Computer Aided Diagnosis Semester Project

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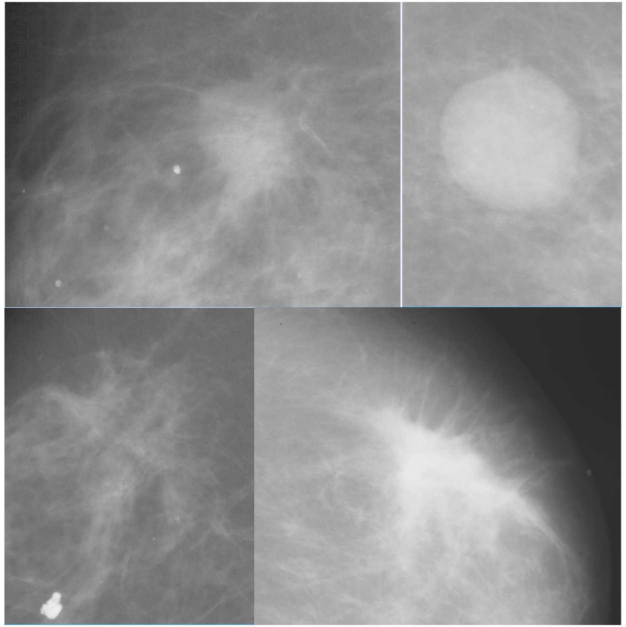
Outline

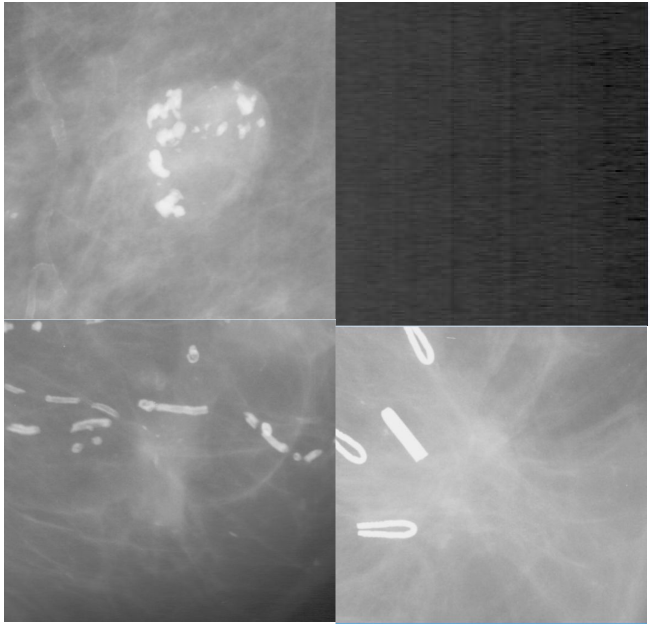
- Challenge and the dataset
- Data preprocessing
- Data augmentation
- Proposed approaches
    - Matlab(AlexNet)
    - Python(VGG16 and InceptionV3)
- Results

