Vision Dataset (Pneumonia classification): LTI

```
from google.colab import drive
drive.mount('/content/drive')
```

```
Mounted at /content/drive
```

```
from google.colab import files
files.upload()

#create a kaggle folder
! mkdir ~/.kaggle
#copy the Kaggle.json file into Kaggle folder
!cp kaggle.json ~/.kaggle/

#permission for json to act
! chmod 600 ~/.kaggle/kaggle.json

! kaggle datasets download -d paultimothymooney/chest-xray-pneumonia
```

Choose files No file chosen Upload widget is only available when the cell has been executed in the current browser session. Please rerun this cell to e

```
Saving kaggle.json to kaggle.json
Downloading chest-xray-pneumonia.zip to /content
100% 2.29G/2.29G [00:28<00:00, 40.5MB/s]
100% 2.29G/2.29G [00:28<00:00, 85.1MB/s]
```

```
! unzip chest-xray-pneumonia.zip
```

Streaming output truncated to the last 5000 lines.

```
  inflating: chest_xray/train/NORMAL/IM-0435-0001-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0435-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0437-0001-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0437-0001-0002.jpeg
  inflating: chest_xray/train/NORMAL/IM-0437-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0438-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0439-0001-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0439-0001-0002.jpeg
  inflating: chest_xray/train/NORMAL/IM-0439-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0440-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0441-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0442-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0444-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0445-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0446-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0447-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0448-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0449-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0450-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0451-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0452-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0453-0001-0002.jpeg
  inflating: chest_xray/train/NORMAL/IM-0453-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0455-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0456-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0457-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0458-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0459-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0460-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0461-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0463-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0464-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0465-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0466-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0467-0001-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0467-0001-0002.jpeg
  inflating: chest_xray/train/NORMAL/IM-0467-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0469-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0471-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0472-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0473-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0474-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0475-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0476-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0477-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0478-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0479-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0480-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0481-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0482-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0483-0001.jpeg
  inflating: chest_xray/train/NORMAL/IM-0484-0001.jpeg
```

```
    inflating: chest_xray/train/NORMAL/IM-0485-0001.jpeg
    inflating: chest_xray/train/NORMAL/IM-0486-0001.jpeg
    inflating: chest_xray/train/NORMAL/IM-0487-0001.jpeg
    inflating: chest_xray/train/NORMAL/IM-0488-0001.jpeg
    inflating: chest_xray/train/NORMAL/IM-0489-0001.jpeg
```

```
import numpy as np # linear algebra
import pandas as pd # data processing, CSV file I/O (e.g. pd.read_csv)
import tensorflow as tf
from tensorflow.keras import models
from tensorflow.keras import layers
import matplotlib.pyplot as plt
import seaborn as sns
import keras
from sklearn.model_selection import train_test_split
from sklearn.metrics import classification_report,confusion_matrix
from keras.callbacks import ReduceLROnPlateau
import cv2
import pathlib
# Input data files are available in the "../input/" directory.
import os
for dirname, _, filenames in os.walk('/kaggle datasets download -d paultimothymooney/chest-xray-pneumonia'):
    for filename in filenames:
        print(os.path.join(dirname, filename))


#to handle .DS_Store 'hidden files'
train = 'chest_xray/chest_xray/train/NORMAL'
train_P = 'chest_xray/chest_xray/train/PNEUMONIA'
test = 'chest_xray/chest_xray/test/NORMAL'
test_P = 'chest_xray/chest_xray/test/PNEUMONIA'
val = 'chest_xray/chest_xray/val/NORMAL'
val_P = 'chest_xray/chest_xray/val/PNEUMONIA'

train = pathlib.Path(train)
train_P = pathlib.Path(train_P)
test = pathlib.Path(test)
test_P = pathlib.Path(test_P)
val = pathlib.Path(val)
val_P = pathlib.Path(val_P)

# for item in train.glob("*"):
#   print(item.name)


list_ds_N = tf.data.Dataset.list_files(str(train/'*.jpeg'))
list_ds_P = tf.data.Dataset.list_files(str(train_P/'*.jpeg'))

list_ds_test_N = tf.data.Dataset.list_files(str(test/'*.jpeg'))
list_ds_test_P = tf.data.Dataset.list_files(str(test_P/'*.jpeg'))

list_ds_val_N = tf.data.Dataset.list_files(str(val/'*.jpeg'))
list_ds_val_P = tf.data.Dataset.list_files(str(val_P/'*.jpeg'))

for f in list_ds_P.take(5):
  print(f.numpy())
```

```
    b'chest_xray/chest_xray/train/PNEUMONIA/person758_bacteria_2662.jpeg'
    b'chest_xray/chest_xray/train/PNEUMONIA/person1644_bacteria_4357.jpeg'
    b'chest_xray/chest_xray/train/PNEUMONIA/person803_bacteria_2710.jpeg'
    b'chest_xray/chest_xray/train/PNEUMONIA/person700_bacteria_2599.jpeg'
    b'chest_xray/chest_xray/train/PNEUMONIA/person292_virus_599.jpeg'
```

```
list_ds = list_ds_N.concatenate(list_ds_P)
list_ds_test = list_ds_test_N.concatenate(list_ds_test_P)
list_ds_val = list_ds_val_N.concatenate(list_ds_val_P)


# Reads an image from a file, decodes it into a dense tensor, and resizes it
# to a fixed shape.
def parse_image(filename):
  parts = tf.strings.split(file_path, '/')
  label = parts[-2]

  image = tf.io.read_file(filename)
  image = tf.io.decode_image(image, expand_animations = False)
  image = tf.image.convert_image_dtype(image, tf.float32)
  image = tf.image.resize(image, [150, 150])
  return image, label


def show(image, label):
  plt.figure()
```

```
  plt.imshow( tf.squeeze(image))
  plt.title(label.numpy().decode('utf-8'))
  plt.axis('off')
```

