COVID Triage with CNN

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Machine Learning II - Prof. Amir Jafari

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Introduction

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

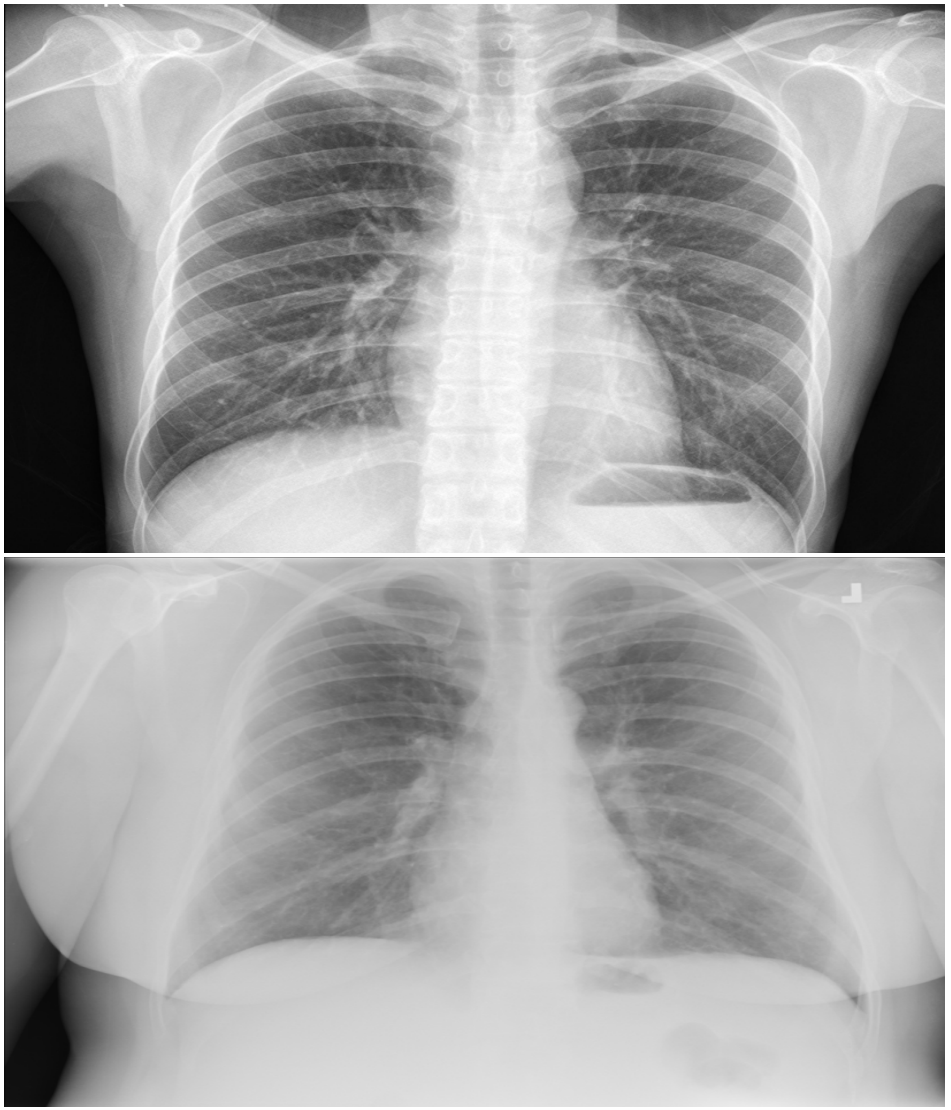
Data

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).