Challenge and dataset

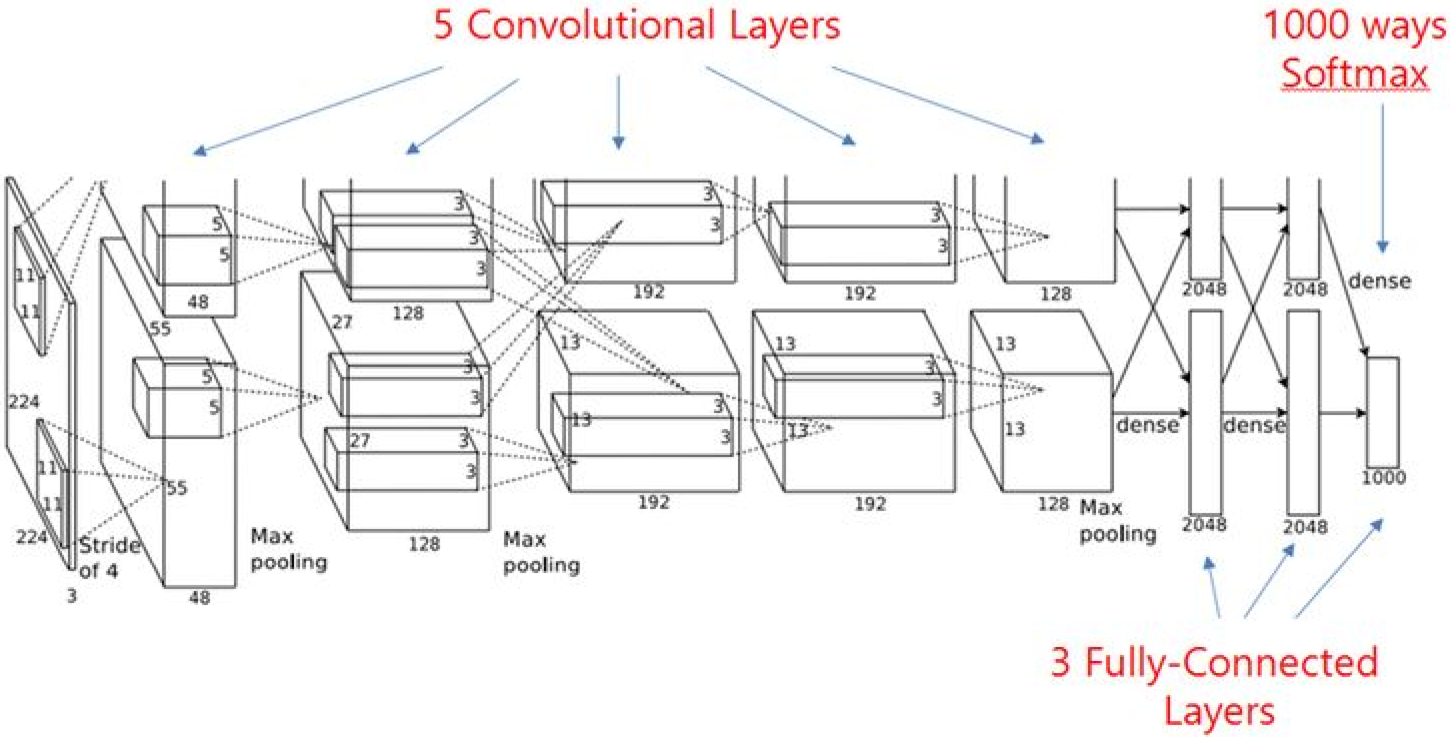
Dataset content

- **Training**
  - Negative - 246
  - Positive - 263
- **Validation**
  - Negative - 164
  - Positive - 174





AlexNet approach



5 Convolutional Layers

1000 ways Softmax

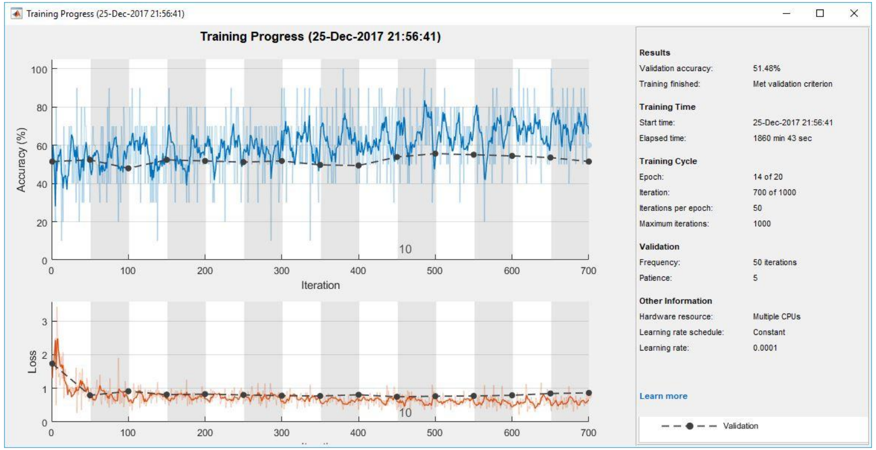
3 Fully-Connected Layers

AlexNet approach

- Perform transfer learning with AlexNet
- Remove 5 last layers of AlexNet and replace them with:
  - FullyConnected - 1024
  - Relu activation layer
  - Fully Connected layer - 2
  - Softmax Layer
  - Classification Layer (2 classes)
- Set the learning rate factors as follows for the top layers:
  - fullyConnectedLayer(1024, 'WeightLearnRateFactor', 10, 'BiasLearnRateFactor', 5)
  - fullyConnectedLayer(numClasses, 'WeightLearnRateFactor', 10,'BiasLearnRateFactor', 20)