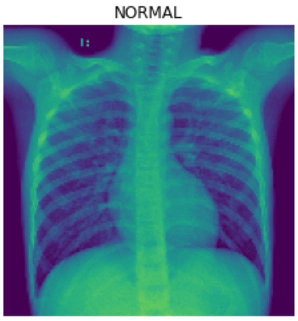
Data Visualization and augmentation

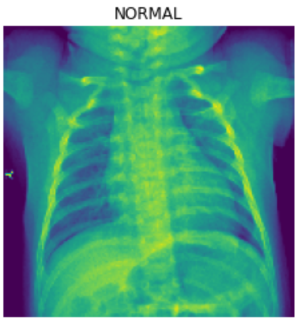
Plot at least two samples from each class of the dataset

Ploting sample data from training data set

```
print('Ploting sample dataset from Training data')

file_path = next(iter(list_ds))
image, label = parse_image(file_path)
show(image, label)
print("------------------")
file_path = next(iter(list_ds))
image, label = parse_image(file_path)
show(image, label)
```

```
Ploting sample dataset from Training data
------------------
```



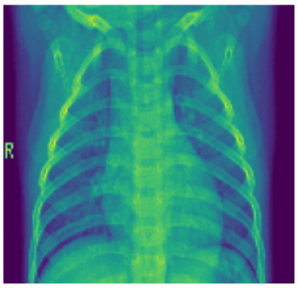


Ploting sample data from testing data set

```
print('Ploting sample dataset from Testing data')

file_path = next(iter(list_ds_test))
image, label = parse_image(file_path)
show(image, label)
print("------------------")
file_path = next(iter(list_ds_test))
image, label = parse_image(file_path)
show(image, label)
```

```
Ploting sample dataset from Testing data
------------------
```

NORMAL

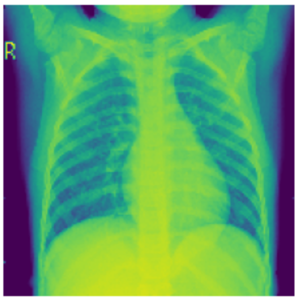


Ploting sample data from validation data set

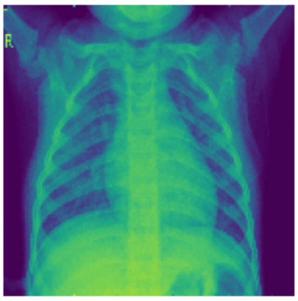
```
print('Ploting sample dataset from validation data')

file_path = next(iter(list_ds_val))
image, label = parse_image(file_path)
show(image, label)
print("------------------")
file_path = next(iter(list_ds_val))
image, label = parse_image(file_path)
show(image, label)
```

```
Ploting sample dataset from validation data
------------------
```

NORMAL



NORMAL



Bringing the train and test data in the required format.

```
# Reading and Parsing the dataset
images_ds = list_ds.map(parse_image)
images_ds_test = list_ds_test.map(parse_image)
images_ds_val = list_ds_val.map(parse_image)
```

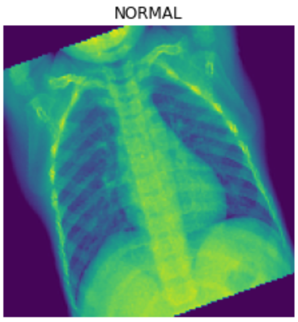
Apply rotation and height shift augmentatio

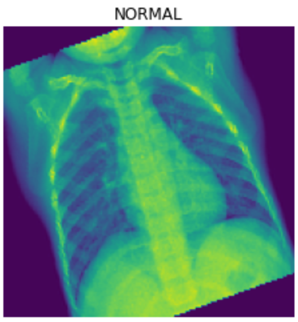
```
# defining rotate and shift function

import scipy.ndimage as ndimage
def random_rotate_image(image):
  image =  ndimage.rotate(image, np.random.uniform(-30,30), reshape=False)
  return image

def random_shift_image(image):
  image =  ndimage.shift(image, shift = 0.080)
  return image
```

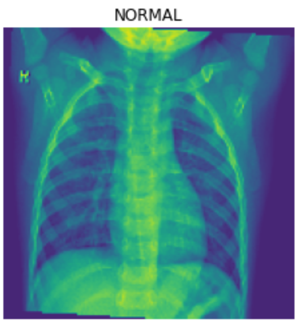
Ploting sample data post rotation and height shift on training data

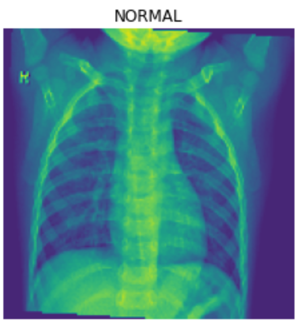
```
print('Ploting sample dataset from Training data post rotation')

image, label = next(iter(images_ds))
image = random_rotate_image(image)
show(image, label)
print('Ploting sample dataset from Training data')
show(image, label)

print("---------------------------------")
print('Ploting sample dataset from Training data post rotation')

image, label = next(iter(images_ds))
image = random_rotate_image(image)
show(image, label)

print('Ploting sample dataset from Training data')
show(image, label)
```

```
Ploting sample dataset from Training data post rotation
Ploting sample dataset from Training data
---------------------------------
Ploting sample dataset from Training data post rotation
Ploting sample dataset from Training data
```