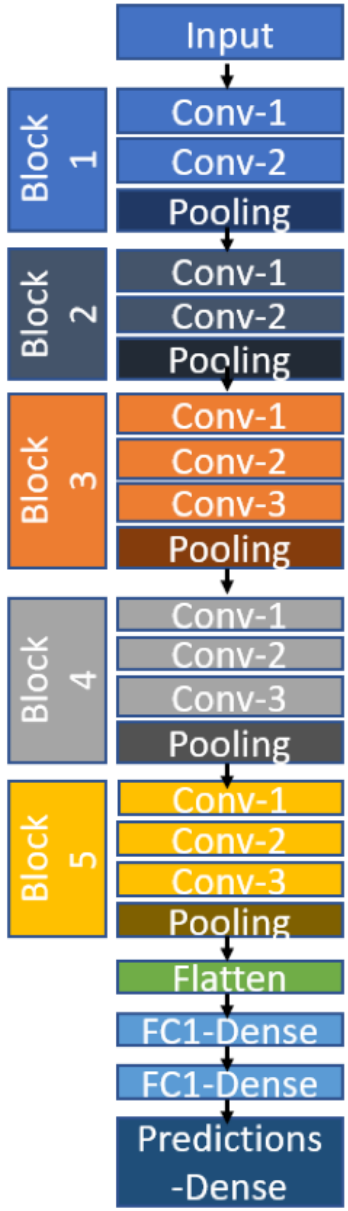


NN Architecture

CNN - VGG16

TensorFlow.Keras

Transfer learning from Imagenet



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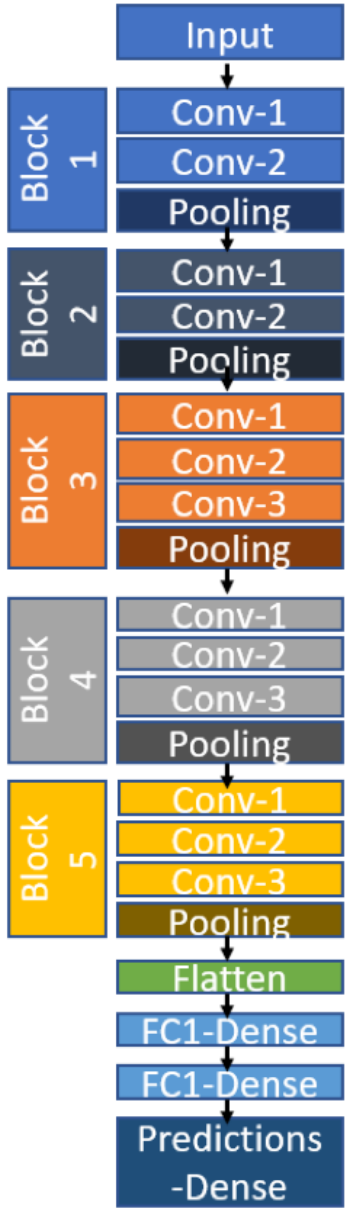

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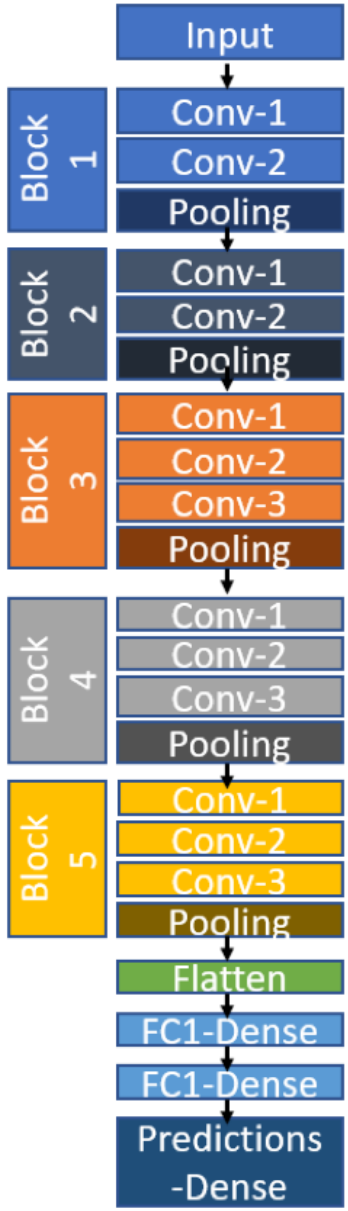


