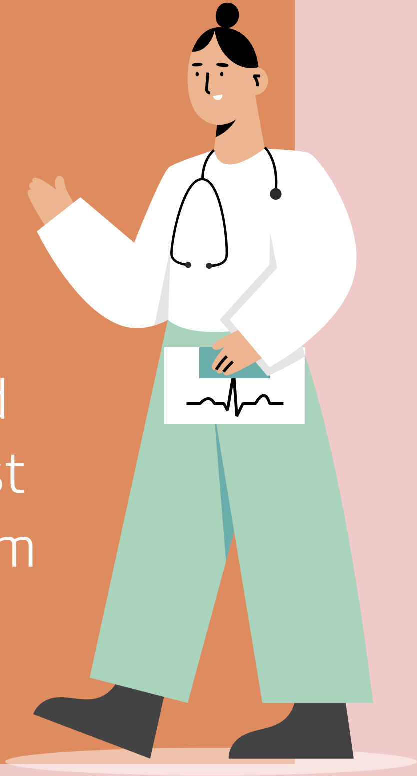
Technology in Medicine

By: Lauren Esser

BACKGROUND

Pneumonia is a lung infection that can cause mild to severe illness in people of all ages. Currently to diagnose pneumonia the doctor will ask about your medical history and may perform a blood test, chest x-ray, pulse oximetry, or sputum test.



Source: Mayoclinic

FACTS ABOUT PNEUMONIA

VACCINE

- There is a vaccine to help fight against pneumonia, 68.9% of adults over the age of 65 have received the vaccine.

HOSPITAL CARE

- More than 250,000 people have to seek hospital care each year due to pneumonia.

TREATMENTS

- Current treatments are antibiotics, cough medicine, fever reducers, pain relievers, and potentially hospital care.

DEATHS

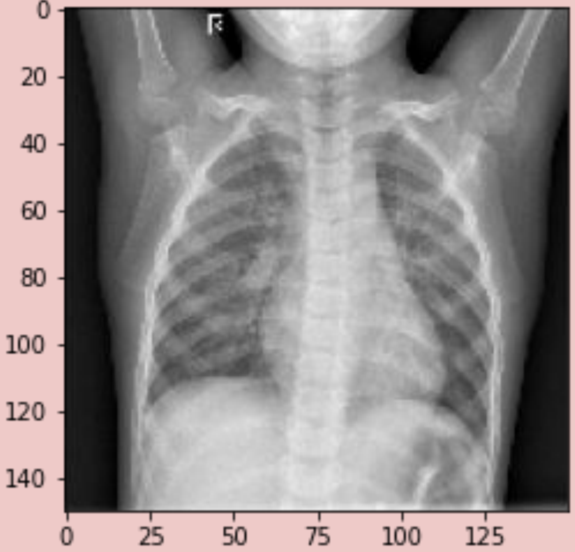
- Pneumonia kills more children younger than 5 years old each year than any other infectious disease.
- About 50,000 people die from the disease each year in the U.S.

Source: Mayo Clinic and CDC

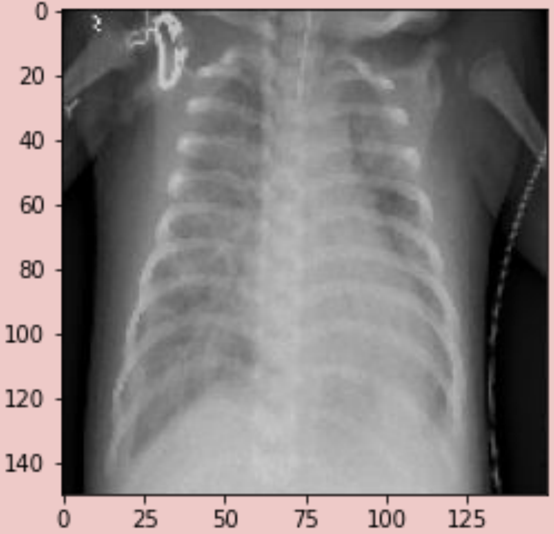
PROBLEM STATEMENT

Build a neural network that classifies x-ray images of pediatric patients to identify whether or not they have pneumonia.

Normal X-Ray



Pneumonia X-Ray



DATASET

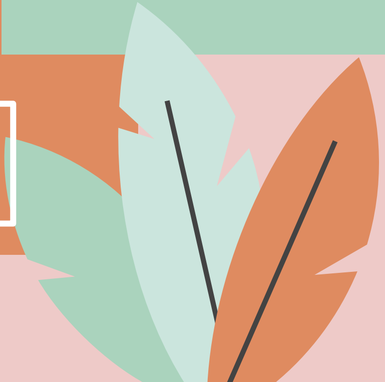
From Kaggle.com titled Chest X-Ray Images (Pneumonia)

	TRAIN	TEST	VALIDATION
NORMAL	1341	234	8
PNEUMONIA	3875	390	8

METHODS USED

OSEMN

- ✓ OBTAIN DATA — Download from Kaggle. Import to Google Drive and unzip file for access.
- ✓ SCRUB DATA — Organize data into proper directories and check length.
- ✓ EXPLORE DATA — Visualizations, prepare model by reshaping and resizing images.
- ✓ MODEL DATA — First create baseline Neural Network models and work up to CNN Models.
- ✓ INTERPRET DATA — Explain best model use.



METHODS USED

CNN

- ✓ Load Images & Design Model
- ✓ Alternate convolutional and pooling layers.
- ✓ Include more parameters in later layers.
- ✓ Add final dense later to add a classifier to the convolutional base

