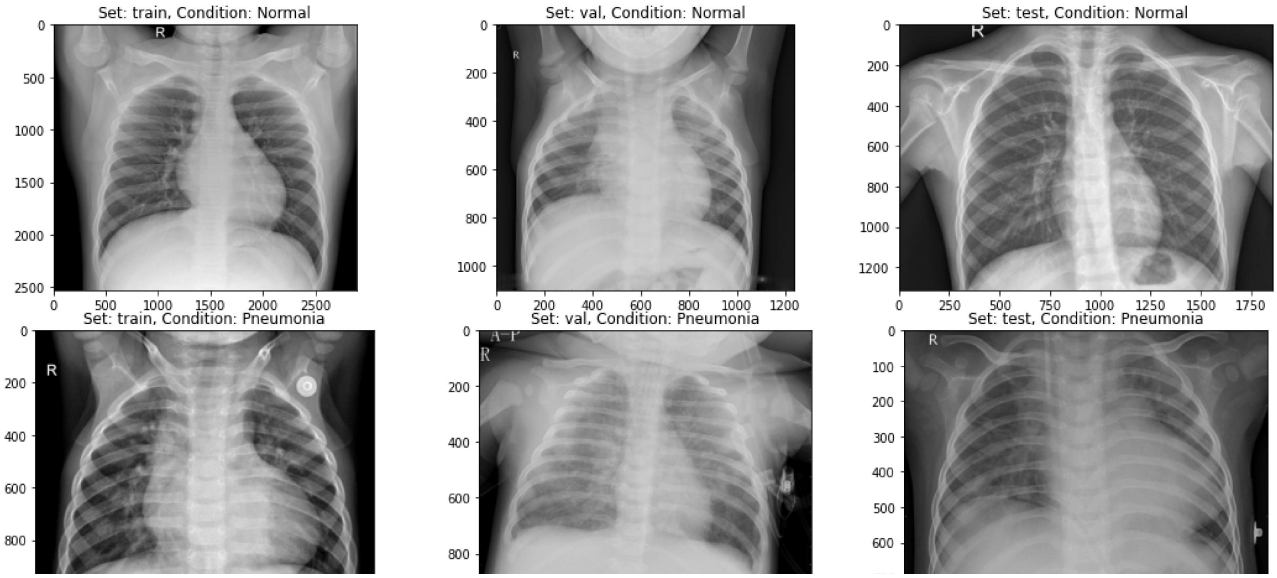
```
import os
import numpy as np
import pandas as pd
import random
import cv2
import matplotlib.pyplot as plt
%matplotlib inline
import keras as K
from keras.models import Model, Sequential
from keras.layers import Input, Dense, Flatten, Dropout, BatchNormalization
from keras.layers import Conv2D, SeparableConv2D, MaxPool2D, LeakyReLU, Activation
"from keras.optimizers import Adam"
from keras.preprocessing.image import ImageDataGenerator
from keras.callbacks import ModelCheckpoint, ReduceLROnPlateau, EarlyStopping
import tensorflow as tf
from mlxtend.plotting import plot_confusion_matrix

seed =232
np.random.seed(seed)
tf.random.set_seed(seed)


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

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.
```

```
input_path = "/content/drive/MyDrive/AI-Project/chest_xray/"

fig, ax = plt.subplots(2,3, figsize=(15, 7))
ax = ax.ravel()
plt.tight_layout()

for i, _set in enumerate(['train', 'val', 'test']):
    set_path =input_path+_set
    ax[i].imshow(plt.imread(set_path+'/NORMAL/'+os.listdir(set_path+'/NORMAL')[0]),cmap='g
    ax[i].set_title('Set: {}, Condition: Normal'.format(_set))
    ax[i+3].imshow(plt.imread(set_path+'/PNEUMONIA/'+os.listdir(set_path+'/PNEUMONIA')[0])
    ax[i+3].set_title('Set: {}, Condition: Pneumonia'.format(_set))
```




```
for _set in ['train', 'val', 'test']:
    n_normal = len(os.listdir(input_path + _set + '/NORMAL'))
    n_infect = len(os.listdir(input_path + _set + '/PNEUMONIA'))
    print('Set: {}, normal images: {}, pneumonia images: {}'.format(_set, n_normal, n_infe
```

```
 Set: train, normal images: 1341, pneumonia images: 3875
 Set: val, normal images: 8, pneumonia images: 8
 Set: test, normal images: 234, pneumonia images: 390
```

```
def process_data(img_dims, batch_size):

    # Data generation objects
    train_datagen = ImageDataGenerator(rescale=1./255, zoom_range=0.3, vertical_flip=True)
    test_val_datagen = ImageDataGenerator(rescale=1./255)

    # This is fed to the network in the specified batch sizes and image dimensions
    train_gen = train_datagen.flow_from_directory(
    directory=input_path+'train',
    target_size=(img_dims, img_dims),
    batch_size=batch_size,
    class_mode='binary',
    shuffle=True)

    test_gen = test_val_datagen.flow_from_directory(
    directory=input_path+'test',
    target_size=(img_dims, img_dims),
    batch_size=batch_size,
    class_mode='binary',
    shuffle=True)

    # I will be making predictions off of the test set in one batch size
    # This is useful to be able to get the confusion matrix
    test_data = []
    test_labels = []

    for cond in ['/NORMAL/', '/PNEUMONIA/']:
        for img in (os.listdir(input_path + 'test' + cond)):
            img = plt.imread(input_path+'test'+cond+img)
```

```
                img = cv2.resize(img, (img_dims, img_dims))
                img = np.dstack([img, img, img])
                img = img.astype('float') / 255
                if cond=='/NORMAL/':
                    label = 0;
                elif cond=='/PNEUMONIA/':
                    label = 1;
                test_data.append(img)
                test_labels.append(label)

        test_data = np.array(test_data)
        test_labels = np.array(test_labels)

        return train_gen, test_gen, test_data, test_labels

    img_dims = 150
    epochs = 10
    batch_size = 32

    train_gen, test_gen, test_data, test_labels = process_data(img_dims, batch_size)
```

```
     Found 5216 images belonging to 2 classes.