AlexNet approach

- Data augmentation of random rotation of -10..10 degrees
- Initial learning rate : 10^{-4}
- Image resizing to 227x227 (aspect ratio not preserved)
- Adaptive histogram equalization
- Image is duplicated to 3 input channels


Training Progress (25-Dec-2017 21:56:41)
Training Progress (25-Dec-2017 21:56:41)
Accuracy (%)
100
80
60
40
20
0
0
100
200
300
400
500
600
700
Iteration
10
Loss
3
2
1
0
Validation

Results

Validation accuracy:	51.48%
Training finished:	Met validation criterion

Training Time

Start time:	25-Dec-2017 21:56:41
Elapsed time:	1860 min 43 sec

Training Cycle

Epoch:	14 of 20
Iteration:	700 of 1000
Iterations per epoch:	50
Maximum iterations:	1000

Validation

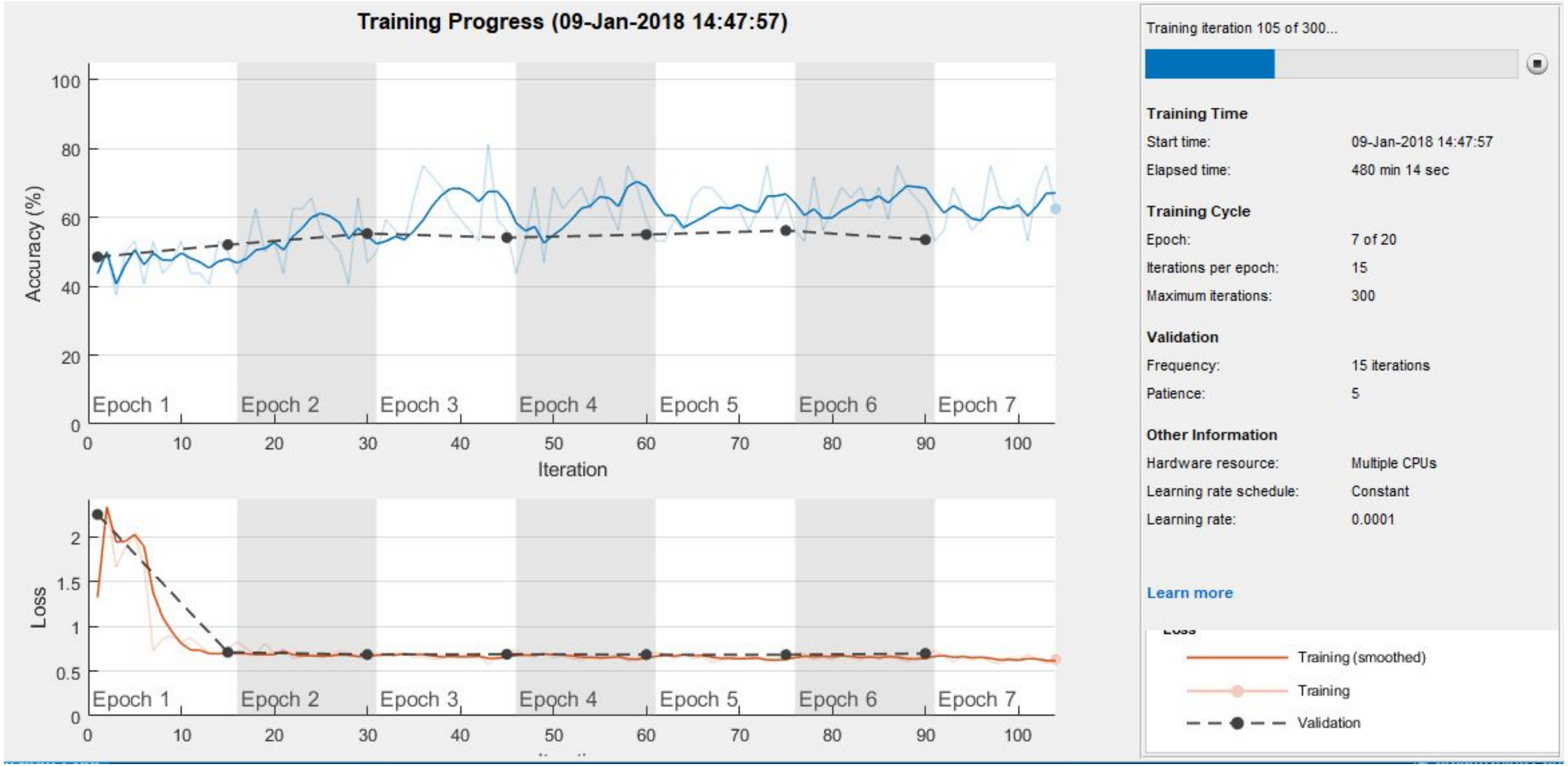
Frequency:	50 iterations
Patience:	5

Other Information

Hardware resource:	Multiple CPUs
Learning rate schedule:	Constant
Learning rate:	0.0001

Learn more

AlexNet approach



Training iteration 105 of 300...