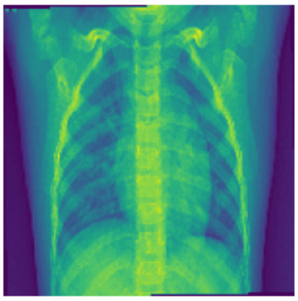



```
print('Ploting sample dataset from Testing data post rotation')
```

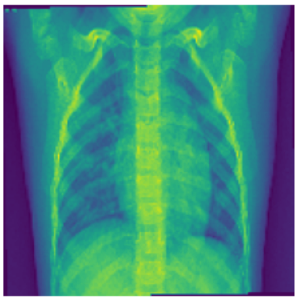
```
image, label = next(iter(images_ds_test))
image = random_rotate_image(image)
show(image, label)
print('Ploting sample dataset from test data')
show(image, label)

print("--------------------------------")
print('Ploting sample dataset from Testing data post rotation')

image, label = next(iter(images_ds_test))
image = random_rotate_image(image)
show(image, label)

print('Ploting sample dataset from test data')
show(image, label)
```

```
Ploting sample dataset from Testing data post rotation
Ploting sample dataset from test data
--------------------------------
Ploting sample dataset from Testing data post rotation
Ploting sample dataset from test data
```

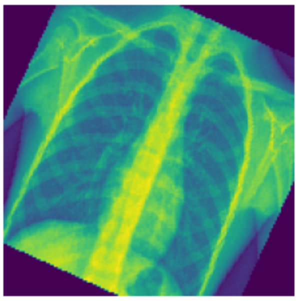
NORMAL



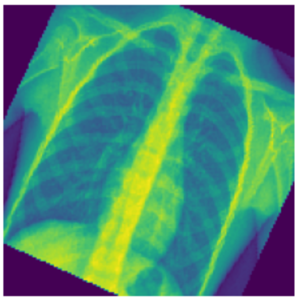
NORMAL



NORMAL



NORMAL

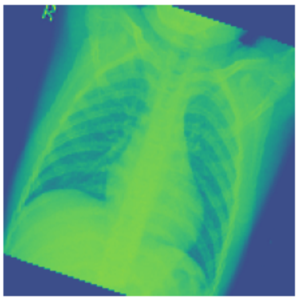


```
print('Ploting sample dataset from validation data post rotation')

image, label = next(iter(images_ds_val))
image = random_rotate_image(image)
show(image, label)
print('Ploting sample dataset from validation data')
show(image, label)
```

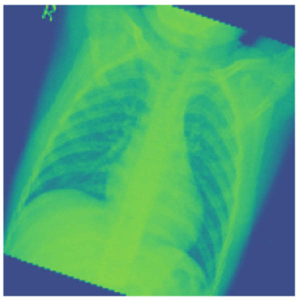
```
print("--------------------------------")
print('Ploting sample dataset from validation data post rotation')

image, label = next(iter(images_ds_val))
image = random_rotate_image(image)
show(image, label)

print('Ploting sample dataset from validation data')
show(image, label)
```

```
Ploting sample dataset from validation data post rotation
Ploting sample dataset from validation data
--------------------------------
Ploting sample dataset from validation data post rotation
Ploting sample dataset from validation data
```

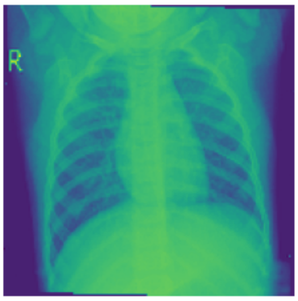
NORMAL



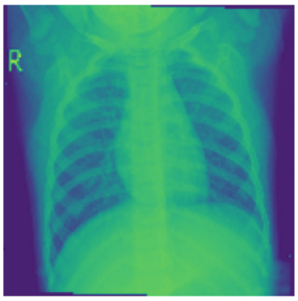
NORMAL



NORMAL



NORMAL



```
# def tf_random_rotate_image(image, label):
#   im_shape = image.shape
#   [image,]= tf.py_function(random_rotate_image, [image], [tf.float32])
#   image.set_shape(im_shape)
#   return image, label

# rot_ds = images_ds.map(tf_random_rotate_image)
# rot_ds_test = images_ds_test.map(tf_random_rotate_image)
# rot_ds_val = images_ds_val.map(tf_random_rotate_image)
```

```
# image, label = next(iter(rot_ds_test))
# plt.figure(figsize = (5,5))
# plt.imshow(tf.squeeze(image), cmap='gray')
# plt.title(label)

# image, label = next(iter(rot_ds_val))
# plt.figure(figsize = (5,5))
# plt.imshow(tf.squeeze(image), cmap='gray')
# plt.title(label)
```