1

IMAGE SIZE

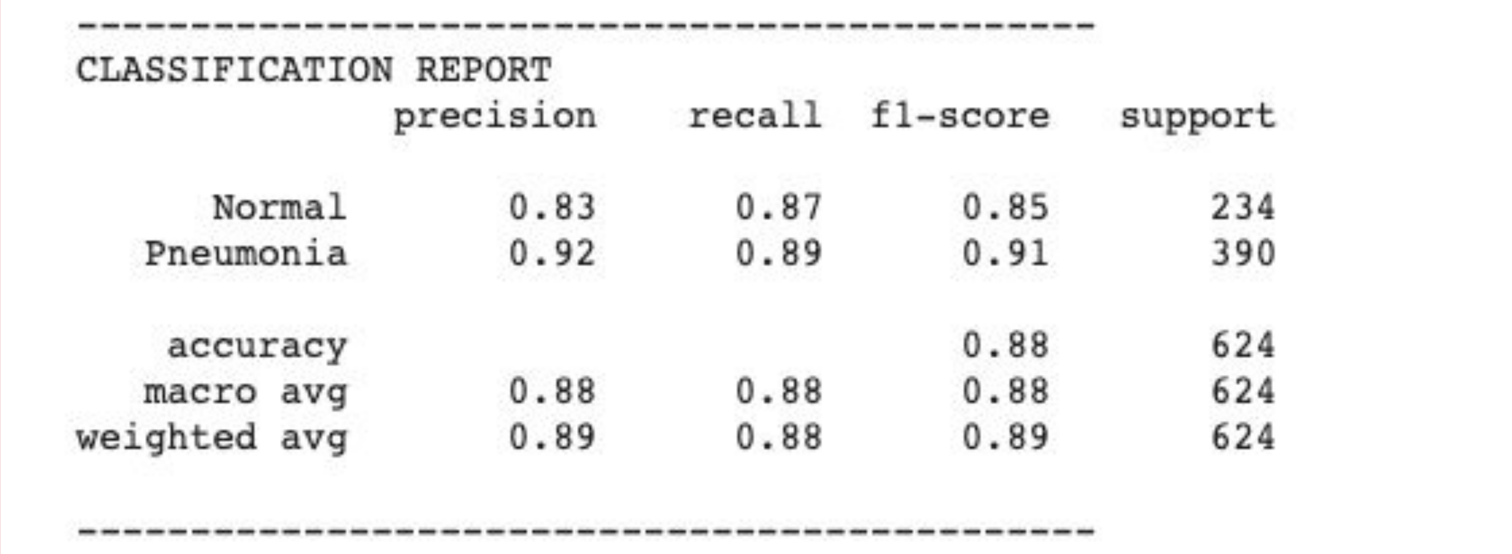
64 x 64 image size took 19.6 seconds to run a baseline neural network model. 82% accuracy

150 x 150 image size took 41.3 seconds to run the same baseline neural network model. 80% accuracy

See Appendix One A & B for Images of runtime/accuracy

2 ACCURACY

CNN Model 3 has the highest accuracy score at 88%.

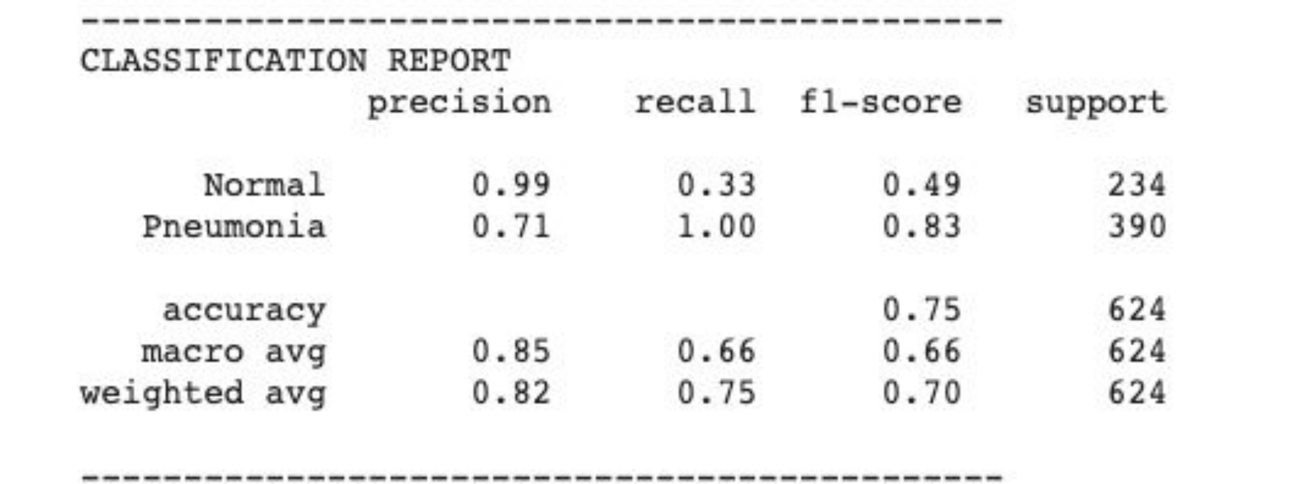


```
---------------------------------------------
CLASSIFICATION REPORT
              precision    recall  f1-score   support

      Normal       0.83      0.87      0.85       234
   Pneumonia       0.92      0.89      0.91       390

    accuracy                           0.88       624
   macro avg       0.88      0.88      0.88       624
weighted avg       0.89      0.88      0.89       624

---------------------------------------------
```

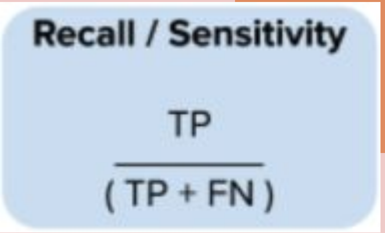
Appendix 2 for Model Structure

HIGHEST PNEUMONIA RECALL

CNN Model 2 had a Pneumonia recall of 100%



```
---------------------------------------------
CLASSIFICATION REPORT
              precision    recall  f1-score   support

      Normal       0.99      0.33      0.49       234
   Pneumonia       0.71      1.00      0.83       390

    accuracy                           0.75       624
   macro avg       0.85      0.66      0.66       624
weighted avg       0.82      0.75      0.70       624

---------------------------------------------
```