     Found 624 images belonging to 2 classes.
```

```
    inputs = Input(shape=(img_dims, img_dims, 3))

    #First conv block
    x = Conv2D(filters=16, kernel_size=(3,3), activation='relu', padding='same')(inputs)
    x = Conv2D(filters=16, kernel_size=(3,3), activation='relu', padding='same')(x)
    x = MaxPool2D(pool_size=(2,2))(x)

    #Second conv block
    x = SeparableConv2D(filters=32, kernel_size=(3,3), activation='relu', padding='same')(x)
    x = SeparableConv2D(filters=32, kernel_size=(3,3), activation='relu', padding='same')(x)
    x = BatchNormalization()(x)
    x = MaxPool2D(pool_size=(2,2))(x)

    #Third conv block
    x = SeparableConv2D(filters=64, kernel_size=(3,3), activation='relu', padding='same')(x)
    x = SeparableConv2D(filters=64, kernel_size=(3,3), activation='relu', padding='same')(x)
    x = BatchNormalization()(x)
    x = MaxPool2D(pool_size=(2,2))(x)

    #Fourth conv block
    x = SeparableConv2D(filters=128, kernel_size=(3,3), activation='relu', padding='same')(x)
    x = SeparableConv2D(filters=128, kernel_size=(3,3), activation='relu', padding='same')(x)
    x = BatchNormalization()(x)
    x = MaxPool2D(pool_size=(2,2))(x)
    x = Dropout(rate=0.2)(x)

    #Fifth conv block
    x = SeparableConv2D(filters=256, kernel_size=(3,3), activation='relu', padding='same')(x)
    x = SeparableConv2D(filters=256, kernel_size=(3,3), activation='relu', padding='same')(x)
    x = BatchNormalization()(x)
```

```
x = MaxPool2D(pool_size=(2,2))(x)
x = Dropout(rate=0.2)(x)

#FC layer
x = Flatten()(x)
x = Dense(units=512, activation='relu')(x)
x = Dropout(rate=0.7)(x)
x = Dense(units=128, activation='relu')(x)
x = Dropout(rate=0.5)(x)
x = Dense(units=64, activation='relu')(x)
x = Dropout(rate=0.3)(x)

#Output Layer
output = Dense(units = 1, activation='sigmoid')(x)

#Creating model and compiling
model = Model(inputs=inputs, outputs=output)
model.compile(optimizer='adam', loss='binary_crossentropy', metrics=['accuracy'])

#Callbacks
checkpoint = ModelCheckpoint(filepath='best_weights.hdf5', save_best_only=True, save_weigh
lr_reduce = ReduceLROnPlateau(monitor='val_loss', factor=0.3, patience=2, verbose=2, mode=
early_stop = EarlyStopping(monitor='val_loss', min_delta=0.1, patience=1, mode='min')

print(model.summary())
```

```
Model: "model"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_2 (InputLayer)        [(None, 150, 150, 3)]     0

 conv2d_2 (Conv2D)           (None, 150, 150, 16)      448

 conv2d_3 (Conv2D)           (None, 150, 150, 16)      2320

 max_pooling2d_5 (MaxPooling  (None, 75, 75, 16)       0
 2D)

 separable_conv2d_8 (Separab  (None, 75, 75, 32)       688
 leConv2D)