Print the shapes of train and test data.

```
image, label = next(iter(images_ds))
print('shape of the training data', len(list_ds), image.shape[0])
print("----------------------------------------")
image, label = next(iter(images_ds_test))
print('shape of the testing data', len(list_ds_test), image.shape[0])
print("----------------------------------------")
image, label = next(iter(images_ds_val))
print('shape of the validation data', len(list_ds_val), image.shape[0])
```

```
shape of the training data 5216 150
----------------------------------------
shape of the testing data 624 150
----------------------------------------
shape of the validation data 16 150
```

```
labels = ['PNEUMONIA', 'NORMAL']
img_size = 150
def get_training_data(data_dir):
    data = []
    for label in labels:
        path = os.path.join(data_dir, label)
        class_num = labels.index(label)
        for img in os.listdir(path):
            try:
                img_arr = cv2.imread(os.path.join(path, img), cv2.IMREAD_GRAYSCALE)
                resized_arr = cv2.resize(img_arr, (img_size, img_size)) # Reshaping images to preferred size
                data.append([resized_arr, class_num])
            except Exception as e:
                print(e)
    return np.array(data)
```

```
train = get_training_data('chest_xray/chest_xray/train/')
test = get_training_data('chest_xray/chest_xray/test/')
val = get_training_data('chest_xray/chest_xray/val/')
```

```
OpenCV(4.1.2) /io/opencv/modules/imgproc/src/resize.cpp:3720: error: (-215:Assertion failed) !ssize.empty() in function '

OpenCV(4.1.2) /io/opencv/modules/imgproc/src/resize.cpp:3720: error: (-215:Assertion failed) !ssize.empty() in function '

/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:15: VisibleDeprecationWarning: Creating an ndarray from rag
  from ipykernel import kernelapp as app
OpenCV(4.1.2) /io/opencv/modules/imgproc/src/resize.cpp:3720: error: (-215:Assertion failed) !ssize.empty() in function '

OpenCV(4.1.2) /io/opencv/modules/imgproc/src/resize.cpp:3720: error: (-215:Assertion failed) !ssize.empty() in function '
```

```
x_train = []
y_train = []

x_val = []
y_val = []

x_test = []
y_test = []

for feature, label in train:
    x_train.append(feature)
    y_train.append(label)

for feature, label in test:
    x_test.append(feature)
    y_test.append(label)
```

```
for feature, label in val:
    x_val.append(feature)
    y_val.append(label)


# Normalize the data
x_train = np.array(x_train) / 255
x_val = np.array(x_val) / 255
x_test = np.array(x_test) / 255

# y_train = np.array(y_train)
# y_val = np.array(y_val)
# y_test = np.array(y_test)
y_train = tf.keras.utils.to_categorical(y_train)
y_test = tf.keras.utils.to_categorical(y_test)
y_val = tf.keras.utils.to_categorical(y_val)

Xtrain = x_train.reshape((5216, 150*150))
Xtest = x_test.reshape((624, 150*150))
Xval = x_val.reshape((16, 150*150))
```

Model building

```
# Create a model object
from keras.layers import Dropout

tf.keras.backend.clear_session()  #clear old tf seesion and models
dnnModel = models.Sequential()
# Layer 1 = input layer
# specify the input size in the first layer.

dnnModel.add(layers.Dense(50, activation='relu', input_shape= (150*150,), kernel_regularizer='l2'))

# Layer 2 = hidden layer
dnnModel.add(layers.Dense(60, activation='relu', kernel_regularizer='l2'))
# dropout in hidden layers with weight constraint
dnnModel.add(Dropout(0.2))
# Layer 3 = hidden layer
dnnModel.add(layers.Dense(30, activation='relu', kernel_regularizer='l2'))

# Layer 4 = output layer
dnnModel.add(layers.Dense(2, activation='softmax', kernel_regularizer='l2'))

dnnModel.summary()
```

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #   
=================================================================
 dense (Dense)               (None, 50)                1125050   
                                                                 
 dense_1 (Dense)             (None, 60)                3060      
                                                                 
 dropout (Dropout)           (None, 60)                0         
                                                                 
 dense_2 (Dense)             (None, 30)                1830      
                                                                 
 dense_3 (Dense)             (None, 2)                 62        
                                                                 
=================================================================
Total params: 1,130,002
Trainable params: 1,130,002
Non-trainable params: 0
_________________________________________________________________
```

Model Compilation

```
dnnModel.compile( optimizer = 'adam', loss = 'binary_crossentropy', metrics=['accuracy', 'mse'] )
```

Model Training

```
import datetime
t1 = datetime.datetime.now()
h  = dnnModel.fit( Xtrain, y_train, batch_size=64, validation_data = (Xtest, y_test), epochs=200)
t2 = datetime.datetime.now()
```