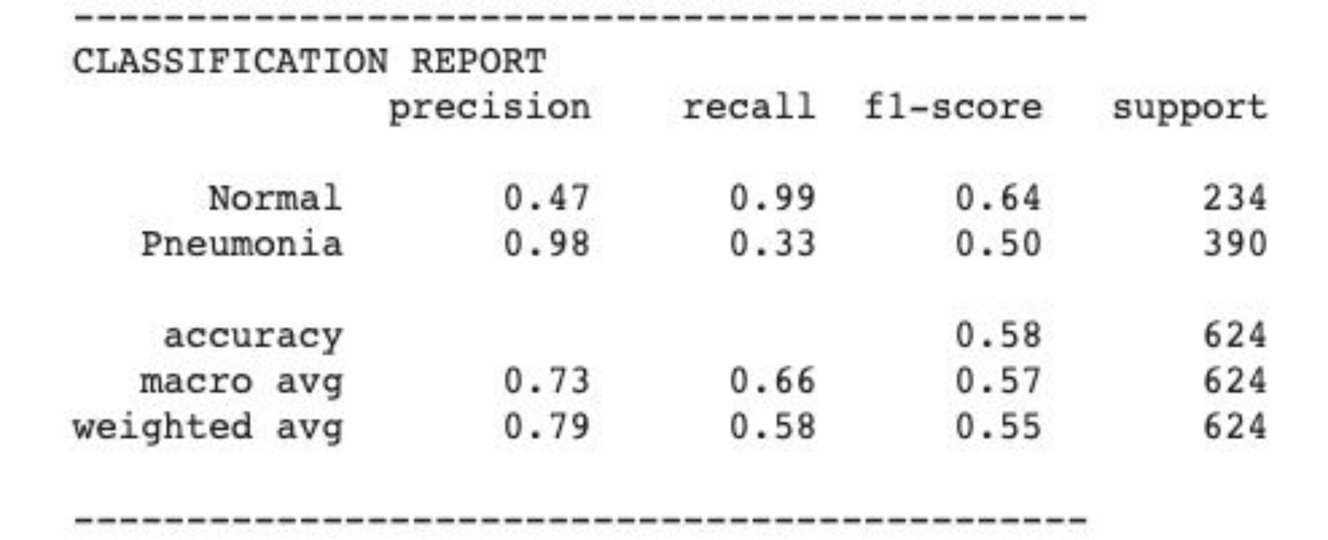
Recall / Sensitivity

$$\frac{TP}{(TP + FN)}$$

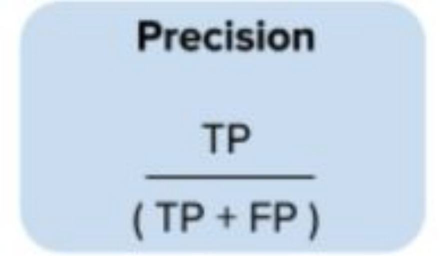
Appendix 3 for Model Structure

4 HIGHEST PNEUMONIA PRECISION

Our Baseline Neural Network Model had the highest precision at 98%



```
--------------------------------------------
CLASSIFICATION REPORT
              precision    recall  f1-score   support

      Normal       0.47      0.99      0.64       234
   Pneumonia       0.98      0.33      0.50       390

    accuracy                           0.58       624
   macro avg       0.73      0.66      0.57       624
weighted avg       0.79      0.58      0.55       624

--------------------------------------------
```



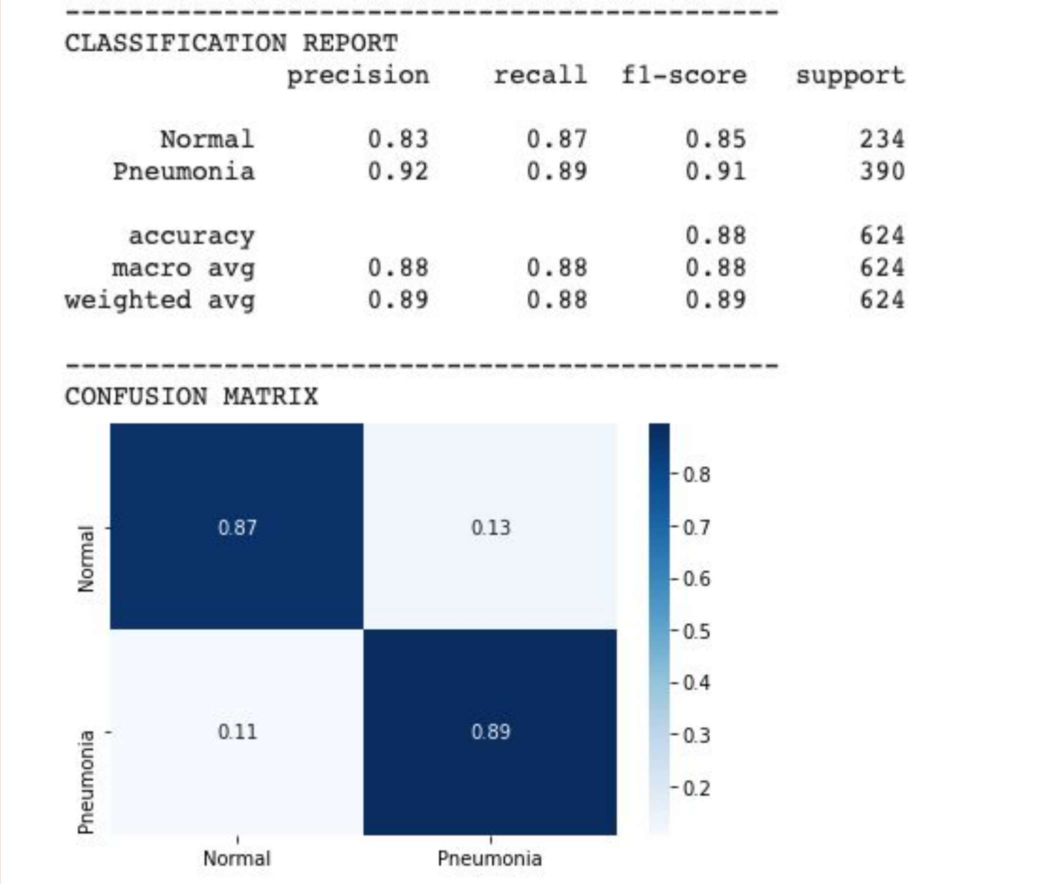
Precision

$$\frac{TP}{(TP + FP)}$$

Appendix 4 for Model Structure

Best Overall Model:

CNN Model 3



```
-----------------------------------------------------
CLASSIFICATION REPORT
              precision    recall  f1-score   support

      Normal       0.83      0.87      0.85       234
   Pneumonia       0.92      0.89      0.91       390

    accuracy                           0.88       624
   macro avg       0.88      0.88      0.88       624
weighted avg       0.89      0.88      0.89       624

-----------------------------------------------------
CONFUSION MATRIX
```

	Normal	Pneumonia
Normal	0.87	0.13
Pneumonia	0.11	0.89

Appendix 5 for Model Structure and visualizations

Future Recommendations

1 Use a larger dataset to improve accuracy and precision

2 Look at X-Rays of adult lungs with and without pneumonia

3 Use premade CNN to see if they could potentially work better.

THANK YOU FOR YOUR TIME!