Training Time

Start time: 09-Jan-2018 14:47:57

Elapsed time: 480 min 14 sec

Training Cycle

Epoch: 7 of 20

Iterations per epoch: 15

Maximum iterations: 300

Validation

Frequency: 15 iterations

Patience: 5

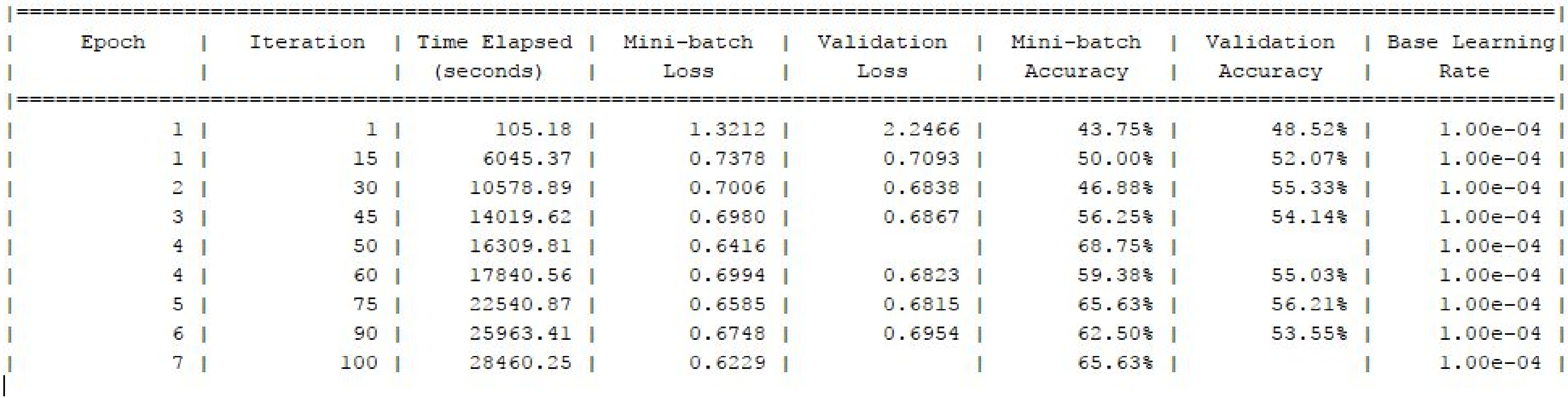
Other Information

Hardware resource: Multiple CPUs

Learning rate schedule: Constant

Learning rate: 0.0001

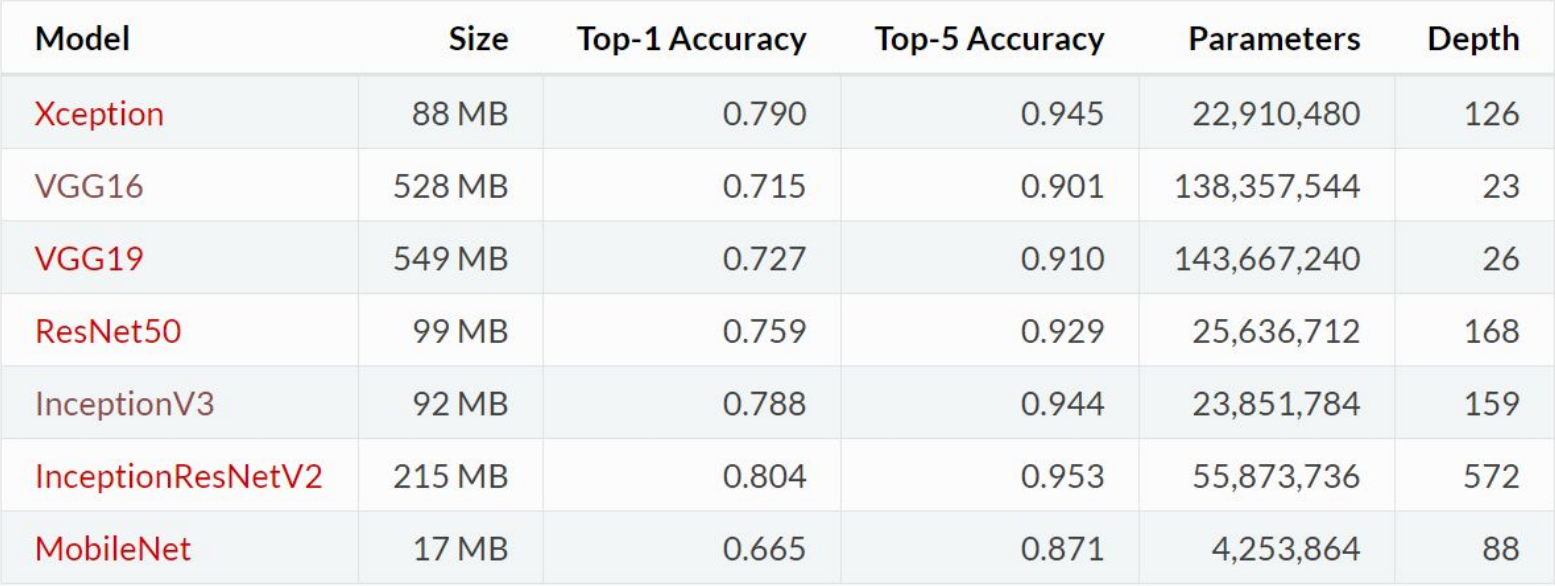
AlexNet approach



```
|=======================================================================================================|
|     Epoch     |   Iteration   | Time Elapsed |  Mini-batch  |  Validation  |  Mini-batch  |  Validation  | Base Learning|
|               |               |  (seconds)   |     Loss     |     Loss     |   Accuracy   |   Accuracy   |     Rate     |
|=======================================================================================================|
|             1 |             1 |       105.18 |       1.3212 |       2.2466 |       43.75% |       48.52% |     1.00e-04 |
|             1 |            15 |      6045.37 |       0.7378 |       0.7093 |       50.00% |       52.07% |     1.00e-04 |
|             2 |            30 |     10578.89 |       0.7006 |       0.6838 |       46.88% |       55.33% |     1.00e-04 |
|             3 |            45 |     14019.62 |       0.6980 |       0.6867 |       56.25% |       54.14% |     1.00e-04 |
|             4 |            50 |     16309.81 |       0.6416 |              |       68.75% |              |     1.00e-04 |
|             4 |            60 |     17840.56 |       0.6994 |       0.6823 |       59.38% |       55.03% |     1.00e-04 |
|             5 |            75 |     22540.87 |       0.6585 |       0.6815 |       65.63% |       56.21% |     1.00e-04 |
|             6 |            90 |     25963.41 |       0.6748 |       0.6954 |       62.50% |       53.55% |     1.00e-04 |
|             7 |           100 |     28460.25 |       0.6229 |              |       65.63% |              |     1.00e-04 |
```

Implementation - Python

- Keras with TensorFlow backend
- List of pre-trained models provided by Keras(Trained on ImageNet)