Training

Layer (type)	Output Shape	Param #
input_1 (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 (AveragePo	(None, 1, 1, 512)	0
flatten (Flatten)	(None, 512)	0
dense (Dense)	(None, 64)	32832
dropout (Dropout)	(None, 64)	0
dense_1 (Dense)	(None, 32)	2080
dropout_1 (Dropout)	(None, 32)	0
dense_2 (Dense)	(None, 1)	33

Total params: 14,749,633
Trainable params: 34,945
Non-trainable params: 14,714,688

Training

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)
```

Training

Hyper-parameters fine-tuning

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

Results

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

Final Evaluation

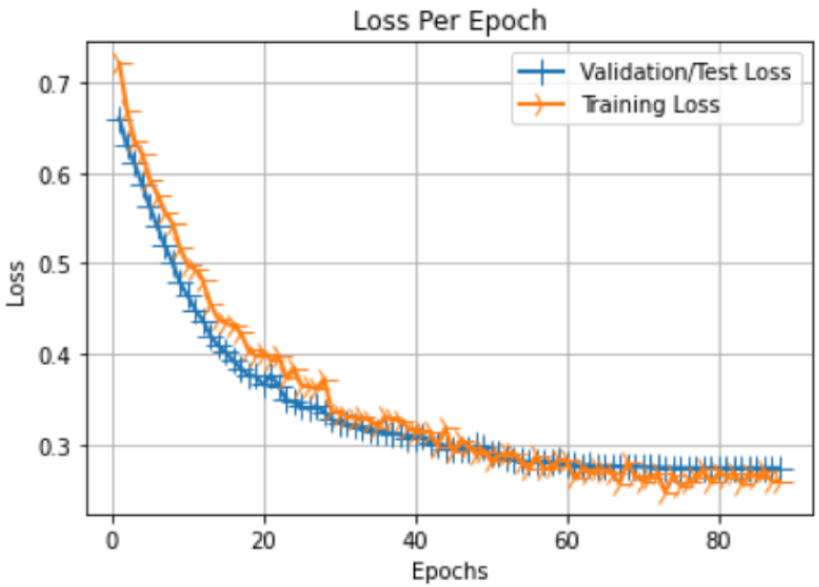
We used the following metrics to train our VGG:

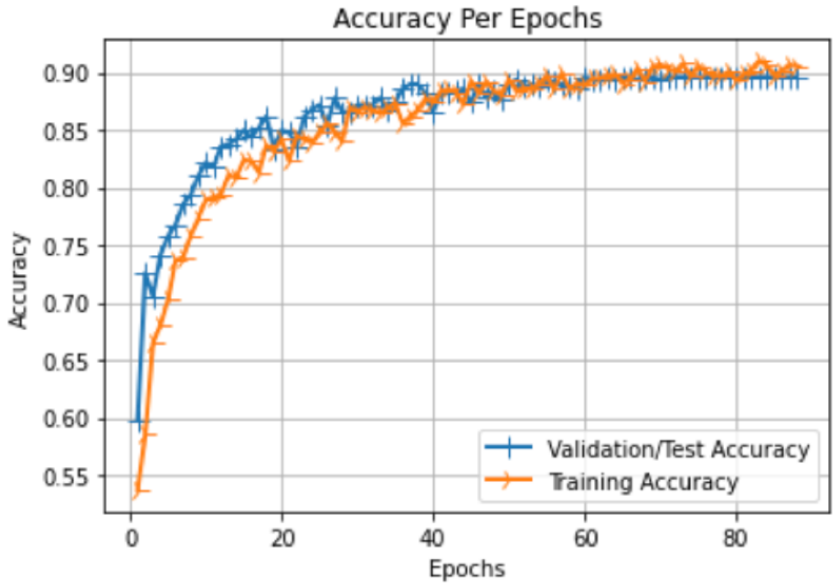
- Binary CrossEntropy for loss
- Accuracy for performance

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





Conclusion

- 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.

References

- 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