Questions?

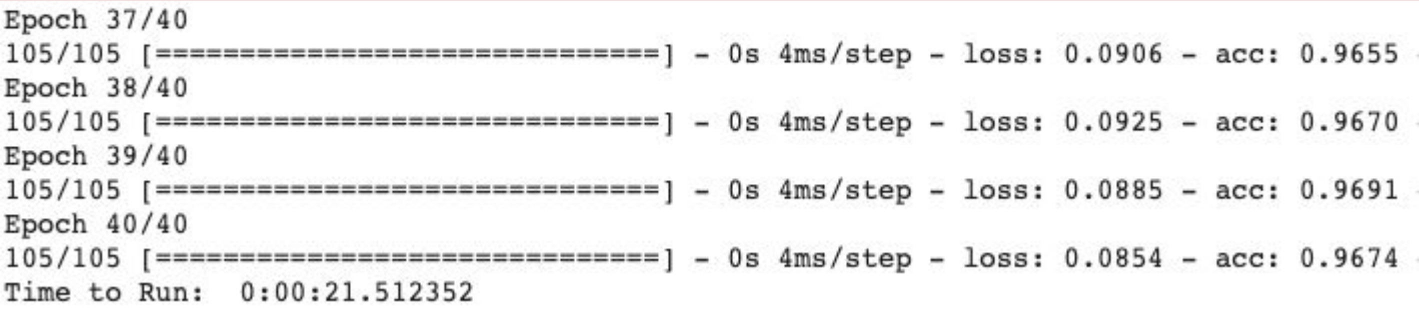
Feel free to contact me at:

Lauren.Esser02@gmail.com

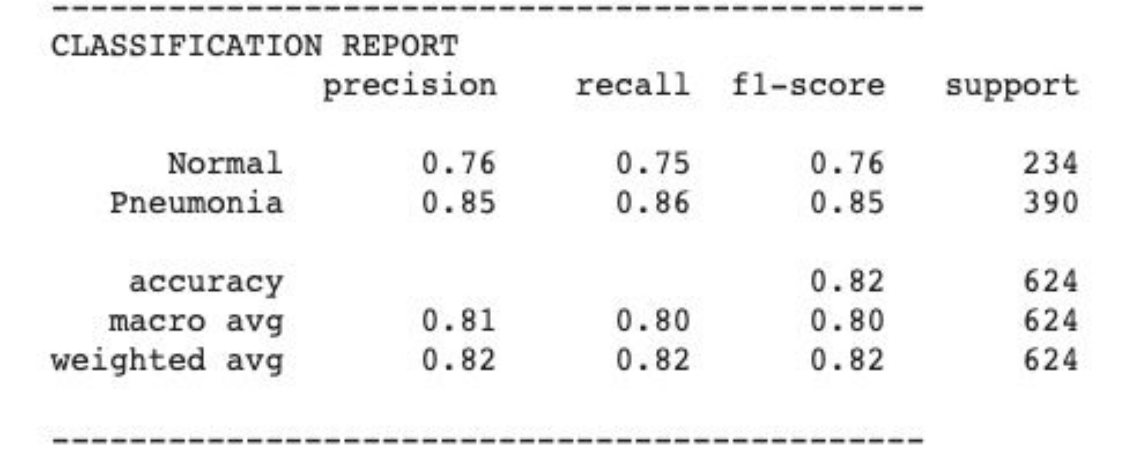
or

Lauren Esser on LinkedIn

APPENDIX 1A: 64x64

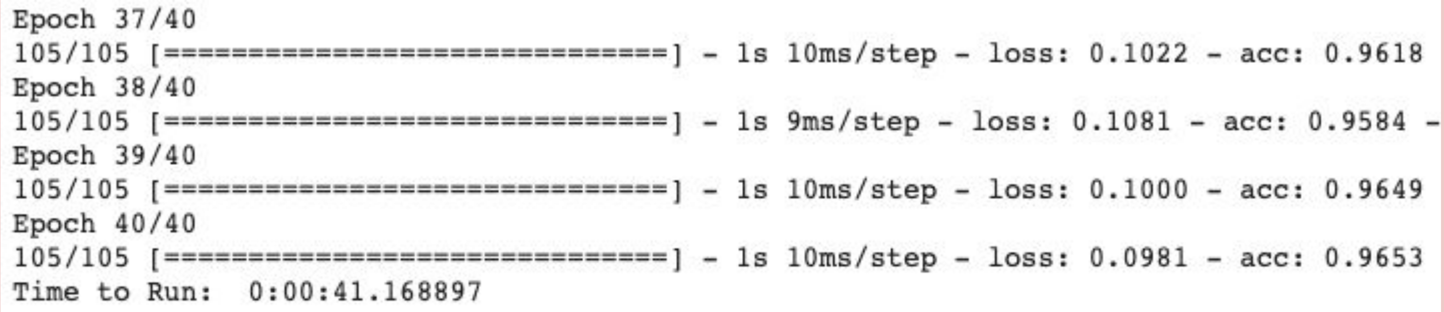


```
Epoch 37/40
105/105 [==============================] - 0s 4ms/step - loss: 0.0906 - acc: 0.9655
Epoch 38/40
105/105 [==============================] - 0s 4ms/step - loss: 0.0925 - acc: 0.9670
Epoch 39/40
105/105 [==============================] - 0s 4ms/step - loss: 0.0885 - acc: 0.9691
Epoch 40/40
105/105 [==============================] - 0s 4ms/step - loss: 0.0854 - acc: 0.9674
Time to Run:  0:00:21.512352
```