Model	Size	Top-1 Accuracy	Top-5 Accuracy	Parameters	Depth
Xception	88 MB	0.790	0.945	22,910,480	126
VGG16	528 MB	0.715	0.901	138,357,544	23
VGG19	549 MB	0.727	0.910	143,667,240	26
ResNet50	99 MB	0.759	0.929	25,636,712	168
InceptionV3	92 MB	0.788	0.944	23,851,784	159
InceptionResNetV2	215 MB	0.804	0.953	55,873,736	572
MobileNet	17 MB	0.665	0.871	4,253,864	88

Source : https://keras.io/applications/

Implementation - Python

- Feature Extraction
  - Extracted features from VGG16/InceptionV3 and trained a separate FC(fully connected) model with 3 layers (1 input, 1 hidden, 1 softmax)
  - Average validation accuracy (15 epochs) -> ~61%

- Fine Tuning
  - Trained the FC network with extracted features
  - Connect the trained FC model to VGG16/InceptionV3
  - Fine tuning last Convolution Block of VGG16 (lower learning rate)
  - Average validation accuracy (15 epochs) -> ~64%

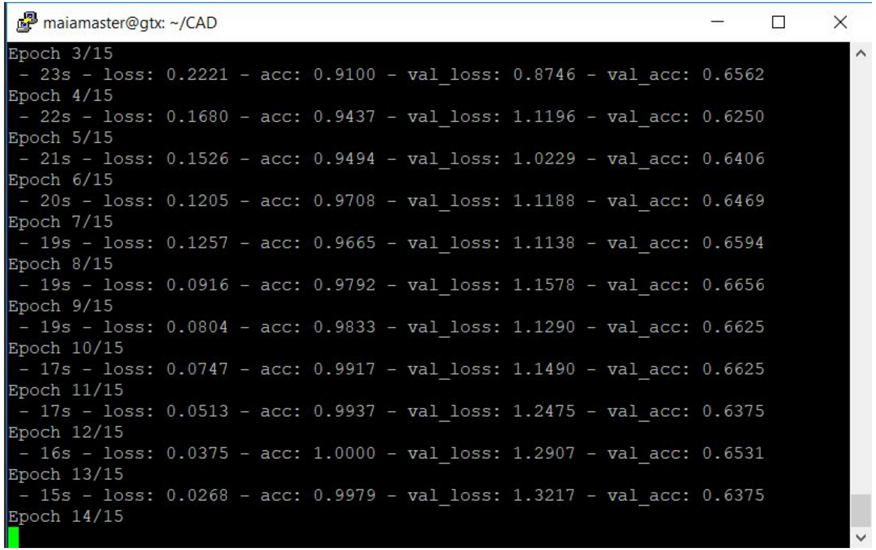
Model Selection

- VGG16
  - Total 18 layers in Keras excluding top layers
  - Fine tune top convolution block (15 - 18)
  - 1 epoch -> ~20s(step size = training size / batch size)
  - 1 epoch -> ~115s(step size = training size / 5)

- InceptionV3
  - Total 310 layers in Keras excluding top layers
  - Fine tune top 2 inception blocks (249 - 310)
  - 1 epoch -> ~30s(step size = training size / batch size)
  - 1 epoch -> ~145s(step size = training size / 5)