```
Epoch 1/200
82/82 [==============================] - 3s 29ms/step - loss: 1.8098 - accuracy: 0.8127 - mse: 0.1363 - val_loss: 1.5892
Epoch 2/200
82/82 [==============================] - 2s 26ms/step - loss: 1.0375 - accuracy: 0.8854 - mse: 0.0845 - val_loss: 1.0381
Epoch 3/200
82/82 [==============================] - 2s 26ms/step - loss: 0.7184 - accuracy: 0.9218 - mse: 0.0572 - val_loss: 1.4043
Epoch 4/200
82/82 [==============================] - 2s 27ms/step - loss: 0.6008 - accuracy: 0.9260 - mse: 0.0547 - val_loss: 1.1106
Epoch 5/200
82/82 [==============================] - 4s 43ms/step - loss: 0.5104 - accuracy: 0.9363 - mse: 0.0466 - val_loss: 0.7531
Epoch 6/200
82/82 [==============================] - 3s 38ms/step - loss: 0.4986 - accuracy: 0.9277 - mse: 0.0543 - val_loss: 1.2790
Epoch 7/200
82/82 [==============================] - 2s 26ms/step - loss: 0.4843 - accuracy: 0.9225 - mse: 0.0571 - val_loss: 1.1906
Epoch 8/200
82/82 [==============================] - 2s 27ms/step - loss: 0.4118 - accuracy: 0.9459 - mse: 0.0422 - val_loss: 0.8347
Epoch 9/200
82/82 [==============================] - 2s 27ms/step - loss: 0.3971 - accuracy: 0.9421 - mse: 0.0447 - val_loss: 0.7081
Epoch 10/200
82/82 [==============================] - 2s 26ms/step - loss: 0.4300 - accuracy: 0.9172 - mse: 0.0609 - val_loss: 0.6804
Epoch 11/200
82/82 [==============================] - 2s 28ms/step - loss: 0.3918 - accuracy: 0.9327 - mse: 0.0503 - val_loss: 0.5622
Epoch 12/200
82/82 [==============================] - 2s 25ms/step - loss: 0.3839 - accuracy: 0.9317 - mse: 0.0514 - val_loss: 0.5947
Epoch 13/200
82/82 [==============================] - 2s 26ms/step - loss: 0.3582 - accuracy: 0.9383 - mse: 0.0479 - val_loss: 1.0117
Epoch 14/200
82/82 [==============================] - 2s 27ms/step - loss: 0.3313 - accuracy: 0.9434 - mse: 0.0431 - val_loss: 1.2462
Epoch 15/200
82/82 [==============================] - 2s 24ms/step - loss: 0.3463 - accuracy: 0.9344 - mse: 0.0500 - val_loss: 0.7679
Epoch 16/200
82/82 [==============================] - 2s 27ms/step - loss: 0.3237 - accuracy: 0.9369 - mse: 0.0472 - val_loss: 0.8396
Epoch 17/200
82/82 [==============================] - 2s 25ms/step - loss: 0.3030 - accuracy: 0.9465 - mse: 0.0417 - val_loss: 0.9019
Epoch 18/200
82/82 [==============================] - 2s 26ms/step - loss: 0.2930 - accuracy: 0.9408 - mse: 0.0436 - val_loss: 0.8371
Epoch 19/200
82/82 [==============================] - 2s 26ms/step - loss: 0.3135 - accuracy: 0.9293 - mse: 0.0505 - val_loss: 0.7632
Epoch 20/200
82/82 [==============================] - 2s 26ms/step - loss: 0.2828 - accuracy: 0.9438 - mse: 0.0426 - val_loss: 0.6930
Epoch 21/200
82/82 [==============================] - 2s 26ms/step - loss: 0.2593 - accuracy: 0.9492 - mse: 0.0381 - val_loss: 1.3076
Epoch 22/200
82/82 [==============================] - 2s 25ms/step - loss: 0.2734 - accuracy: 0.9402 - mse: 0.0440 - val_loss: 1.1349
Epoch 23/200
82/82 [==============================] - 2s 26ms/step - loss: 0.2576 - accuracy: 0.9461 - mse: 0.0404 - val_loss: 0.8486
Epoch 24/200
82/82 [==============================] - 2s 25ms/step - loss: 0.2480 - accuracy: 0.9503 - mse: 0.0382 - val_loss: 0.6571
Epoch 25/200
82/82 [==============================] - 2s 26ms/step - loss: 0.2430 - accuracy: 0.9500 - mse: 0.0390 - val_loss: 1.7212
Epoch 26/200
82/82 [==============================] - 2s 25ms/step - loss: 0.2386 - accuracy: 0.9498 - mse: 0.0390 - val_loss: 1.2329
Epoch 27/200
82/82 [==============================] - 2s 24ms/step - loss: 0.2618 - accuracy: 0.9398 - mse: 0.0462 - val_loss: 0.7149
Epoch 28/200
82/82 [==============================] - 1s 18ms/step - loss: 0.2331 - accuracy: 0.9486 - mse: 0.0388 - val_loss: 0.6511
Epoch 29/200
82/82 [==============================] - 1s 18ms/step - loss: 0.2281 - accuracy: 0.9532 - mse: 0.0376 - val_loss: 0.8447
```

summarize history for accuracy and loss

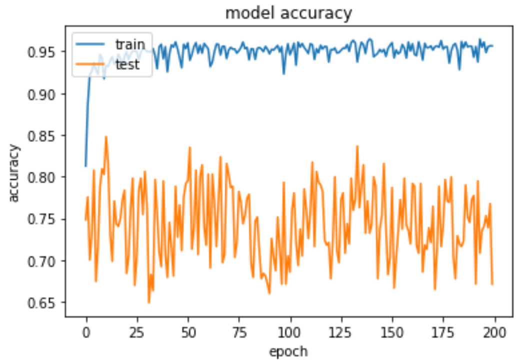
```
print('time taken by the model', t2-t1)
```

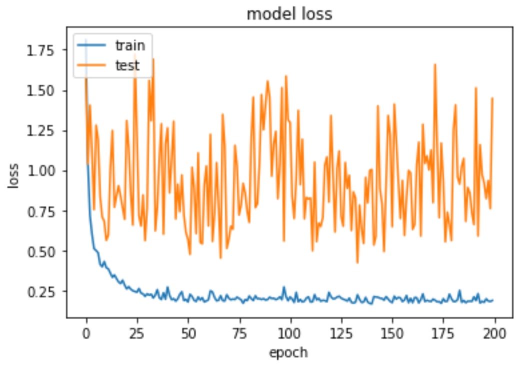
```
time taken by the model 0:06:26.746463
```