 separable_conv2d_9 (Separab  (None, 75, 75, 32)       1344
 leConv2D)

 batch_normalization_4 (Batc  (None, 75, 75, 32)       128
 hNormalization)

 max_pooling2d_6 (MaxPooling  (None, 37, 37, 32)       0
 2D)

 separable_conv2d_10 (Separa  (None, 37, 37, 64)       2400
 bleConv2D)

 separable_conv2d_11 (Separa  (None, 37, 37, 64)       4736
 bleConv2D)
```

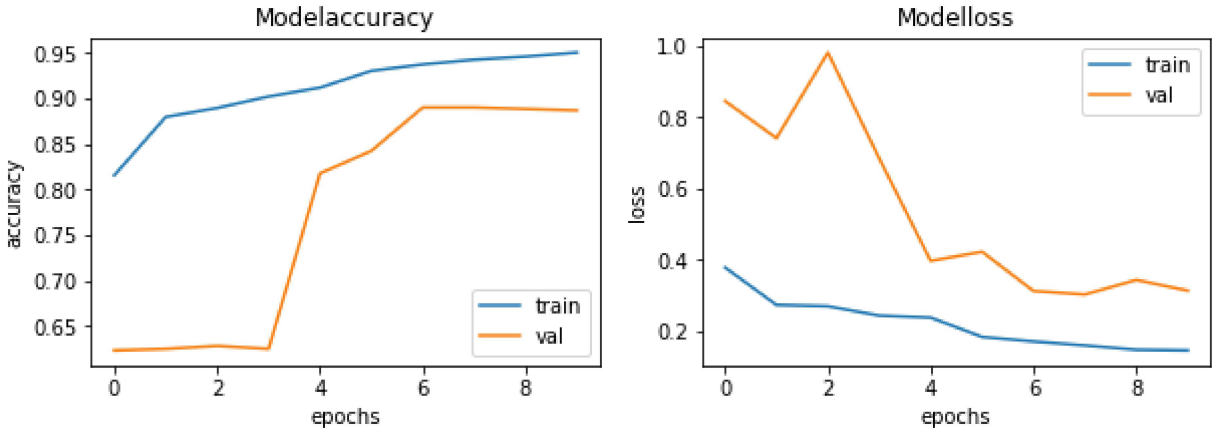
```
batch_normalization_5 (Batc  (None, 37, 37, 64)       256
hNormalization)

max_pooling2d_7 (MaxPooling  (None, 18, 18, 64)       0
2D)

separable_conv2d_12 (Separa  (None, 18, 18, 128)      8896
bleConv2D)

separable_conv2d_13 (Separa  (None, 18, 18, 128)      17664
bleConv2D)

batch_normalization_6 (Batc  (None, 18, 18, 128)      512
hNormalization)

max_pooling2d_8 (MaxPooling  (None, 9, 9, 128)        0
2D)

dropout_5 (Dropout)         (None, 9, 9, 128)         0

separable_conv2d_14 (Separa  (None, 9, 9, 256)        34176
bleConv2D)

separable_conv2d_15 (Separa  (None, 9, 9, 256)        68096
bleConv2D)
```

```
hist = model.fit_generator(
        train_gen, steps_per_epoch = train_gen.samples //batch_size,
        epochs=epochs, validation_data=test_gen,
        validation_steps=test_gen.samples //batch_size, callbacks=[checkpoint, lr_redu
```

```
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:4: UserWarning: `Model.
  after removing the cwd from sys.path.
Epoch 1/10
163/163 [==============================] - 2710s 17s/step - loss: 0.3792 - accuracy:
Epoch 2/10
163/163 [==============================] - 318s 2s/step - loss: 0.2742 - accuracy: 0
Epoch 3/10
163/163 [==============================] - 318s 2s/step - loss: 0.2707 - accuracy: 0
Epoch 4/10
163/163 [==============================] - 312s 2s/step - loss: 0.2445 - accuracy: 0
Epoch 5/10
163/163 [==============================] - ETA: 0s - loss: 0.2388 - accuracy: 0.9114
Epoch 00005: ReduceLROnPlateau reducing learning rate to 0.0003000000142492354.
163/163 [==============================] - 317s 2s/step - loss: 0.2388 - accuracy: 0
Epoch 6/10
163/163 [==============================] - 315s 2s/step - loss: 0.1848 - accuracy: 0
Epoch 7/10
163/163 [==============================] - ETA: 0s - loss: 0.1722 - accuracy: 0.9369
Epoch 00007: ReduceLROnPlateau reducing learning rate to 9.000000427477062e-05.
163/163 [==============================] - 318s 2s/step - loss: 0.1722 - accuracy: 0
Epoch 8/10
163/163 [==============================] - 319s 2s/step - loss: 0.1610 - accuracy: 0
Epoch 9/10
163/163 [==============================] - ETA: 0s - loss: 0.1490 - accuracy: 0.9456
Epoch 00009: ReduceLROnPlateau reducing learning rate to 2.700000040931627e-05.