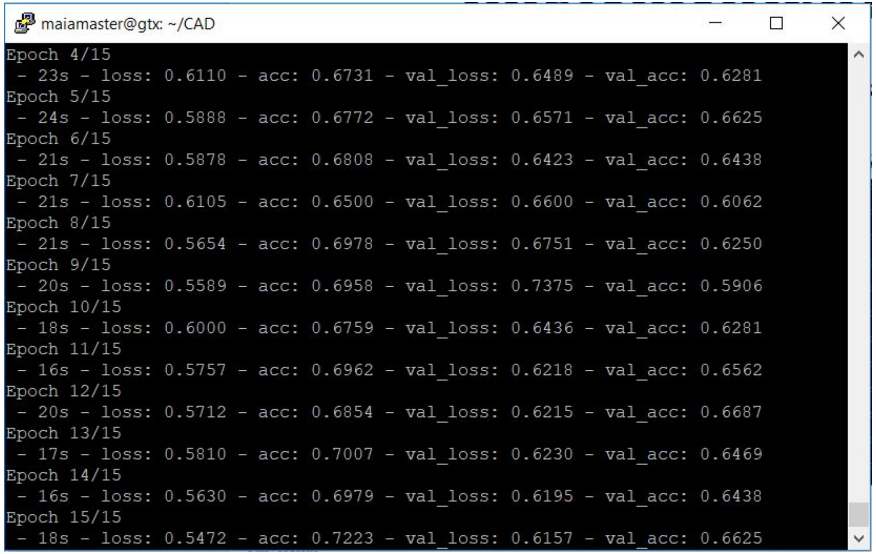
Data Normalization

- ➢ Overfitting -> Huge difference between training accuracy and validation accuracy



```
Epoch 3/15
 - 23s - loss: 0.2221 - acc: 0.9100 - val_loss: 0.8746 - val_acc: 0.6562
Epoch 4/15
 - 22s - loss: 0.1680 - acc: 0.9437 - val_loss: 1.1196 - val_acc: 0.6250
Epoch 5/15
 - 21s - loss: 0.1526 - acc: 0.9494 - val_loss: 1.0229 - val_acc: 0.6406
Epoch 6/15
 - 20s - loss: 0.1205 - acc: 0.9708 - val_loss: 1.1188 - val_acc: 0.6469
Epoch 7/15
 - 19s - loss: 0.1257 - acc: 0.9665 - val_loss: 1.1138 - val_acc: 0.6594
Epoch 8/15
 - 19s - loss: 0.0916 - acc: 0.9792 - val_loss: 1.1578 - val_acc: 0.6656
Epoch 9/15
 - 19s - loss: 0.0804 - acc: 0.9833 - val_loss: 1.1290 - val_acc: 0.6625
Epoch 10/15
 - 17s - loss: 0.0747 - acc: 0.9917 - val_loss: 1.1490 - val_acc: 0.6625
Epoch 11/15
 - 17s - loss: 0.0513 - acc: 0.9937 - val_loss: 1.2475 - val_acc: 0.6375
Epoch 12/15
 - 16s - loss: 0.0375 - acc: 1.0000 - val_loss: 1.2907 - val_acc: 0.6531
Epoch 13/15
 - 15s - loss: 0.0268 - acc: 0.9979 - val_loss: 1.3217 - val_acc: 0.6375
Epoch 14/15
```

Before Normalization



```
Epoch 4/15
 - 23s - loss: 0.6110 - acc: 0.6731 - val_loss: 0.6489 - val_acc: 0.6281
Epoch 5/15
 - 24s - loss: 0.5888 - acc: 0.6772 - val_loss: 0.6571 - val_acc: 0.6625
Epoch 6/15
 - 21s - loss: 0.5878 - acc: 0.6808 - val_loss: 0.6423 - val_acc: 0.6438
Epoch 7/15
 - 21s - loss: 0.6105 - acc: 0.6500 - val_loss: 0.6600 - val_acc: 0.6062
Epoch 8/15
 - 21s - loss: 0.5654 - acc: 0.6978 - val_loss: 0.6751 - val_acc: 0.6250
Epoch 9/15
 - 20s - loss: 0.5589 - acc: 0.6958 - val_loss: 0.7375 - val_acc: 0.5906
Epoch 10/15
 - 18s - loss: 0.6000 - acc: 0.6759 - val_loss: 0.6436 - val_acc: 0.6281
Epoch 11/15
 - 16s - loss: 0.5757 - acc: 0.6962 - val_loss: 0.6218 - val_acc: 0.6562
Epoch 12/15
 - 20s - loss: 0.5712 - acc: 0.6854 - val_loss: 0.6215 - val_acc: 0.6687
Epoch 13/15
 - 17s - loss: 0.5810 - acc: 0.7007 - val_loss: 0.6230 - val_acc: 0.6469
Epoch 14/15
 - 16s - loss: 0.5630 - acc: 0.6979 - val_loss: 0.6195 - val_acc: 0.6438
Epoch 15/15
 - 18s - loss: 0.5472 - acc: 0.7223 - val_loss: 0.6157 - val_acc: 0.6625
```

