In [1]:
```
# Import libraries
import os,cv2
import time
import numpy as np
import matplotlib.pyplot as plt

from sklearn.utils import shuffle
from sklearn.model_selection import train_test_split
from keras.preprocessing import image
from keras.utils import np_utils
from keras.models import Sequential
from keras.layers import Input
from keras.layers.core import Dense, Dropout, Activation, Flatten
from keras.layers.convolutional import Convolution2D, MaxPooling2D
from keras import callbacks
from keras import backend as K
K.set_image_data_format('channels_last')
from sklearn.metrics import classification_report,confusion_matrix
import itertools
from keras.models import Model
# from tensorflow.keras.applications.resnet import ResNet50
# from tensorflow.keras.applications.inception_v3 import InceptionV3
# from tensorflow.keras.applications.mobilenet import MobileNet
# from tensorflow.keras.applications.vgg19 import VGG19
from tensorflow.keras.applications.mobilenet_v2 import MobileNetV2
from tensorflow.keras.applications.inception_v3 import decode_predictions
```

Set path for application

In [2]:
```
data_path = 'D:/Harold/MyDNN/DataSet/Chest_xray_seperate'
data_dir_list = os.listdir(data_path)
print(data_path)
```

```
D:/Harold/MyDNN/DataSet/Chest_xray_seperate
```

Set Image Size and Epocs

In [3]:
```
img_rows=128
img_cols=128
num_channel=3
num_epoch=100
```

Define the number of classes

In [4]:
```
num_classes = 2

img_data_list=[]
```

In [5]:
```
def preprocess_input(x):
    x[:, :, :, 0] -= 103.939
    x[:, :, :, 1] -= 116.779
    x[:, :, :, 2] -= 123.68
    # 'RGB'->'BGR'
    x = x[:, :, :, ::-1]
    return x

def data_preperation():
    for dataset in data_dir_list:
        img_list=os.listdir(data_path+'/'+ dataset)
        print ('Loading the images of dataset-'+'{}\n'.format(dataset))
        for img in img_list:
            img_path = data_path + '/'+ dataset + '/'+ img
            img = image.load_img(img_path, target_size=(224, 224))
            x = image.img_to_array(img)
            x = np.expand_dims(x, axis=0)
            x = preprocess_input(x)
#             print('Input image shape:', x.shape)
            img_data_list.append(x)
        print('Loading Complete')

#     for dataset in data_dir_list:
#         img_list=os.listdir(data_path+'/'+ dataset)
#         print ('Loading the images of dataset-'+'{}\n'.format(dataset))
#         for img in img_list:
#             img_path = data_path + '/'+ dataset + '/'+ img
#             img = image.load_img(img_path, target_size=(224, 224))
#             x = image.img_to_array(img)
#             x = np.expand_dims(x, axis=0)
#             x = preprocess_input(x)
# #             print('Input image shape:', x.shape)
#             img_data_list.append(x)
#         print('Loading Complete')

def display_loss_accuracy(hist):
    train_loss=hist.history['loss']
    val_loss=hist.history['val_loss']
    train_acc=hist.history['accuracy']
    val_acc=hist.history['val_accuracy']
    xc=range(num_epoch)

    plt.figure(1,figsize=(7,5))
    plt.plot(xc,train_loss)
    plt.plot(xc,val_loss)
    plt.xlabel('num of Epochs')
    plt.ylabel('loss')
    plt.title('train_loss vs val_loss')
    plt.grid(True)
    plt.legend(['train','val'])
    #print plt.style.available # use bmh, classic,ggplot for big pictures
    plt.style.use(['classic'])

    plt.figure(2,figsize=(7,5))
    plt.plot(xc,train_acc)
    plt.plot(xc,val_acc)
    plt.xlabel('num of Epochs')
    plt.ylabel('accuracy')
    plt.title('train_acc vs val_acc')
    plt.grid(True)
    plt.legend(['train','val'],loc=4)
    #print plt.style.available # use bmh, classic,ggplot for big pictures
    plt.style.use(['classic'])
```

```
def get_featuremaps(model, layer_idx, X_batch):
    get_activations = K.function([model.layers[0].input, K.learning_phase()],[mode
l.layers[layer_idx].output,])
    activations = get_activations([X_batch,0])
    return activations

def plot_featuremap_activations(activations):
    print (np.shape(activations))
    feature_maps = activations[0][0]
    print (np.shape(feature_maps))
    print (feature_maps.shape)

    fig=plt.figure(figsize=(16,16))
    plt.imshow(feature_maps[:,:,filter_num],cmap='gray')
    plt.savefig("featuremaps-layer-{}".format(layer_num) + "-filternum-{}".format(f
ilter_num)+'.jpg')

    num_of_featuremaps=feature_maps.shape[2]
    fig=plt.figure(figsize=(16,16))
    plt.title("featuremaps-layer-{}".format(layer_num))
    subplot_num=int(np.ceil(np.sqrt(num_of_featuremaps)))
    for i in range(int(num_of_featuremaps)):
        ax = fig.add_subplot(subplot_num, subplot_num, i+1)
        #ax.imshow(output_image[0,:,:,i],interpolation='nearest' ) #to see the firs
t filter
        ax.imshow(feature_maps[:,:,i],cmap='gray')
        plt.xticks([])
        plt.yticks([])
        plt.tight_layout()
    plt.show()
    fig.savefig("featuremaps-layer-{}".format(layer_num) + '.jpg')

# Plotting the confusion matrix
def plot_confusion_matrix(cm, classes,
                          normalize=False,
                          title='Confusion matrix',
                          cmap=plt.cm.Blues):
    """
    This function prints and plots the confusion matrix.
    Normalization can be applied by setting `normalize=True`.
    """
    plt.figure()
    plt.imshow(cm, interpolation='nearest', cmap=cmap)
    plt.title(title)
    plt.colorbar()
    tick_marks = np.arange(len(classes))
    plt.xticks(tick_marks, classes, rotation=45)
    plt.yticks(tick_marks, classes)

    if normalize:
        cm = cm.astype('float') / cm.sum(axis=1)[:, np.newaxis]
        print("Normalized confusion matrix")
    else:
        print('Confusion matrix, without normalization')

    print(cm)

    thresh = cm.max() / 2.
    for i, j in itertools.product(range(cm.shape[0]), range(cm.shape[1])):
        plt.text(j, i, cm[i, j],
                 horizontalalignment="center",
                 color="white" if cm[i, j] > thresh else "black")
```

```
    plt.tight_layout()
    plt.ylabel('True label')
    plt.xlabel('Predicted label')
    plt.show()
```

Data Preperation

In [6]:
```
# Calling Data Preperation
data_preperation()
```

```
Loading the images of dataset-NORMAL

Loading Complete
Loading the images of dataset-PNEUMONIA

Loading Complete
```

In [7]:
```
print (len(img_data_list))
img_data = np.array(img_data_list)
#img_data = img_data.astype('float32')
print (img_data.shape)
img_data=np.rollaxis(img_data,1,0)
print (img_data.shape)
img_data=img_data[0]
print (img_data.shape)
```

```
5856
(5856, 1, 224, 224, 3)
(1, 5856, 224, 224, 3)
(5856, 224, 224, 3)
```

Assiging Labels

In [8]:
```
num_of_samples = img_data.shape[0]
labels = np.ones((num_of_samples,),dtype='int64')

labels[0:1582]=0
labels[1583:5856]=1

names = ['normal','pneumonia']
```