163/163 [==============================] - 316s 2s/step - loss: 0.1490 - accuracy: 0
```

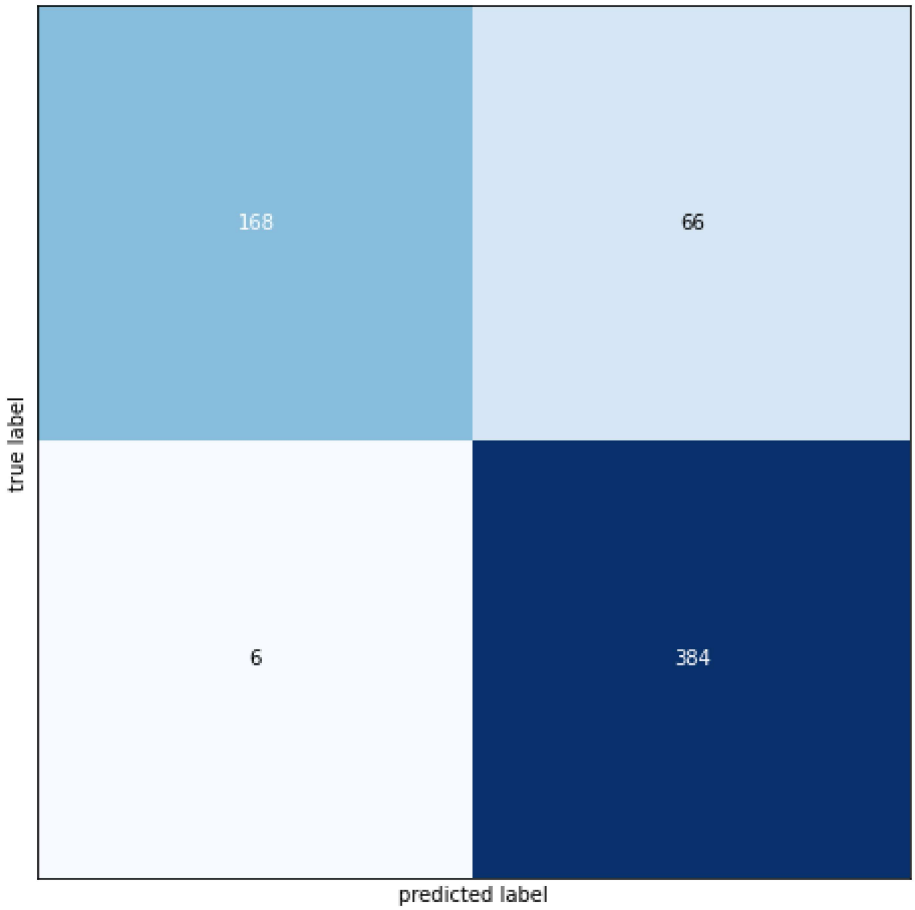
```
Epoch 10/10
163/163 [==============================] - 314s 2s/step - loss: 0.1472 - accuracy: 0
```

```
fig, ax = plt.subplots(1,2, figsize=(10,3))
ax = ax.ravel()

for i, met in enumerate(['accuracy', 'loss']):
    ax[i].plot(hist.history[met])
    ax[i].plot(hist.history['val_' + met])
    ax[i].set_title('Model{}'.format(met))
    ax[i].set_xlabel('epochs')
    ax[i].set_ylabel(met)
    ax[i].legend(['train', 'val'])
```




```
from sklearn.metrics import accuracy_score, confusion_matrix

preds = model.predict(test_data)

accuracy = accuracy_score(test_labels, np.round(preds))*100
cm = confusion_matrix(test_labels, np.round(preds))
tn, fp, fn, tp = cm.ravel()


print('---------------CONFUSION MATRIX---------------')

fig, ax = plot_confusion_matrix(conf_mat=cm, figsize=(10,8), hide_ticks=True, cmap=plt.cm.
plt.show()

print('\n---------------TRAIN METRIC---------------')
print('Train accuracy: {}'.format(np.round((hist.history['accuracy'][-1])*100,2)))

print('\n---------------TEST METRIC---------------')
precision = tp/(tp+fp)*100
recall = tp/(tp+fn)*100
print('Accuracy: {}%'.format(accuracy))
print('Precision: {}%'.format(precision))
print('Recall: {}%'.format(recall))
print('F1-score: {}'.format(2*precision*recall/(precision+recall)))
```

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




```
---------------TRAIN METRIC---------------
Train accuracy: 95.0

---------------TEST METRIC---------------
Accuracy: 88.46153846153845%
Precision: 85.33333333333334%
Recall: 98.46153846153847%
F1-score: 91.42857142857143
```

✓ 7s completed at 5:23 PM