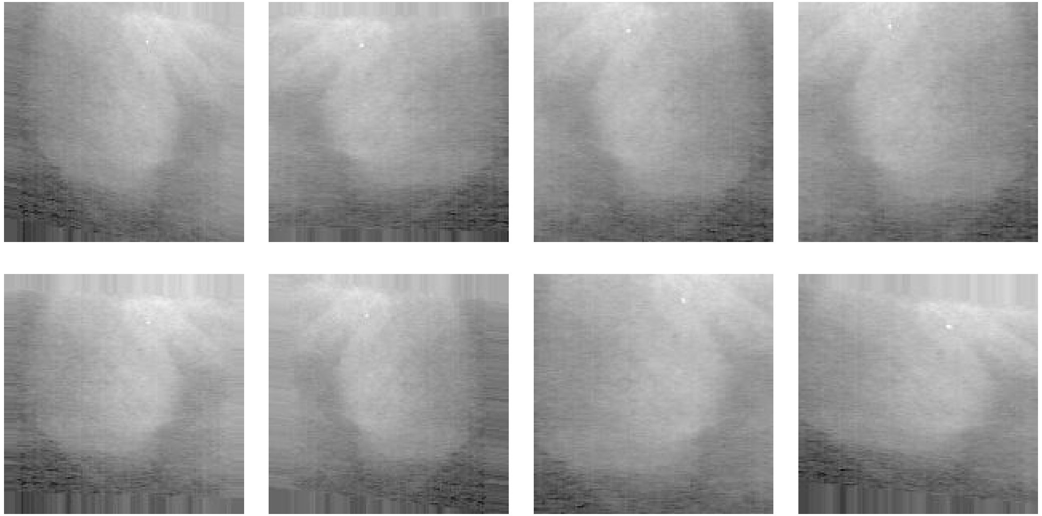
After Samplewise Normalization

Parameters Tuning

- Number of epochs(15 - 50)
- Mini-batch size (16 - 32)
- Learning rate (0.0001)
- Optimizers (rmsprop & SGD)

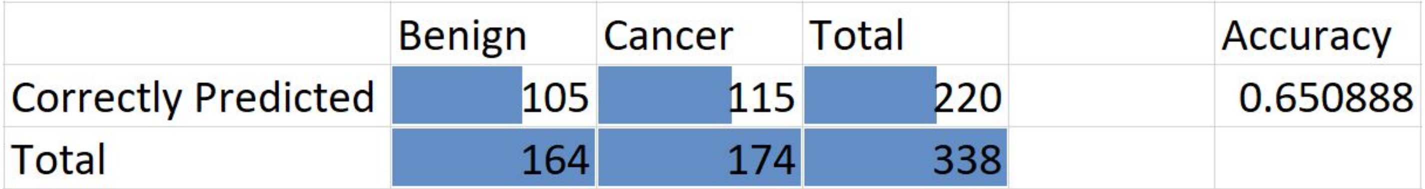
Data Augmentation

- Augmentation range values
  - Scaling -> 0.2
  - Horizontal shift -> 0.2
  - Vertical shift -> 0.2
  - Rotation -> 180
  - Horizontal flip
- Longer training time
  - Decreased step size



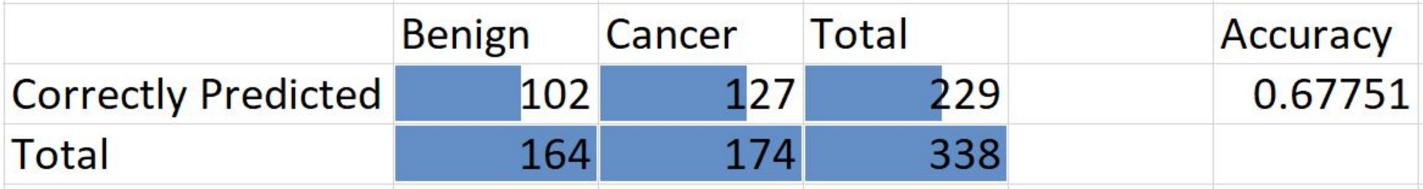
Final Results

- VGG16 -> 30 epochs



	Benign	Cancer	Total		Accuracy
Correctly Predicted	105	115	220		0.650888
Total	164	174	338		

- InceptionV3 -> 50 epochs



	Benign	Cancer	Total		Accuracy
Correctly Predicted	102	127	229		0.67751
Total	164	174	338		

THANK YOU