Creating clasas labels to one-hot encoding

In [9]:
```
# convert class labels to on-hot encoding
Y = np_utils.to_categorical(labels, num_classes)
```

Split Data set into training and validation set

In [10]:
```
#Shuffle the dataset
x,y = shuffle(img_data,Y, random_state=2)
# Split the dataset
X_train, X_test, y_train, y_test = train_test_split(x, y, test_size=0.2, random_sta
te=2)
```

Model Definition

Training the classifier alone

In [11]:
```
image_input = Input(shape=(224, 224, 3))
model = MobileNetV2(input_tensor=image_input, include_top=True,weights='imagenet')
model.summary()
output_layer = model(image_input)

# last_layer = model.get_layer('avg_pool').output
x= Flatten(name='flatten')(output_layer)
out = Dense(num_classes, activation='softmax', name='output_layer')(x)
custom_resnet_model = Model(inputs=image_input,outputs= out)
custom_resnet_model.summary()
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-applicatio
ns/mobilenet_v2/mobilenet_v2_weights_tf_dim_ordering_tf_kernels_1.0_224.h5
14540800/14536120 [==============================] - 1s 0us/step
Model: "mobilenetv2_1.00_224"
________________________________________________________________________________
__________________
Layer (type)                    Output Shape         Param #     Connected to
================================================================================
==================
input_1 (InputLayer)            [(None, 224, 224, 3) 0
________________________________________________________________________________
__________________
Conv1_pad (ZeroPadding2D)       (None, 225, 225, 3)  0           input_1[0][0]
________________________________________________________________________________
__________________
Conv1 (Conv2D)                  (None, 112, 112, 32) 864         Conv1_pad[0][0]
________________________________________________________________________________
__________________
bn_Conv1 (BatchNormalization)   (None, 112, 112, 32) 128         Conv1[0][0]
________________________________________________________________________________
__________________
Conv1_relu (ReLU)               (None, 112, 112, 32) 0           bn_Conv1[0][0]
________________________________________________________________________________
__________________
expanded_conv_depthwise (Depthw (None, 112, 112, 32) 288         Conv1_relu
[0][0]
________________________________________________________________________________
__________________
expanded_conv_depthwise_BN (Bat (None, 112, 112, 32) 128         expanded_conv_d
epthwise[0][0]
________________________________________________________________________________
__________________
expanded_conv_depthwise_relu (R (None, 112, 112, 32) 0           expanded_conv_d
epthwise_BN[0][0]
________________________________________________________________________________
__________________
expanded_conv_project (Conv2D)  (None, 112, 112, 16) 512         expanded_conv_d
epthwise_relu[0][0
________________________________________________________________________________
__________________
expanded_conv_project_BN (Batch (None, 112, 112, 16) 64          expanded_conv_p
roject[0][0]
________________________________________________________________________________
__________________
block_1_expand (Conv2D)         (None, 112, 112, 96) 1536        expanded_conv_p
roject_BN[0][0]
________________________________________________________________________________
__________________
block_1_expand_BN (BatchNormali (None, 112, 112, 96) 384         block_1_expand
[0][0]
________________________________________________________________________________
__________________
block_1_expand_relu (ReLU)      (None, 112, 112, 96) 0           block_1_expand_
BN[0][0]
________________________________________________________________________________
__________________
block_1_pad (ZeroPadding2D)     (None, 113, 113, 96) 0           block_1_expand_
relu[0][0]
________________________________________________________________________________
__________________
block_1_depthwise (DepthwiseCon (None, 56, 56, 96)   864         block_1_pad
[0][0]
________________________________________________________________________________
```

```
__________________
block_1_depthwise_BN (BatchNorm (None, 56, 56, 96)   384         block_1_depthwi
se[0][0]
________________________________________________________________________________
__________________
block_1_depthwise_relu (ReLU)   (None, 56, 56, 96)   0           block_1_depthwi
se_BN[0][0]
________________________________________________________________________________
__________________
block_1_project (Conv2D)        (None, 56, 56, 24)   2304        block_1_depthwi
se_relu[0][0]
________________________________________________________________________________
__________________
block_1_project_BN (BatchNormal (None, 56, 56, 24)   96          block_1_project
[0][0]
________________________________________________________________________________
__________________
block_2_expand (Conv2D)         (None, 56, 56, 144)  3456        block_1_project
_BN[0][0]
________________________________________________________________________________
__________________
block_2_expand_BN (BatchNormali (None, 56, 56, 144)  576         block_2_expand
[0][0]
________________________________________________________________________________
__________________
block_2_expand_relu (ReLU)      (None, 56, 56, 144)  0           block_2_expand_
BN[0][0]
________________________________________________________________________________
__________________
block_2_depthwise (DepthwiseCon (None, 56, 56, 144)  1296        block_2_expand_
relu[0][0]
________________________________________________________________________________
__________________
block_2_depthwise_BN (BatchNorm (None, 56, 56, 144)  576         block_2_depthwi
se[0][0]
________________________________________________________________________________
__________________
block_2_depthwise_relu (ReLU)   (None, 56, 56, 144)  0           block_2_depthwi
se_BN[0][0]
________________________________________________________________________________
__________________
block_2_project (Conv2D)        (None, 56, 56, 24)   3456        block_2_depthwi
se_relu[0][0]
________________________________________________________________________________
__________________
block_2_project_BN (BatchNormal (None, 56, 56, 24)   96          block_2_project
[0][0]
________________________________________________________________________________
__________________
block_2_add (Add)               (None, 56, 56, 24)   0           block_1_project
_BN[0][0]
                                                                 block_2_project
_BN[0][0]
________________________________________________________________________________
__________________
block_3_expand (Conv2D)         (None, 56, 56, 144)  3456        block_2_add
[0][0]
________________________________________________________________________________
__________________
block_3_expand_BN (BatchNormali (None, 56, 56, 144)  576         block_3_expand
[0][0]
________________________________________________________________________________
__________________
block_3_expand_relu (ReLU)      (None, 56, 56, 144)  0           block_3_expand_
```

```
BN[0][0]
__________________________________________________________________________________________________
block_3_pad (ZeroPadding2D)     (None, 57, 57, 144)  0           block_3_expand_relu[0][0]
__________________________________________________________________________________________________
block_3_depthwise (DepthwiseCon (None, 28, 28, 144)  1296        block_3_pad[0][0]
__________________________________________________________________________________________________
block_3_depthwise_BN (BatchNorm (None, 28, 28, 144)  576         block_3_depthwise[0][0]
__________________________________________________________________________________________________
block_3_depthwise_relu (ReLU)   (None, 28, 28, 144)  0           block_3_depthwise_BN[0][0]
__________________________________________________________________________________________________
block_3_project (Conv2D)        (None, 28, 28, 32)   4608        block_3_depthwise_relu[0][0]
__________________________________________________________________________________________________
block_3_project_BN (BatchNormal (None, 28, 28, 32)   128         block_3_project[0][0]
__________________________________________________________________________________________________
block_4_expand (Conv2D)         (None, 28, 28, 192)  6144        block_3_project_BN[0][0]
__________________________________________________________________________________________________
block_4_expand_BN (BatchNormali (None, 28, 28, 192)  768         block_4_expand[0][0]
__________________________________________________________________________________________________
block_4_expand_relu (ReLU)      (None, 28, 28, 192)  0           block_4_expand_BN[0][0]
__________________________________________________________________________________________________
block_4_depthwise (DepthwiseCon (None, 28, 28, 192)  1728        block_4_expand_relu[0][0]
__________________________________________________________________________________________________
block_4_depthwise_BN (BatchNorm (None, 28, 28, 192)  768         block_4_depthwise[0][0]
__________________________________________________________________________________________________
block_4_depthwise_relu (ReLU)   (None, 28, 28, 192)  0           block_4_depthwise_BN[0][0]
__________________________________________________________________________________________________
block_4_project (Conv2D)        (None, 28, 28, 32)   6144        block_4_depthwise_relu[0][0]
__________________________________________________________________________________________________
block_4_project_BN (BatchNormal (None, 28, 28, 32)   128         block_4_project[0][0]
__________________________________________________________________________________________________
block_4_add (Add)               (None, 28, 28, 32)   0           block_3_project_BN[0][0]
                                                                 block_4_project_BN[0][0]
__________________________________________________________________________________________________
```

```
__________________
block_5_expand (Conv2D)         (None, 28, 28, 192)  6144        block_4_add
[0][0]
__________________________________________________________________________________
__________________
block_5_expand_BN (BatchNormali (None, 28, 28, 192)  768         block_5_expand
[0][0]
__________________________________________________________________________________
__________________
block_5_expand_relu (ReLU)      (None, 28, 28, 192)  0           block_5_expand_
BN[0][0]
__________________________________________________________________________________
__________________
block_5_depthwise (DepthwiseCon (None, 28, 28, 192)  1728        block_5_expand_
relu[0][0]