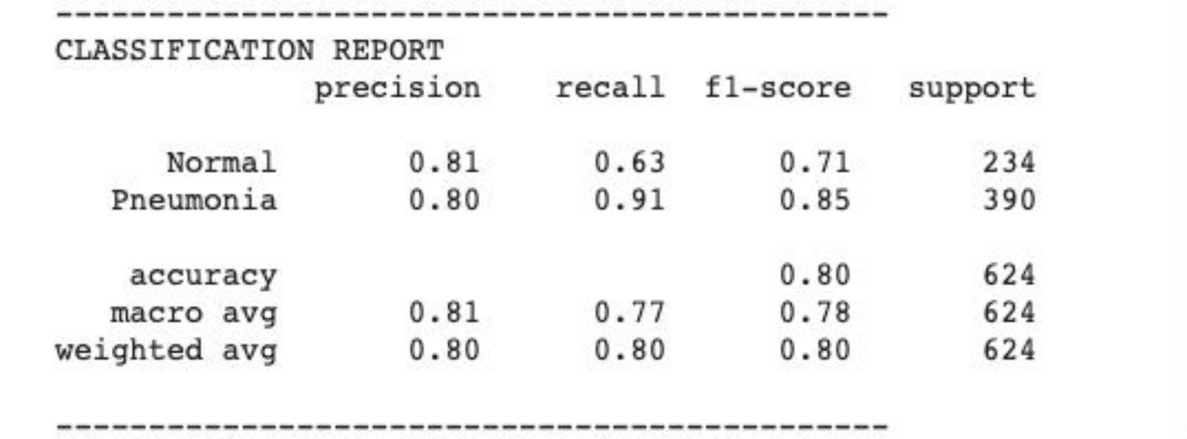


```
--------------------------------------------------
CLASSIFICATION REPORT
              precision    recall  f1-score   support

      Normal       0.76      0.75      0.76       234
   Pneumonia       0.85      0.86      0.85       390

    accuracy                           0.82       624
   macro avg       0.81      0.80      0.80       624
weighted avg       0.82      0.82      0.82       624

--------------------------------------------------
```

APPENDIX 1B: 150x150

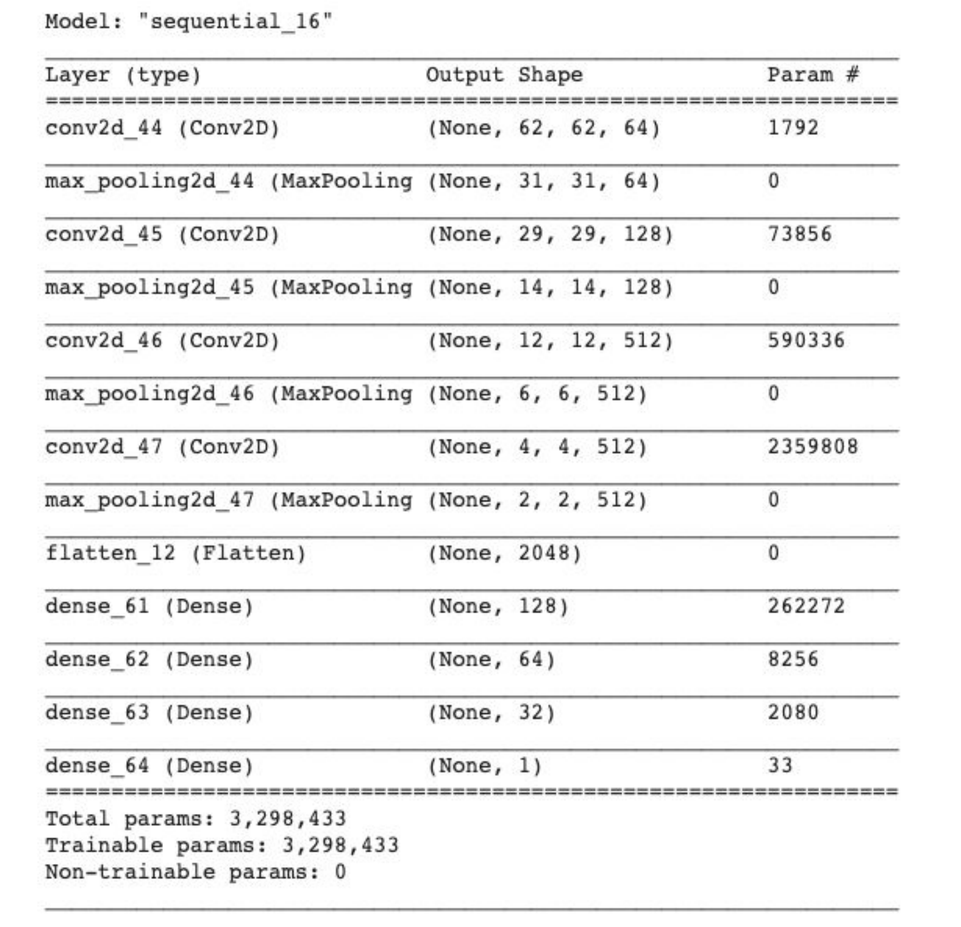


```
Epoch 37/40
105/105 [==============================] - 1s 10ms/step - loss: 0.1022 - acc: 0.9618
Epoch 38/40
105/105 [==============================] - 1s 9ms/step - loss: 0.1081 - acc: 0.9584 -
Epoch 39/40
105/105 [==============================] - 1s 10ms/step - loss: 0.1000 - acc: 0.9649
Epoch 40/40
105/105 [==============================] - 1s 10ms/step - loss: 0.0981 - acc: 0.9653
Time to Run:  0:00:41.168897
```



