
0	0.89	0.91	0.90
1	0.91	0.88	0.89
accuracy			0.90
macro avg	0.90	0.90	0.90
weighted avg	0.90	0.90	0.90

# Final Evaluation



- 0.90 accuracy and F1 scores confirms the strength of the VGG model for this task and provides a reliable tool for the healthcare system in times of crisis.
- Use of callbacks for LR and Epoch helped to achieve good results without delaying training unnecessarily.
- Future integration with TensorFlow Lite to run MobileNets on mobile devices.

- Dataset: El-Shafai, Walid; Abd El-Samie, Fathi (2020), “Extensive COVID-19 X-Ray and CT Chest Images Dataset”, Mendeley Data, V3, doi: 10.17632/8h65ywd2jr.3
- <https://keras.io/api/callbacks/reducelronplateau/>
- <https://keras.io/api/callbacks/earlystopping/>
- <https://towardsdatascience.com/a-demonstration-of-transfer-learning-of-vgg-convolutional-neural-network-pre-trained-model-with-c9f5b8b1ab0a>
- Joseph Paul Cohen and Paul Morrison and Lan Dao and Karsten Roth and Tim Q Duong and Marzyeh Ghassemi (2020) “COVID-19 Image Data Collection: Prospective Predictions Are the Future” arXiv:2006.11988
- Simonyan, K., Zisserman A. (2015) “Very Deep Convolutional Networks for Large-Scale Image Recognition” ICLR, arXiv:1409.1556