__________________________________________________________________________________
__________________
block_5_depthwise_BN (BatchNorm (None, 28, 28, 192)  768         block_5_depthwi
se[0][0]
__________________________________________________________________________________
__________________
block_5_depthwise_relu (ReLU)   (None, 28, 28, 192)  0           block_5_depthwi
se_BN[0][0]
__________________________________________________________________________________
__________________
block_5_project (Conv2D)        (None, 28, 28, 32)   6144        block_5_depthwi
se_relu[0][0]
__________________________________________________________________________________
__________________
block_5_project_BN (BatchNormal (None, 28, 28, 32)   128         block_5_project
[0][0]
__________________________________________________________________________________
__________________
block_5_add (Add)               (None, 28, 28, 32)   0           block_4_add
[0][0]
                                                                 block_5_project
_BN[0][0]
__________________________________________________________________________________
__________________
block_6_expand (Conv2D)         (None, 28, 28, 192)  6144        block_5_add
[0][0]
__________________________________________________________________________________
__________________
block_6_expand_BN (BatchNormali (None, 28, 28, 192)  768         block_6_expand
[0][0]
__________________________________________________________________________________
__________________
block_6_expand_relu (ReLU)      (None, 28, 28, 192)  0           block_6_expand_
BN[0][0]
__________________________________________________________________________________
__________________
block_6_pad (ZeroPadding2D)     (None, 29, 29, 192)  0           block_6_expand_
relu[0][0]
__________________________________________________________________________________
__________________
block_6_depthwise (DepthwiseCon (None, 14, 14, 192)  1728        block_6_pad
[0][0]
__________________________________________________________________________________
__________________
block_6_depthwise_BN (BatchNorm (None, 14, 14, 192)  768         block_6_depthwi
se[0][0]
__________________________________________________________________________________
__________________
block_6_depthwise_relu (ReLU)   (None, 14, 14, 192)  0           block_6_depthwi
```

```
se_BN[0][0]
__________________________________________________________________________________________________
block_6_project (Conv2D)        (None, 14, 14, 64)   12288       block_6_depthwise_relu[0][0]
__________________________________________________________________________________________________
block_6_project_BN (BatchNormal (None, 14, 14, 64)   256         block_6_project[0][0]
__________________________________________________________________________________________________
block_7_expand (Conv2D)         (None, 14, 14, 384)  24576       block_6_project_BN[0][0]
__________________________________________________________________________________________________
block_7_expand_BN (BatchNormali (None, 14, 14, 384)  1536        block_7_expand[0][0]
__________________________________________________________________________________________________
block_7_expand_relu (ReLU)      (None, 14, 14, 384)  0           block_7_expand_BN[0][0]
__________________________________________________________________________________________________
block_7_depthwise (DepthwiseCon (None, 14, 14, 384)  3456        block_7_expand_relu[0][0]
__________________________________________________________________________________________________
block_7_depthwise_BN (BatchNorm (None, 14, 14, 384)  1536        block_7_depthwise[0][0]
__________________________________________________________________________________________________
block_7_depthwise_relu (ReLU)   (None, 14, 14, 384)  0           block_7_depthwise_BN[0][0]
__________________________________________________________________________________________________
block_7_project (Conv2D)        (None, 14, 14, 64)   24576       block_7_depthwise_relu[0][0]
__________________________________________________________________________________________________
block_7_project_BN (BatchNormal (None, 14, 14, 64)   256         block_7_project[0][0]
__________________________________________________________________________________________________
block_7_add (Add)               (None, 14, 14, 64)   0           block_6_project_BN[0][0]
                                                                 block_7_project_BN[0][0]
__________________________________________________________________________________________________
block_8_expand (Conv2D)         (None, 14, 14, 384)  24576       block_7_add[0][0]
__________________________________________________________________________________________________
block_8_expand_BN (BatchNormali (None, 14, 14, 384)  1536        block_8_expand[0][0]
__________________________________________________________________________________________________
block_8_expand_relu (ReLU)      (None, 14, 14, 384)  0           block_8_expand_BN[0][0]
__________________________________________________________________________________________________
block_8_depthwise (DepthwiseCon (None, 14, 14, 384)  3456        block_8_expand_relu[0][0]
__________________________________________________________________________________________________
```

```
__________________
block_8_depthwise_BN (BatchNorm (None, 14, 14, 384)  1536        block_8_depthwi
se[0][0]
________________________________________________________________________________
__________________
block_8_depthwise_relu (ReLU)   (None, 14, 14, 384)  0           block_8_depthwi
se_BN[0][0]
________________________________________________________________________________
__________________
block_8_project (Conv2D)        (None, 14, 14, 64)   24576       block_8_depthwi
se_relu[0][0]
________________________________________________________________________________
__________________
block_8_project_BN (BatchNormal (None, 14, 14, 64)   256         block_8_project
[0][0]
________________________________________________________________________________
__________________
block_8_add (Add)               (None, 14, 14, 64)   0           block_7_add
[0][0]
                                                                 block_8_project
_BN[0][0]
________________________________________________________________________________
__________________
block_9_expand (Conv2D)         (None, 14, 14, 384)  24576       block_8_add
[0][0]
________________________________________________________________________________
__________________
block_9_expand_BN (BatchNormali (None, 14, 14, 384)  1536        block_9_expand
[0][0]
________________________________________________________________________________
__________________
block_9_expand_relu (ReLU)      (None, 14, 14, 384)  0           block_9_expand_
BN[0][0]
________________________________________________________________________________
__________________
block_9_depthwise (DepthwiseCon (None, 14, 14, 384)  3456        block_9_expand_
relu[0][0]
________________________________________________________________________________
__________________
block_9_depthwise_BN (BatchNorm (None, 14, 14, 384)  1536        block_9_depthwi
se[0][0]
________________________________________________________________________________
__________________
block_9_depthwise_relu (ReLU)   (None, 14, 14, 384)  0           block_9_depthwi
se_BN[0][0]
________________________________________________________________________________
__________________
block_9_project (Conv2D)        (None, 14, 14, 64)   24576       block_9_depthwi
se_relu[0][0]
________________________________________________________________________________
__________________
block_9_project_BN (BatchNormal (None, 14, 14, 64)   256         block_9_project
[0][0]
________________________________________________________________________________
__________________
block_9_add (Add)               (None, 14, 14, 64)   0           block_8_add
[0][0]
                                                                 block_9_project
_BN[0][0]
________________________________________________________________________________
__________________
block_10_expand (Conv2D)        (None, 14, 14, 384)  24576       block_9_add
[0][0]
________________________________________________________________________________
```

```
__________________
block_10_expand_BN (BatchNormal (None, 14, 14, 384)  1536        block_10_expand
[0][0]
__________________________________________________________________________________
__________________
block_10_expand_relu (ReLU)     (None, 14, 14, 384)  0           block_10_expand
_BN[0][0]
__________________________________________________________________________________
__________________
block_10_depthwise (DepthwiseCo (None, 14, 14, 384)  3456        block_10_expand
_relu[0][0]
__________________________________________________________________________________
__________________
block_10_depthwise_BN (BatchNor (None, 14, 14, 384)  1536        block_10_depthw
ise[0][0]
__________________________________________________________________________________
__________________
block_10_depthwise_relu (ReLU)  (None, 14, 14, 384)  0           block_10_depthw
ise_BN[0][0]
__________________________________________________________________________________
__________________
block_10_project (Conv2D)       (None, 14, 14, 96)   36864       block_10_depthw
ise_relu[0][0]
__________________________________________________________________________________
__________________
block_10_project_BN (BatchNorma (None, 14, 14, 96)   384         block_10_projec
t[0][0]
__________________________________________________________________________________
__________________
block_11_expand (Conv2D)        (None, 14, 14, 576)  55296       block_10_projec
t_BN[0][0]
__________________________________________________________________________________
__________________
block_11_expand_BN (BatchNormal (None, 14, 14, 576)  2304        block_11_expand
[0][0]
__________________________________________________________________________________
__________________
block_11_expand_relu (ReLU)     (None, 14, 14, 576)  0           block_11_expand
_BN[0][0]
__________________________________________________________________________________
__________________
block_11_depthwise (DepthwiseCo (None, 14, 14, 576)  5184        block_11_expand
_relu[0][0]
__________________________________________________________________________________
__________________
block_11_depthwise_BN (BatchNor (None, 14, 14, 576)  2304        block_11_depthw
ise[0][0]
__________________________________________________________________________________
__________________
block_11_depthwise_relu (ReLU)  (None, 14, 14, 576)  0           block_11_depthw
ise_BN[0][0]
__________________________________________________________________________________
__________________
block_11_project (Conv2D)       (None, 14, 14, 96)   55296       block_11_depthw