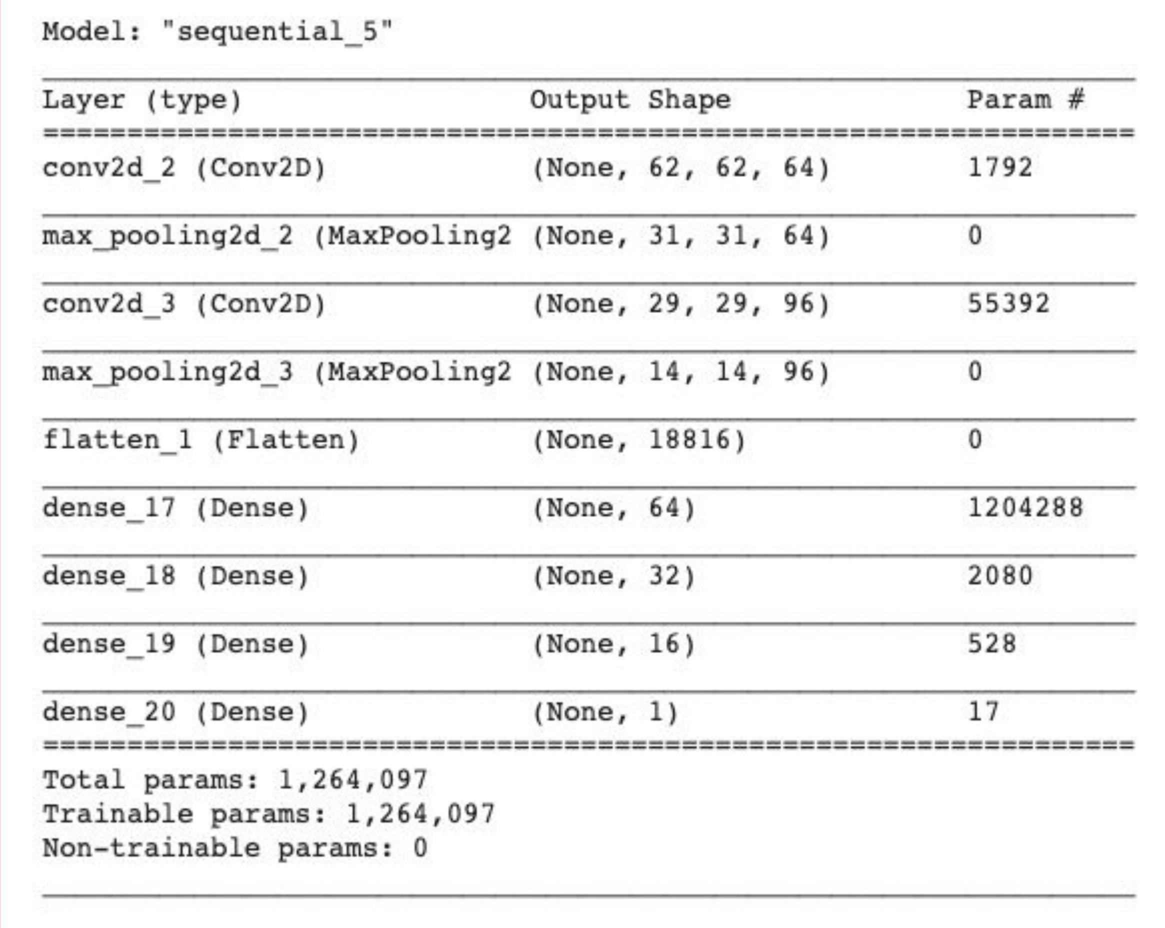
```
---------------------------------------------
CLASSIFICATION REPORT
              precision    recall  f1-score   support

      Normal       0.81      0.63      0.71       234
   Pneumonia       0.80      0.91      0.85       390

    accuracy                           0.80       624
   macro avg       0.81      0.77      0.78       624
weighted avg       0.80      0.80      0.80       624

---------------------------------------------
```

APPENDIX 2



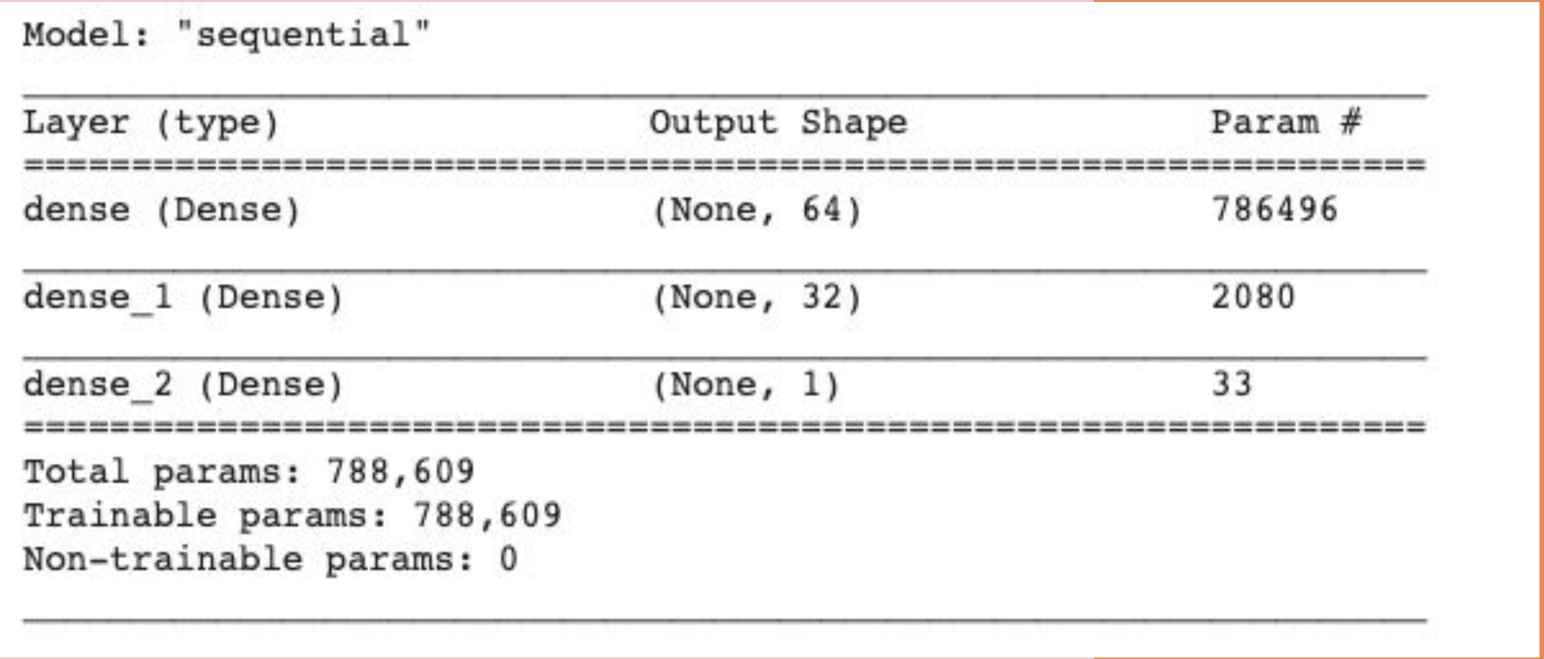
```
Model: "sequential_16"
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
conv2d_44 (Conv2D)           (None, 62, 62, 64)        1792      
_________________________________________________________________
max_pooling2d_44 (MaxPooling (None, 31, 31, 64)        0         
_________________________________________________________________
conv2d_45 (Conv2D)           (None, 29, 29, 128)       73856     
_________________________________________________________________
max_pooling2d_45 (MaxPooling (None, 14, 14, 128)       0         
_________________________________________________________________
conv2d_46 (Conv2D)           (None, 12, 12, 512)       590336    
_________________________________________________________________
max_pooling2d_46 (MaxPooling (None, 6, 6, 512)         0         
_________________________________________________________________
conv2d_47 (Conv2D)           (None, 4, 4, 512)         2359808   
_________________________________________________________________
max_pooling2d_47 (MaxPooling (None, 2, 2, 512)         0         
_________________________________________________________________
flatten_12 (Flatten)         (None, 2048)              0         
_________________________________________________________________
dense_61 (Dense)             (None, 128)               262272    
_________________________________________________________________
dense_62 (Dense)             (None, 64)                8256      
_________________________________________________________________
dense_63 (Dense)             (None, 32)                2080      
_________________________________________________________________
dense_64 (Dense)             (None, 1)                 33        
=================================================================
Total params: 3,298,433
Trainable params: 3,298,433
Non-trainable params: 0
_________________________________________________________________
```