```
# summarize history for accuracy
def plot_acc(history):
  plt.plot(history.history['accuracy'])
  plt.plot(history.history['val_accuracy'])
  plt.title('model accuracy')
  plt.ylabel('accuracy')
  plt.xlabel('epoch')
  plt.legend(['train', 'test'], loc='upper left')
  plt.show()
# summarize history for loss
def plot_loss(history):
  plt.plot(history.history['loss'])
  plt.plot(history.history['val_loss'])
  plt.title('model loss')
```

```
  plt.ylabel('loss')
  plt.xlabel('epoch')
  plt.legend(['train', 'test'], loc='upper left')
  plt.show()
```

```
plot_acc(h)
plot_loss(h)
```





Model Evaluation

```
#prediction
result = dnnModel.predict(Xval)
print(result.shape)

result = pd.DataFrame(result)
result.columns = ['proba1', 'proba2']
result['output'] = result['proba1'].apply(lambda x : 1 if x >= 0.50 else 0)
result.head()
```

```
WARNING:tensorflow:5 out of the last 13 calls to <function Model.make_predict_
(16, 2)
```

	proba1	proba2	output
0	0.998612	0.001388	1
1	0.996382	0.003618	1
2	0.997664	0.002336	1
3	0.995824	0.004176	1
4	0.998222	0.001778	1

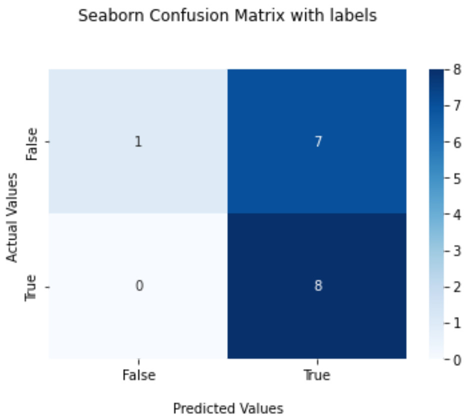
```
yval = pd.DataFrame(y_val)
yval.columns = ['trueval1', 'trueval2']
yval = yval[['trueval1']]
```

```
yval.head()
```

trueval1

Model confusion matrix report

```
import seaborn as sns
from sklearn.metrics import confusion_matrix
cf_matrix = confusion_matrix(yval['trueval1'], result['output'])

ax = sns.heatmap(cf_matrix, annot=True, cmap='Blues')

ax.set_title('Seaborn Confusion Matrix with labels\n\n');
ax.set_xlabel('\nPredicted Values')
ax.set_ylabel('Actual Values ');

## Ticket labels - List must be in alphabetical order
ax.xaxis.set_ticklabels(['False','True'])
ax.yaxis.set_ticklabels(['False','True'])

## Display the visualization of the Confusion Matrix.
plt.show()
```



Model classification report

```
from sklearn.metrics import classification_report

target_names = ['class pneumonia', 'class normal']
print(classification_report(yval['trueval1'], result['output'], target_names=target_names))
```

```
                 precision    recall  f1-score   support

class pneumonia       1.00      0.12      0.22         8
   class normal       0.53      1.00      0.70         8

       accuracy                           0.56        16
      macro avg       0.77      0.56      0.46        16
   weighted avg       0.77      0.56      0.46        16
```

Hyperparameter Tuning

1. Optimiser: Use a different optimizer with the appropriate LR value.

```
# learning rate schedule
def step_decay(epoch):
    initial_lrate = 0.1
    drop = 0.5
    epochs_drop = 10.0
    lrate = initial_lrate * math.pow(drop, math.floor((1+epoch)/epochs_drop))
    return lrate
```

```
# Create a model object
from keras.layers import Dropout
from keras.callbacks import LearningRateScheduler
import math
import random
import numpy as np

tf.keras.backend.clear_session()  #clear old tf seesion and models
dnnModel = models.Sequential()
# Layer 1 = input layer
# specify the input size in the first layer.

dnnModel.add(layers.Dense(50, activation='relu', input_shape= (150*150,), kernel_regularizer='l2'))

# Layer 2 = hidden layer
dnnModel.add(layers.Dense(60, activation='relu', kernel_regularizer='l2'))
# dropout in hidden layers with weight constraint
dnnModel.add(Dropout(0.2))
# Layer 3 = hidden layer
dnnModel.add(layers.Dense(30, activation='relu', kernel_regularizer='l2'))

# Layer 4 = output layer
dnnModel.add(layers.Dense(2, activation='softmax', kernel_regularizer='l2'))

dnnModel.summary()
# learning schedule callback
lrate = LearningRateScheduler(step_decay)
callback = tf.keras.callbacks.EarlyStopping(monitor='loss', patience=50)