ise_relu[0][0]
__________________________________________________________________________________
__________________
block_11_project_BN (BatchNorma (None, 14, 14, 96)   384         block_11_projec
t[0][0]
__________________________________________________________________________________
__________________
block_11_add (Add)              (None, 14, 14, 96)   0           block_10_projec
t_BN[0][0]

                                                                 block_11_projec
```

```
t_BN[0][0]
________________________________________________________________________________
__________________
block_12_expand (Conv2D)        (None, 14, 14, 576)  55296       block_11_add
[0][0]
________________________________________________________________________________
__________________
block_12_expand_BN (BatchNormal (None, 14, 14, 576)  2304        block_12_expand
[0][0]
________________________________________________________________________________
__________________
block_12_expand_relu (ReLU)     (None, 14, 14, 576)  0           block_12_expand
_BN[0][0]
________________________________________________________________________________
__________________
block_12_depthwise (DepthwiseCo (None, 14, 14, 576)  5184        block_12_expand
_relu[0][0]
________________________________________________________________________________
__________________
block_12_depthwise_BN (BatchNor (None, 14, 14, 576)  2304        block_12_depthw
ise[0][0]
________________________________________________________________________________
__________________
block_12_depthwise_relu (ReLU)  (None, 14, 14, 576)  0           block_12_depthw
ise_BN[0][0]
________________________________________________________________________________
__________________
block_12_project (Conv2D)       (None, 14, 14, 96)   55296       block_12_depthw
ise_relu[0][0]
________________________________________________________________________________
__________________
block_12_project_BN (BatchNorma (None, 14, 14, 96)   384         block_12_projec
t[0][0]
________________________________________________________________________________
__________________
block_12_add (Add)              (None, 14, 14, 96)   0           block_11_add
[0][0]
                                                                 block_12_projec
t_BN[0][0]
________________________________________________________________________________
__________________
block_13_expand (Conv2D)        (None, 14, 14, 576)  55296       block_12_add
[0][0]
________________________________________________________________________________
__________________
block_13_expand_BN (BatchNormal (None, 14, 14, 576)  2304        block_13_expand
[0][0]
________________________________________________________________________________
__________________
block_13_expand_relu (ReLU)     (None, 14, 14, 576)  0           block_13_expand
_BN[0][0]
________________________________________________________________________________
__________________
block_13_pad (ZeroPadding2D)    (None, 15, 15, 576)  0           block_13_expand
_relu[0][0]
________________________________________________________________________________
__________________
block_13_depthwise (DepthwiseCo (None, 7, 7, 576)    5184        block_13_pad
[0][0]
________________________________________________________________________________
__________________
block_13_depthwise_BN (BatchNor (None, 7, 7, 576)    2304        block_13_depthw
ise[0][0]
________________________________________________________________________________
```

```
__________________
block_13_depthwise_relu (ReLU)  (None, 7, 7, 576)    0           block_13_depthw
ise_BN[0][0]

________________________________________________________________________________
__________________
block_13_project (Conv2D)       (None, 7, 7, 160)    92160       block_13_depthw
ise_relu[0][0]

________________________________________________________________________________
__________________
block_13_project_BN (BatchNorma (None, 7, 7, 160)    640         block_13_projec
t[0][0]

________________________________________________________________________________
__________________
block_14_expand (Conv2D)        (None, 7, 7, 960)    153600      block_13_projec
t_BN[0][0]

________________________________________________________________________________
__________________
block_14_expand_BN (BatchNormal (None, 7, 7, 960)    3840        block_14_expand
[0][0]

________________________________________________________________________________
__________________
block_14_expand_relu (ReLU)     (None, 7, 7, 960)    0           block_14_expand
_BN[0][0]

________________________________________________________________________________
__________________
block_14_depthwise (DepthwiseCo (None, 7, 7, 960)    8640        block_14_expand
_relu[0][0]

________________________________________________________________________________
__________________
block_14_depthwise_BN (BatchNor (None, 7, 7, 960)    3840        block_14_depthw
ise[0][0]

________________________________________________________________________________
__________________
block_14_depthwise_relu (ReLU)  (None, 7, 7, 960)    0           block_14_depthw
ise_BN[0][0]

________________________________________________________________________________
__________________
block_14_project (Conv2D)       (None, 7, 7, 160)    153600      block_14_depthw
ise_relu[0][0]

________________________________________________________________________________
__________________
block_14_project_BN (BatchNorma (None, 7, 7, 160)    640         block_14_projec
t[0][0]

________________________________________________________________________________
__________________
block_14_add (Add)              (None, 7, 7, 160)    0           block_13_projec
t_BN[0][0]
                                                                 block_14_projec
t_BN[0][0]

________________________________________________________________________________
__________________
block_15_expand (Conv2D)        (None, 7, 7, 960)    153600      block_14_add
[0][0]

________________________________________________________________________________
__________________
block_15_expand_BN (BatchNormal (None, 7, 7, 960)    3840        block_15_expand
[0][0]

________________________________________________________________________________
__________________
block_15_expand_relu (ReLU)     (None, 7, 7, 960)    0           block_15_expand
_BN[0][0]

________________________________________________________________________________
__________________
block_15_depthwise (DepthwiseCo (None, 7, 7, 960)    8640        block_15_expand
```

```
_relu[0][0]
__________________________________________________________________________________________________
block_15_depthwise_BN (BatchNor (None, 7, 7, 960)    3840        block_15_depthwise[0][0]
__________________________________________________________________________________________________
block_15_depthwise_relu (ReLU)  (None, 7, 7, 960)    0           block_15_depthwise_BN[0][0]
__________________________________________________________________________________________________
block_15_project (Conv2D)       (None, 7, 7, 160)    153600      block_15_depthwise_relu[0][0]
__________________________________________________________________________________________________
block_15_project_BN (BatchNorma (None, 7, 7, 160)    640         block_15_project[0][0]
__________________________________________________________________________________________________
block_15_add (Add)              (None, 7, 7, 160)    0           block_14_add[0][0]
                                                                 block_15_project_BN[0][0]
__________________________________________________________________________________________________
block_16_expand (Conv2D)        (None, 7, 7, 960)    153600      block_15_add[0][0]
__________________________________________________________________________________________________
block_16_expand_BN (BatchNormal (None, 7, 7, 960)    3840        block_16_expand[0][0]
__________________________________________________________________________________________________
block_16_expand_relu (ReLU)     (None, 7, 7, 960)    0           block_16_expand_BN[0][0]
__________________________________________________________________________________________________
block_16_depthwise (DepthwiseCo (None, 7, 7, 960)    8640        block_16_expand_relu[0][0]
__________________________________________________________________________________________________
block_16_depthwise_BN (BatchNor (None, 7, 7, 960)    3840        block_16_depthwise[0][0]
__________________________________________________________________________________________________
block_16_depthwise_relu (ReLU)  (None, 7, 7, 960)    0           block_16_depthwise_BN[0][0]
__________________________________________________________________________________________________
block_16_project (Conv2D)       (None, 7, 7, 320)    307200      block_16_depthwise_relu[0][0]
__________________________________________________________________________________________________
block_16_project_BN (BatchNorma (None, 7, 7, 320)    1280        block_16_project[0][0]
__________________________________________________________________________________________________
Conv_1 (Conv2D)                 (None, 7, 7, 1280)   409600      block_16_project_BN[0][0]
__________________________________________________________________________________________________
Conv_1_bn (BatchNormalization)  (None, 7, 7, 1280)   5120        Conv_1[0][0]
__________________________________________________________________________________________________
```

```
out_relu (ReLU)                 (None, 7, 7, 1280)   0           Conv_1_bn[0][0]
________________________________________________________________________________
__________________
global_average_pooling2d (Globa (None, 1280)         0           out_relu[0][0]
________________________________________________________________________________
__________________
predictions (Dense)             (None, 1000)         1281000     global_average_
pooling2d[0][0]
================================================================================
==================
Total params: 3,538,984
Trainable params: 3,504,872
Non-trainable params: 34,112
________________________________________________________________________________
__________________
Model: "functional_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
input_1 (InputLayer)         [(None, 224, 224, 3)]     0
_________________________________________________________________
mobilenetv2_1.00_224 (Functi (None, 1000)              3538984
_________________________________________________________________
flatten (Flatten)            (None, 1000)              0
_________________________________________________________________
output_layer (Dense)         (None, 2)                 2002
=================================================================
```