APPENDIX 3



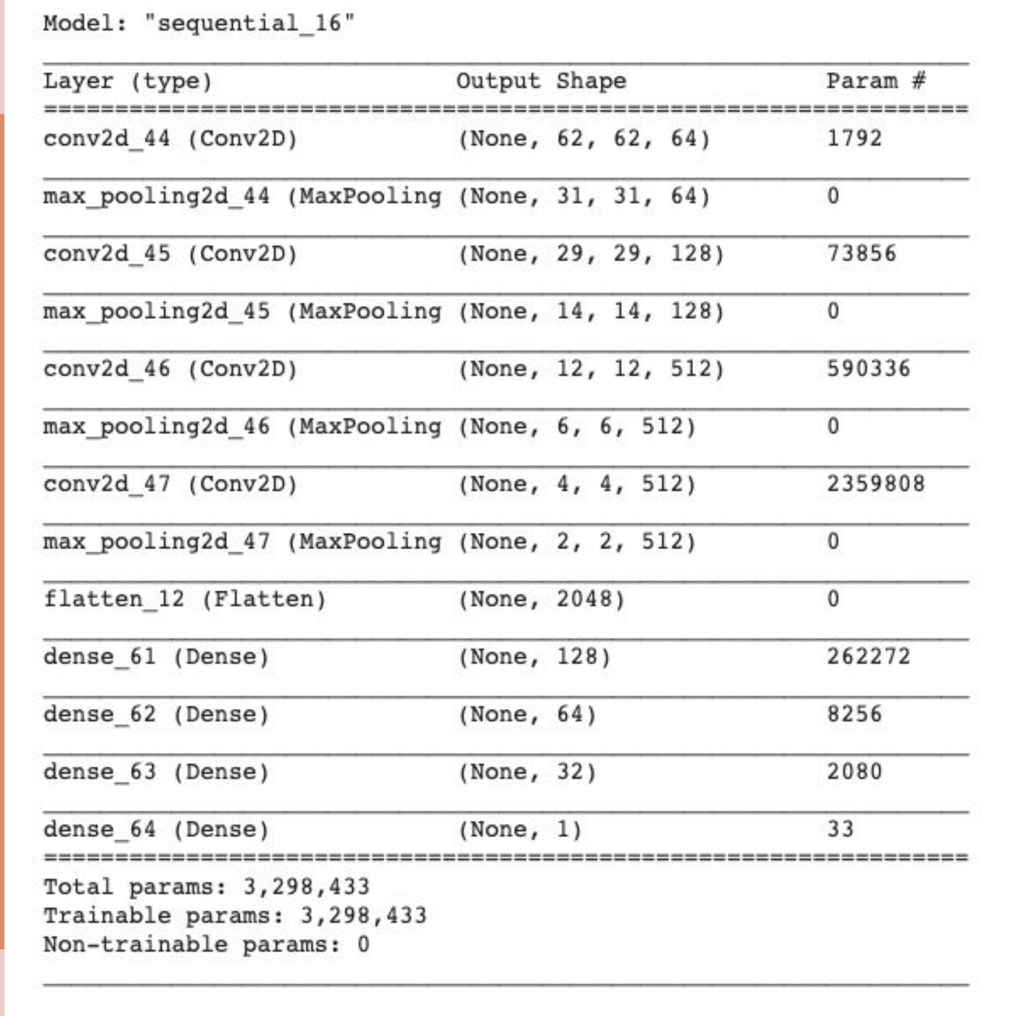
```
Model: "sequential_5"
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
conv2d_2 (Conv2D)            (None, 62, 62, 64)        1792      
_________________________________________________________________
max_pooling2d_2 (MaxPooling2 (None, 31, 31, 64)        0         
_________________________________________________________________
conv2d_3 (Conv2D)            (None, 29, 29, 96)        55392     
_________________________________________________________________
max_pooling2d_3 (MaxPooling2 (None, 14, 14, 96)        0         
_________________________________________________________________
flatten_1 (Flatten)          (None, 18816)             0         
_________________________________________________________________
dense_17 (Dense)             (None, 64)                1204288   
_________________________________________________________________
dense_18 (Dense)             (None, 32)                2080      
_________________________________________________________________
dense_19 (Dense)             (None, 16)                528       
_________________________________________________________________
dense_20 (Dense)             (None, 1)                 17        
=================================================================
Total params: 1,264,097
Trainable params: 1,264,097
Non-trainable params: 0
_________________________________________________________________
```