# Configure  the model for training, by using appropriate optimizers and regularizations
# Available optimizer: adam, rmsprop, adagrad, sgd
# loss:  objective that the model will try to minimize.
# Available loss: categorical_crossentropy, binary_crossentropy, mean_squared_error
# metrics: List of metrics to be evaluated by the model during training and testing.
dnnModel.compile(optimizer = tf.keras.optimizers.SGD(learning_rate=0.0, momentum=0.9), loss = 'binary_crossentropy', metrics=[
h  = dnnModel.fit( Xtrain, y_train, batch_size=64, validation_data = (Xtest, y_test), epochs=50,  callbacks=[callback, lrate])
```

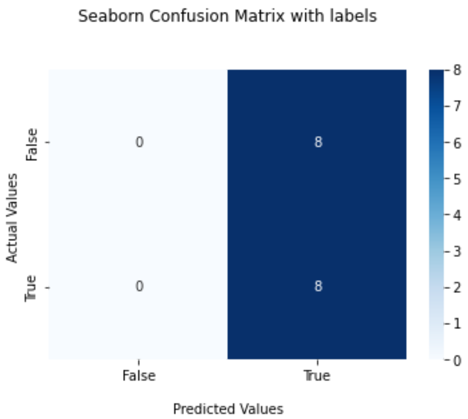
```
Epoch 47/50
82/82 [==============================] - 1s 17ms/step - loss: 0.5701 - accuracy: 0.7429 - mse: 0.2132 - val_loss: 0.6951
Epoch 48/50
82/82 [==============================] - 1s 17ms/step - loss: 0.5700 - accuracy: 0.7429 - mse: 0.2136 - val_loss: 0.6954
Epoch 49/50
82/82 [==============================] - 1s 17ms/step - loss: 0.5700 - accuracy: 0.7429 - mse: 0.2137 - val_loss: 0.6952
Epoch 50/50
82/82 [==============================] - 1s 17ms/step - loss: 0.5700 - accuracy: 0.7429 - mse: 0.2134 - val_loss: 0.6951
```

```
#prediction
result = dnnModel.predict(Xval)
print(result.shape)

result = pd.DataFrame(result)
result.columns = ['proba1', 'proba2']
result['output'] = result['proba1'].apply(lambda x : 1 if x >= 0.50 else 0)
result.head()
```

```
(16, 2)
```

	proba1	proba2	output
0	0.892996	0.107004	1
1	0.892996	0.107004	1
2	0.892996	0.107004	1
3	0.892996	0.107004	1
4	0.892996	0.107004	1

```
import seaborn as sns
from sklearn.metrics import confusion_matrix
cf_matrix = confusion_matrix(yval['trueval1'], result['output'])

ax = sns.heatmap(cf_matrix, annot=True, cmap='Blues')

ax.set_title('Seaborn Confusion Matrix with labels\n\n');
ax.set_xlabel('\nPredicted Values')
ax.set_ylabel('Actual Values ');

## Ticket labels - List must be in alphabetical order
ax.xaxis.set_ticklabels(['False','True'])
ax.yaxis.set_ticklabels(['False','True'])

## Display the visualization of the Confusion Matrix.
plt.show()
```




```
from sklearn.metrics import classification_report

target_names = ['class pneumonia', 'class normal']
print(classification_report(yval['trueval1'], result['output'], target_names=target_names))
```

```
                 precision    recall  f1-score   support

class pneumonia       0.00      0.00      0.00         8
   class normal       0.50      1.00      0.67         8

       accuracy                           0.50        16
      macro avg       0.25      0.50      0.33        16
   weighted avg       0.25      0.50      0.33        16

/usr/local/lib/python3.7/dist-packages/sklearn/metrics/_classification.py:1308: UndefinedMetricWarning: Precision and F-s
  _warn_prf(average, modifier, msg_start, len(result))
/usr/local/lib/python3.7/dist-packages/sklearn/metrics/_classification.py:1308: UndefinedMetricWarning: Precision and F-s
  _warn_prf(average, modifier, msg_start, len(result))
```

```
/usr/local/lib/python3.7/dist-packages/sklearn/metrics/_classification.py:1308: UndefinedMetricWarning: Precision and F-s
  _warn_prf(average, modifier, msg_start, len(result))
```

```
# Create a model object
from keras.layers import Dropout
from keras.callbacks import LearningRateScheduler
import math
import random
import numpy as np

tf.keras.backend.clear_session()  #clear old tf seesion and models
dnnModel = models.Sequential()
# Layer 1 = input layer
# specify the input size in the first layer.

dnnModel.add(layers.Dense(50, activation='relu', input_shape= (150*150,), kernel_regularizer='l2'))
# Layer 2 = hidden layer
dnnModel.add(layers.Dense(80, activation='relu', kernel_regularizer='l2'))
# dropout in hidden layers with weight constraint
dnnModel.add(Dropout(0.2))
# Layer 3 = hidden layer
dnnModel.add(layers.Dense(60, activation='relu', kernel_regularizer='l2'))
# dropout in hidden layers with weight constraint
dnnModel.add(Dropout(0.2))
# Layer 4 = hidden layer
dnnModel.add(layers.Dense(30, activation='relu', kernel_regularizer='l2'))
# Layer 5 = hidden layer
dnnModel.add(layers.Dense(10, activation='relu', kernel_regularizer='l2'))
# Layer 6 = output layer
dnnModel.add(layers.Dense(2, activation='softmax', kernel_regularizer='l2'))

dnnModel.summary()
# learning schedule callback
lrate = LearningRateScheduler(step_decay)
callback = tf.keras.callbacks.EarlyStopping(monitor='loss', patience=50)