In [12]:

```
for layer in custom_resnet_model.layers[:-1]:
    layer.trainable = False

custom_resnet_model.layers[-1].trainable
```

Out[12]:

```
True
```

In [13]:

```
custom_resnet_model.compile(loss='categorical_crossentropy',optimizer='adam',metric
s=['accuracy'])
```

In [14]:
```
t = time.time()
hist = custom_resnet_model.fit(X_train, y_train, batch_size=32, epochs=num_epoch, v
erbose=1, validation_data=(X_test, y_test))
print('Training time: %s' % (t - time.time()))
(loss, accuracy) = custom_resnet_model.evaluate(X_test, y_test, batch_size=10, verb
ose=1)
print("[INFO] loss={:.4f}, accuracy: {:.4f}%".format(loss,accuracy * 100))
```

```
Epoch 1/100
147/147 [==============================] - 7s 48ms/step - loss: 0.6437 - accurac
y: 0.7252 - val_loss: 0.6028 - val_accuracy: 0.7338
Epoch 2/100
147/147 [==============================] - 6s 41ms/step - loss: 0.5841 - accurac
y: 0.7289 - val_loss: 0.5623 - val_accuracy: 0.7338
Epoch 3/100
147/147 [==============================] - 6s 41ms/step - loss: 0.5552 - accurac
y: 0.7289 - val_loss: 0.5391 - val_accuracy: 0.7338
Epoch 4/100
147/147 [==============================] - 6s 41ms/step - loss: 0.5367 - accurac
y: 0.7293 - val_loss: 0.5222 - val_accuracy: 0.7338
Epoch 5/100
147/147 [==============================] - 6s 41ms/step - loss: 0.5217 - accurac
y: 0.7312 - val_loss: 0.5073 - val_accuracy: 0.7398
Epoch 6/100
147/147 [==============================] - 6s 41ms/step - loss: 0.5084 - accurac
y: 0.7340 - val_loss: 0.4940 - val_accuracy: 0.7406
Epoch 7/100
147/147 [==============================] - 6s 41ms/step - loss: 0.4961 - accurac
y: 0.7376 - val_loss: 0.4815 - val_accuracy: 0.7449
Epoch 8/100
147/147 [==============================] - 6s 41ms/step - loss: 0.4846 - accurac
y: 0.7427 - val_loss: 0.4699 - val_accuracy: 0.7517
Epoch 9/100
147/147 [==============================] - 6s 41ms/step - loss: 0.4740 - accurac
y: 0.7487 - val_loss: 0.4591 - val_accuracy: 0.7568
Epoch 10/100
147/147 [==============================] - 6s 41ms/step - loss: 0.4642 - accurac
y: 0.7556 - val_loss: 0.4488 - val_accuracy: 0.7568
Epoch 11/100
147/147 [==============================] - 6s 41ms/step - loss: 0.4549 - accurac
y: 0.7626 - val_loss: 0.4394 - val_accuracy: 0.7619
Epoch 12/100
147/147 [==============================] - 6s 41ms/step - loss: 0.4463 - accurac
y: 0.7690 - val_loss: 0.4305 - val_accuracy: 0.7628
Epoch 13/100
147/147 [==============================] - 6s 41ms/step - loss: 0.4381 - accurac
y: 0.7763 - val_loss: 0.4221 - val_accuracy: 0.7713
Epoch 14/100
147/147 [==============================] - 6s 41ms/step - loss: 0.4306 - accurac
y: 0.7835 - val_loss: 0.4143 - val_accuracy: 0.7807
Epoch 15/100
147/147 [==============================] - 6s 41ms/step - loss: 0.4235 - accurac
y: 0.7912 - val_loss: 0.4069 - val_accuracy: 0.7850
Epoch 16/100
147/147 [==============================] - 6s 41ms/step - loss: 0.4169 - accurac
y: 0.7965 - val_loss: 0.4000 - val_accuracy: 0.7884
Epoch 17/100
147/147 [==============================] - 6s 41ms/step - loss: 0.4106 - accurac
y: 0.8019 - val_loss: 0.3934 - val_accuracy: 0.7986
Epoch 18/100
147/147 [==============================] - 6s 41ms/step - loss: 0.4046 - accurac
y: 0.8104 - val_loss: 0.3872 - val_accuracy: 0.8063
Epoch 19/100
147/147 [==============================] - 6s 41ms/step - loss: 0.3991 - accurac
y: 0.8164 - val_loss: 0.3813 - val_accuracy: 0.8217
Epoch 20/100
147/147 [==============================] - 6s 41ms/step - loss: 0.3939 - accurac
y: 0.8228 - val_loss: 0.3758 - val_accuracy: 0.8294
Epoch 21/100
147/147 [==============================] - 6s 41ms/step - loss: 0.3888 - accurac
y: 0.8256 - val_loss: 0.3705 - val_accuracy: 0.8345
```

```
Epoch 22/100
147/147 [==============================] - 6s 41ms/step - loss: 0.3842 - accurac
y: 0.8309 - val_loss: 0.3656 - val_accuracy: 0.8370
Epoch 23/100
147/147 [==============================] - 6s 41ms/step - loss: 0.3797 - accurac
y: 0.8373 - val_loss: 0.3608 - val_accuracy: 0.8413
Epoch 24/100
147/147 [==============================] - 6s 41ms/step - loss: 0.3755 - accurac
y: 0.8407 - val_loss: 0.3563 - val_accuracy: 0.8456
Epoch 25/100
147/147 [==============================] - 6s 41ms/step - loss: 0.3715 - accurac
y: 0.8448 - val_loss: 0.3520 - val_accuracy: 0.8473
Epoch 26/100
147/147 [==============================] - 6s 41ms/step - loss: 0.3676 - accurac
y: 0.8486 - val_loss: 0.3480 - val_accuracy: 0.8549
Epoch 27/100
147/147 [==============================] - 6s 41ms/step - loss: 0.3639 - accurac
y: 0.8499 - val_loss: 0.3441 - val_accuracy: 0.8592
Epoch 28/100
147/147 [==============================] - 6s 41ms/step - loss: 0.3605 - accurac
y: 0.8540 - val_loss: 0.3403 - val_accuracy: 0.8601
Epoch 29/100
147/147 [==============================] - 6s 41ms/step - loss: 0.3572 - accurac
y: 0.8559 - val_loss: 0.3368 - val_accuracy: 0.8626
Epoch 30/100
147/147 [==============================] - 6s 41ms/step - loss: 0.3540 - accurac
y: 0.8589 - val_loss: 0.3334 - val_accuracy: 0.8686
Epoch 31/100
147/147 [==============================] - 6s 41ms/step - loss: 0.3509 - accurac
y: 0.8610 - val_loss: 0.3301 - val_accuracy: 0.8712
Epoch 32/100
147/147 [==============================] - 6s 41ms/step - loss: 0.3480 - accurac
y: 0.8649 - val_loss: 0.3270 - val_accuracy: 0.8754
Epoch 33/100
147/147 [==============================] - 6s 41ms/step - loss: 0.3452 - accurac
y: 0.8678 - val_loss: 0.3240 - val_accuracy: 0.8763
Epoch 34/100
147/147 [==============================] - 6s 41ms/step - loss: 0.3425 - accurac
y: 0.8706 - val_loss: 0.3211 - val_accuracy: 0.8788
Epoch 35/100
147/147 [==============================] - 6s 41ms/step - loss: 0.3399 - accurac
y: 0.8711 - val_loss: 0.3183 - val_accuracy: 0.8823
Epoch 36/100
147/147 [==============================] - 6s 41ms/step - loss: 0.3375 - accurac
y: 0.8723 - val_loss: 0.3157 - val_accuracy: 0.8848
Epoch 37/100
147/147 [==============================] - 6s 41ms/step - loss: 0.3351 - accurac
y: 0.8762 - val_loss: 0.3131 - val_accuracy: 0.8874
Epoch 38/100
147/147 [==============================] - 6s 41ms/step - loss: 0.3328 - accurac
y: 0.8772 - val_loss: 0.3106 - val_accuracy: 0.8865
Epoch 39/100
147/147 [==============================] - 6s 41ms/step - loss: 0.3306 - accurac
y: 0.8787 - val_loss: 0.3083 - val_accuracy: 0.8891
Epoch 40/100
147/147 [==============================] - 6s 41ms/step - loss: 0.3284 - accurac
y: 0.8796 - val_loss: 0.3060 - val_accuracy: 0.8916
Epoch 41/100
147/147 [==============================] - 6s 41ms/step - loss: 0.3264 - accurac
y: 0.8798 - val_loss: 0.3038 - val_accuracy: 0.8916
Epoch 42/100
147/147 [==============================] - 6s 41ms/step - loss: 0.3244 - accurac
y: 0.8813 - val_loss: 0.3017 - val_accuracy: 0.8925
Epoch 43/100
```

```
147/147 [==============================] - 6s 41ms/step - loss: 0.3225 - accurac
y: 0.8817 - val_loss: 0.2996 - val_accuracy: 0.8933
Epoch 44/100
147/147 [==============================] - 6s 41ms/step - loss: 0.3206 - accurac
y: 0.8826 - val_loss: 0.2977 - val_accuracy: 0.8933
Epoch 45/100
147/147 [==============================] - 6s 41ms/step - loss: 0.3188 - accurac
y: 0.8830 - val_loss: 0.2958 - val_accuracy: 0.8951
Epoch 46/100
147/147 [==============================] - 6s 41ms/step - loss: 0.3170 - accurac