APPENDIX 4



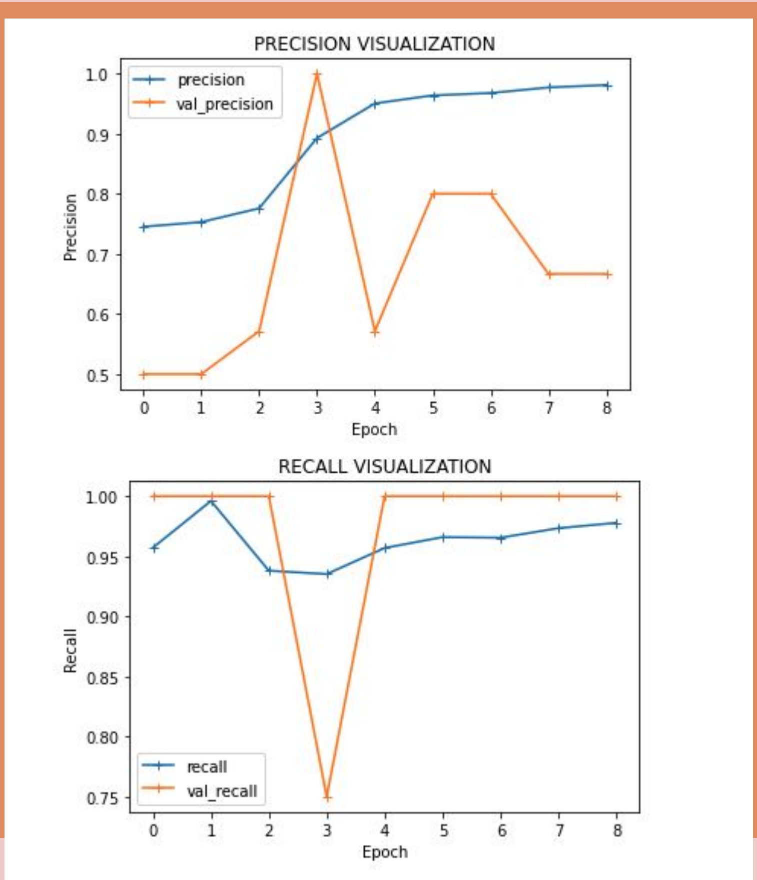
```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense (Dense)                (None, 64)                786496
_________________________________________________________________
dense_1 (Dense)              (None, 32)                2080
_________________________________________________________________
dense_2 (Dense)              (None, 1)                 33
=================================================================
Total params: 788,609
Trainable params: 788,609
Non-trainable params: 0
_________________________________________________________________
```

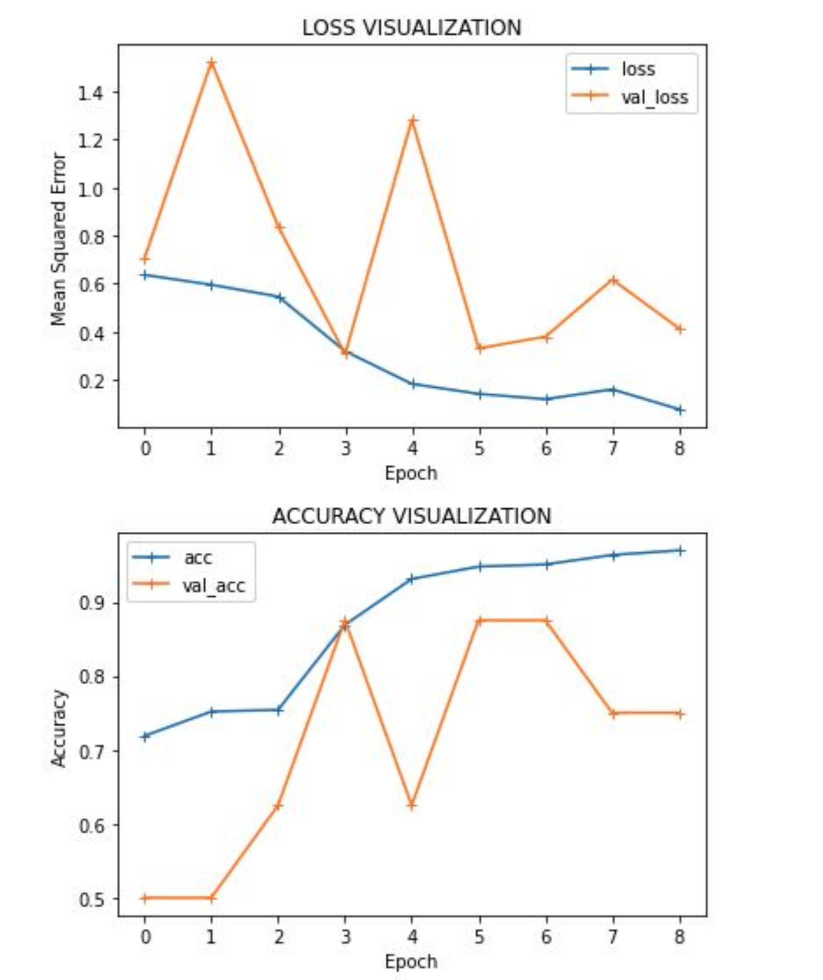
APPENDIX 5A



```
Model: "sequential_16"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_44 (Conv2D)           (None, 62, 62, 64)        1792
_________________________________________________________________
max_pooling2d_44 (MaxPooling (None, 31, 31, 64)        0
_________________________________________________________________
conv2d_45 (Conv2D)           (None, 29, 29, 128)       73856
_________________________________________________________________
max_pooling2d_45 (MaxPooling (None, 14, 14, 128)       0
_________________________________________________________________
conv2d_46 (Conv2D)           (None, 12, 12, 512)       590336
_________________________________________________________________
max_pooling2d_46 (MaxPooling (None, 6, 6, 512)         0
_________________________________________________________________
conv2d_47 (Conv2D)           (None, 4, 4, 512)         2359808
_________________________________________________________________
max_pooling2d_47 (MaxPooling (None, 2, 2, 512)         0
_________________________________________________________________
flatten_12 (Flatten)         (None, 2048)              0
_________________________________________________________________
dense_61 (Dense)             (None, 128)               262272
_________________________________________________________________
dense_62 (Dense)             (None, 64)                8256
_________________________________________________________________
dense_63 (Dense)             (None, 32)                2080
_________________________________________________________________
dense_64 (Dense)             (None, 1)                 33
=================================================================
Total params: 3,298,433
Trainable params: 3,298,433
Non-trainable params: 0
_________________________________________________________________
```

APPENDIX 5B


PRECISION VISUALIZATION
precision
val_precision
Precision
1.0
0.9
0.8
0.7
0.6
0.5
0
1
2
3
4
5
6
7
8
Epoch
RECALL VISUALIZATION
Recall
1.00
0.95
0.90
0.85
0.80
0.75
recall
val_recall
0
1
2
3
4
5
6
7
8
Epoch


LOSS VISUALIZATION
loss
val_loss
Mean Squared Error
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
1
2
3
4
5
6
7
8
Epoch
ACCURACY VISUALIZATION
acc
val_acc
Accuracy
0.9
0.8
0.7
0.6
0.5
0
1
2
3
4
5
6
7
8
Epoch