# Configure  the model for training, by using appropriate optimizers and regularizations
# Available optimizer: adam, rmsprop, adagrad, sgd
# loss:  objective that the model will try to minimize.
# Available loss: categorical_crossentropy, binary_crossentropy, mean_squared_error
# metrics: List of metrics to be evaluated by the model during training and testing.
dnnModel.compile(optimizer = tf.keras.optimizers.SGD(learning_rate=0.0, momentum=0.9), loss = 'binary_crossentropy', metrics=[
h  = dnnModel.fit( Xtrain, y_train, batch_size=64, validation_data = (Xtest, y_test), epochs=50,  callbacks=[callback, lrate])
```

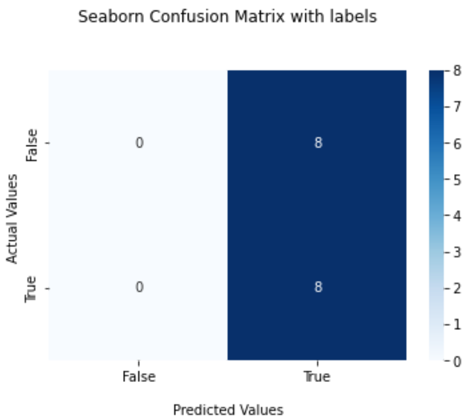
```
82/82 [==============================] - 3s 39ms/step - loss: 0.5700 - accuracy: 0.7429 - mse: 0.2134 - val_loss: 0.6947
Epoch 43/50
82/82 [==============================] - 2s 26ms/step - loss: 0.5700 - accuracy: 0.7429 - mse: 0.2134 - val_loss: 0.6948
Epoch 44/50
82/82 [==============================] - 2s 24ms/step - loss: 0.5700 - accuracy: 0.7429 - mse: 0.2132 - val_loss: 0.6948
Epoch 45/50
82/82 [==============================] - 2s 26ms/step - loss: 0.5700 - accuracy: 0.7429 - mse: 0.2137 - val_loss: 0.6950
Epoch 46/50
82/82 [==============================] - 2s 27ms/step - loss: 0.5700 - accuracy: 0.7429 - mse: 0.2134 - val_loss: 0.6948
Epoch 47/50
82/82 [==============================] - 2s 24ms/step - loss: 0.5701 - accuracy: 0.7429 - mse: 0.2142 - val_loss: 0.6954
Epoch 48/50
82/82 [==============================] - 2s 25ms/step - loss: 0.5701 - accuracy: 0.7429 - mse: 0.2134 - val_loss: 0.6953
Epoch 49/50
82/82 [==============================] - 2s 23ms/step - loss: 0.5700 - accuracy: 0.7429 - mse: 0.2136 - val_loss: 0.6949
Epoch 50/50
82/82 [==============================] - 2s 24ms/step - loss: 0.5700 - accuracy: 0.7429 - mse: 0.2132 - val_loss: 0.6947
```

```
#prediction
result = dnnModel.predict(Xval)
print(result.shape)

result = pd.DataFrame(result)
result.columns = ['proba1', 'proba2']
result['output'] = result['proba1'].apply(lambda x : 1 if x >= 0.50 else 0)
result.head()
```

```
(16, 2)
```

	proba1	proba2	output
0	0.892324	0.107676	1
1	0.892324	0.107676	1
2	0.892324	0.107676	1
3	0.892324	0.107676	1
4	0.892324	0.107676	1

```
import seaborn as sns
from sklearn.metrics import confusion_matrix
cf_matrix = confusion_matrix(yval['trueval1'], result['output'])

ax = sns.heatmap(cf_matrix, annot=True, cmap='Blues')

ax.set_title('Seaborn Confusion Matrix with labels\n\n');
ax.set_xlabel('\nPredicted Values')
ax.set_ylabel('Actual Values ');

## Ticket labels - List must be in alphabetical order
ax.xaxis.set_ticklabels(['False','True'])
ax.yaxis.set_ticklabels(['False','True'])

## Display the visualization of the Confusion Matrix.
plt.show()
```




```
from sklearn.metrics import classification_report

target_names = ['class pneumonia', 'class normal']
print(classification_report(yval['trueval1'], result['output'], target_names=target_names))
```

```
                 precision    recall  f1-score   support

class pneumonia       0.00      0.00      0.00         8
   class normal       0.50      1.00      0.67         8
```

```
    accuracy                           0.50        16
   macro avg       0.25      0.50      0.33        16
weighted avg       0.25      0.50      0.33        16

/usr/local/lib/python3.7/dist-packages/sklearn/metrics/_classification.py:1308: UndefinedMetricWarning: Precision and F-s
  _warn_prf(average, modifier, msg_start, len(result))
/usr/local/lib/python3.7/dist-packages/sklearn/metrics/_classification.py:1308: UndefinedMetricWarning: Precision and F-s
  _warn_prf(average, modifier, msg_start, len(result))
/usr/local/lib/python3.7/dist-packages/sklearn/metrics/_classification.py:1308: UndefinedMetricWarning: Precision and F-s
  _warn_prf(average, modifier, msg_start, len(result))
```

Description on function used in model building

Problem Statement: Classification

Output: Binary output

Final activation function: Sigmoid

Loss Funciton: Binary cross entropy/ categorial_crossentropy

ReLU — This results in a numerical value greater than 0

Sigmoid — This results in a value between 0 and 1 which we can infer to be how confident it is of it being in the class

Binary Cross Entropy — Cross entropy quantifies the difference between two probability distribution. Our model predicts a model distribution of {p, 1-p} (binary distribution) for each of the classes. We use binary cross-entropy to compare these with the true distributions {y, 1-y} for each class and sum up their results

Conclusion:

Adam optimization has performed better with training accuracy of 95.63% than Stochastic Gradient Descent (SGD) model with accuracy of 74.0%