y: 0.8847 - val_loss: 0.2939 - val_accuracy: 0.8951
Epoch 47/100
147/147 [==============================] - 6s 41ms/step - loss: 0.3154 - accurac
y: 0.8854 - val_loss: 0.2921 - val_accuracy: 0.8942
Epoch 48/100
147/147 [==============================] - 6s 41ms/step - loss: 0.3137 - accurac
y: 0.8875 - val_loss: 0.2903 - val_accuracy: 0.8951
Epoch 49/100
147/147 [==============================] - 6s 41ms/step - loss: 0.3121 - accurac
y: 0.8871 - val_loss: 0.2886 - val_accuracy: 0.8959
Epoch 50/100
147/147 [==============================] - 6s 41ms/step - loss: 0.3106 - accurac
y: 0.8881 - val_loss: 0.2870 - val_accuracy: 0.8968
Epoch 51/100
147/147 [==============================] - 6s 41ms/step - loss: 0.3090 - accurac
y: 0.8890 - val_loss: 0.2854 - val_accuracy: 0.8976
Epoch 52/100
147/147 [==============================] - 6s 41ms/step - loss: 0.3076 - accurac
y: 0.8894 - val_loss: 0.2838 - val_accuracy: 0.8976
Epoch 53/100
147/147 [==============================] - 6s 41ms/step - loss: 0.3062 - accurac
y: 0.8898 - val_loss: 0.2823 - val_accuracy: 0.8976
Epoch 54/100
147/147 [==============================] - 6s 41ms/step - loss: 0.3048 - accurac
y: 0.8911 - val_loss: 0.2809 - val_accuracy: 0.8985
Epoch 55/100
147/147 [==============================] - 6s 41ms/step - loss: 0.3034 - accurac
y: 0.8907 - val_loss: 0.2795 - val_accuracy: 0.8985
Epoch 56/100
147/147 [==============================] - 6s 41ms/step - loss: 0.3021 - accurac
y: 0.8915 - val_loss: 0.2781 - val_accuracy: 0.9019
Epoch 57/100
147/147 [==============================] - 6s 41ms/step - loss: 0.3008 - accurac
y: 0.8920 - val_loss: 0.2768 - val_accuracy: 0.9019
Epoch 58/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2995 - accurac
y: 0.8922 - val_loss: 0.2755 - val_accuracy: 0.9019
Epoch 59/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2984 - accurac
y: 0.8924 - val_loss: 0.2742 - val_accuracy: 0.9027
Epoch 60/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2971 - accurac
y: 0.8930 - val_loss: 0.2730 - val_accuracy: 0.9036
Epoch 61/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2960 - accurac
y: 0.8928 - val_loss: 0.2718 - val_accuracy: 0.9053
Epoch 62/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2949 - accurac
y: 0.8922 - val_loss: 0.2706 - val_accuracy: 0.9061
Epoch 63/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2937 - accurac
y: 0.8943 - val_loss: 0.2695 - val_accuracy: 0.9070
Epoch 64/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2927 - accurac
```

```
y: 0.8950 - val_loss: 0.2684 - val_accuracy: 0.9070
Epoch 65/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2916 - accurac
y: 0.8950 - val_loss: 0.2673 - val_accuracy: 0.9078
Epoch 66/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2906 - accurac
y: 0.8952 - val_loss: 0.2663 - val_accuracy: 0.9078
Epoch 67/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2897 - accurac
y: 0.8960 - val_loss: 0.2652 - val_accuracy: 0.9087
Epoch 68/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2887 - accurac
y: 0.8954 - val_loss: 0.2642 - val_accuracy: 0.9096
Epoch 69/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2877 - accurac
y: 0.8975 - val_loss: 0.2633 - val_accuracy: 0.9096
Epoch 70/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2867 - accurac
y: 0.8975 - val_loss: 0.2623 - val_accuracy: 0.9096
Epoch 71/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2858 - accurac
y: 0.8986 - val_loss: 0.2614 - val_accuracy: 0.9113
Epoch 72/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2849 - accurac
y: 0.8986 - val_loss: 0.2605 - val_accuracy: 0.9104
Epoch 73/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2841 - accurac
y: 0.8984 - val_loss: 0.2596 - val_accuracy: 0.9113
Epoch 74/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2832 - accurac
y: 0.8984 - val_loss: 0.2588 - val_accuracy: 0.9113
Epoch 75/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2823 - accurac
y: 0.8982 - val_loss: 0.2579 - val_accuracy: 0.9113
Epoch 76/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2815 - accurac
y: 0.8990 - val_loss: 0.2571 - val_accuracy: 0.9113
Epoch 77/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2807 - accurac
y: 0.8997 - val_loss: 0.2563 - val_accuracy: 0.9121
Epoch 78/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2799 - accurac
y: 0.8999 - val_loss: 0.2555 - val_accuracy: 0.9104
Epoch 79/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2792 - accurac
y: 0.9005 - val_loss: 0.2548 - val_accuracy: 0.9113
Epoch 80/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2784 - accurac
y: 0.9005 - val_loss: 0.2540 - val_accuracy: 0.9113
Epoch 81/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2776 - accurac
y: 0.9007 - val_loss: 0.2533 - val_accuracy: 0.9113
Epoch 82/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2769 - accurac
y: 0.9016 - val_loss: 0.2525 - val_accuracy: 0.9121
Epoch 83/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2762 - accurac
y: 0.9018 - val_loss: 0.2518 - val_accuracy: 0.9130
Epoch 84/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2755 - accurac
y: 0.9022 - val_loss: 0.2512 - val_accuracy: 0.9121
Epoch 85/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2748 - accurac
y: 0.9014 - val_loss: 0.2505 - val_accuracy: 0.9130
```

```
Epoch 86/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2741 - accurac
y: 0.9022 - val_loss: 0.2498 - val_accuracy: 0.9138
Epoch 87/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2734 - accurac
y: 0.9014 - val_loss: 0.2492 - val_accuracy: 0.9138
Epoch 88/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2727 - accurac
y: 0.9024 - val_loss: 0.2485 - val_accuracy: 0.9138
Epoch 89/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2721 - accurac
y: 0.9024 - val_loss: 0.2479 - val_accuracy: 0.9130
Epoch 90/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2714 - accurac
y: 0.9029 - val_loss: 0.2473 - val_accuracy: 0.9130
Epoch 91/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2708 - accurac
y: 0.9024 - val_loss: 0.2466 - val_accuracy: 0.9130
Epoch 92/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2702 - accurac
y: 0.9029 - val_loss: 0.2460 - val_accuracy: 0.9121
Epoch 93/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2696 - accurac
y: 0.9026 - val_loss: 0.2454 - val_accuracy: 0.9121
Epoch 94/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2690 - accurac
y: 0.9026 - val_loss: 0.2449 - val_accuracy: 0.9121
Epoch 95/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2684 - accurac
y: 0.9033 - val_loss: 0.2443 - val_accuracy: 0.9121
Epoch 96/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2678 - accurac
y: 0.9035 - val_loss: 0.2437 - val_accuracy: 0.9130
Epoch 97/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2672 - accurac
y: 0.9033 - val_loss: 0.2432 - val_accuracy: 0.9130
Epoch 98/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2667 - accurac
y: 0.9037 - val_loss: 0.2426 - val_accuracy: 0.9138
Epoch 99/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2661 - accurac
y: 0.9037 - val_loss: 0.2421 - val_accuracy: 0.9138
Epoch 100/100
147/147 [==============================] - 6s 41ms/step - loss: 0.2655 - accurac
y: 0.9039 - val_loss: 0.2416 - val_accuracy: 0.9147
Training time: -609.8109776973724
118/118 [==============================] - 2s 17ms/step - loss: 0.2416 - accurac
y: 0.9147
```

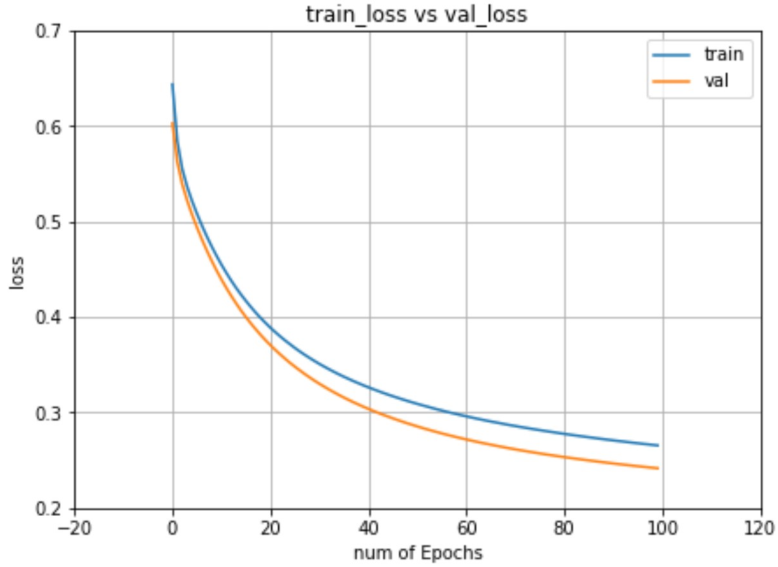
In [15]:

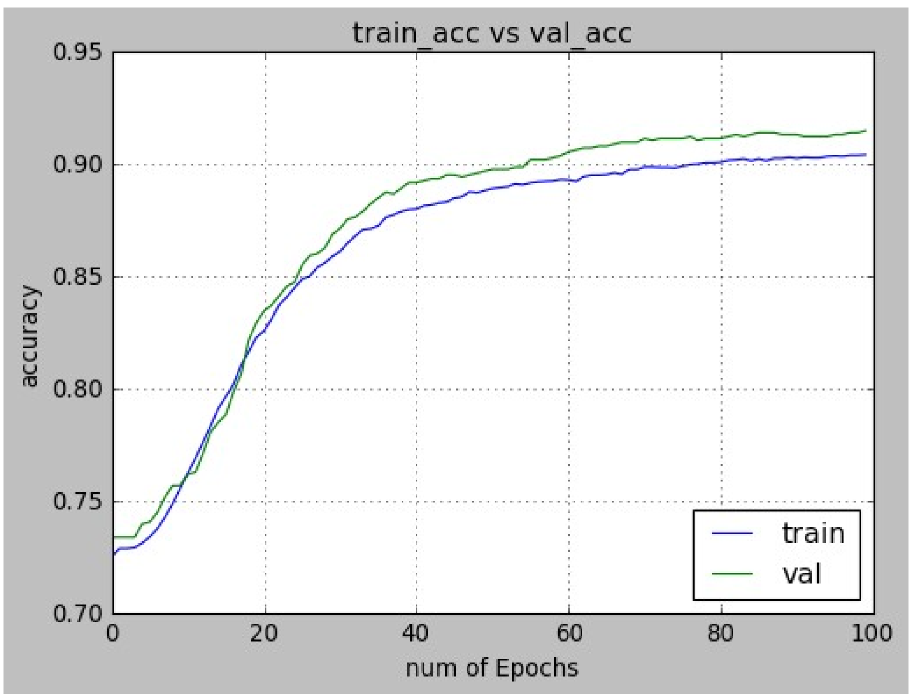
```
(loss, accuracy) = custom_resnet_model.evaluate(X_test, y_test, batch_size=10, verb
ose=1)

print("[INFO] loss={:.4f}, accuracy: {:.4f}%".format(loss,accuracy * 100))
```

```
118/118 [==============================] - 2s 15ms/step - loss: 0.2416 - accurac
y: 0.9147
[INFO] loss=0.2416, accuracy: 91.4676%
```

visualizing losses and accuracy

In [16]:
```
display_loss_accuracy(hist)
```





Evaluating the model

In [17]:
```
score = custom_resnet_model.evaluate(X_test, y_test, verbose=0)
print('Test Loss:', score[0])
print('Test accuracy:', score[1])

test_image = X_test[0:1]
print (test_image.shape)

print(model.predict(test_image))
print(model.predict_classes(test_image))
print(y_test[0:1])
```

```
Test Loss: 0.24162615835666656
Test accuracy: 0.914675772190094
(1, 224, 224, 3)
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  3.03070352e-04 4.57870956e-05 1.19120559e-04 8.90225492e-05
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  7.53177155e-05 1.09933528e-04 2.17667766e-04 1.03260376e-04
  1.68310271e-05 4.71250714e-05 2.25656520e-04 1.11117632e-04
  1.19079450e-04 3.50336049e-05 7.37054288e-05 1.12858543e-04
  1.31092936e-04 5.13734412e-05 1.09661698e-04 1.33358277e-04
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2.14696829e-05 1.93196393e-04 6.29920323e-05 1.38893153e-03
1.97276357e-03 3.87275737e-04 4.70409956e-04 1.04977466e-04
8.66038899e-05 2.10130784e-05 2.21918861e-04 1.92755160e-05
9.36520300e-05 3.28548958e-05 1.16980786e-03 4.76077330e-05
5.36649197e-04 1.12778936e-04 3.09132611e-06 1.16967904e-05
3.23557877e-04 2.54508495e-06 4.74176253e-04 6.56044402e-04
8.27612123e-04 6.55535914e-05 1.99410575e-03 1.48264132e-03
8.31854195e-05 9.95933297e-05 4.19858785e-04 4.76322530e-05
4.94358654e-04 2.63915467e-03 7.25556747e-04 7.74318527e-04
7.02826772e-04 3.97677359e-05 9.80811380e-03 2.64382761e-05
4.16843759e-05 7.06135994e-04 2.61750283e-05 8.92328855e-04
1.27251481e-03 1.58596595e-04 2.71753408e-04 6.71056274e-04
1.84216391e-04 3.36448866e-04 4.11851470e-05 1.33671318e-04
1.52624969e-04 2.06730019e-05 3.06273869e-04 2.71964981e-03
4.70857427e-04 3.60155609e-05 7.55196816e-05 1.57036399e-03
1.54864065e-05 2.31870697e-04 1.19008953e-02 3.09153111e-04
1.25879757e-04 1.03011444e-04 1.46702502e-03 7.43132041e-05
2.84773414e-05 5.63574489e-04 1.61093209e-04 8.43522896e-04
9.58754797e-04 5.08159465e-05 2.06946715e-04 6.66140520e-04
5.87129070e-05 2.06479308e-06 2.25120777e-04 1.80725110e-05
1.10015128e-04 4.83739830e-04 1.34500238e-04 4.28811356e-04
5.18853834e-04 1.01364413e-02 3.64524050e-04 5.43028364e-05
2.39440371e-04 2.05363482e-04 1.51743268e-04 9.51730253e-05
1.73279313e-05 5.83487927e-05 1.47452345e-04 3.08834296e-03
1.24863713e-04 1.79667713e-05 3.07209697e-03 2.79738251e-05
7.99115587e-05 2.34446015e-05 9.82822618e-04 2.34153867e-03
1.13934024e-04 2.91827037e-05 1.47375016e-04 5.59431974e-05
1.17024174e-04 1.57576782e-04 3.46450892e-04 7.32991204e-04
1.69161067e-04 1.59455743e-03 1.73376029e-05 8.59025677e-05
1.01042865e-03 1.09213754e-04 1.79306717e-05 5.39152825e-04
1.89648981e-05 7.20300188e-04 1.79962174e-03 3.27884639e-03
7.25260616e-05 3.15109646e-04 7.32668326e-04 1.53096189e-05
4.52849163e-05 3.47554538e-04 2.79870495e-04 6.85701016e-05
1.07863576e-04 1.66341953e-04 1.45367114e-04 1.51955945e-04
1.18492193e-04 7.17391435e-04 2.06604693e-03 2.06299519e-04
2.54458486e-04 6.54346426e-04 2.97473860e-04 7.34544301e-04
6.25758403e-05 2.90876233e-05 1.74098328e-04 1.11928071e-04
1.14851497e-01 2.62955250e-03 2.40852195e-03 1.72162443e-04
8.75283731e-05 6.66758686e-04 1.76057420e-05 1.84296805e-04
1.70327738e-04 2.79838045e-04 4.37207578e-04 8.90741474e-04
2.95937969e-03 3.18998966e-04 7.71548730e-05 1.85021563e-04
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1.29134523e-05 2.94119789e-04 9.48211455e-05 6.97282157e-05
6.17292535e-05 4.16714574e-05 5.00194401e-05 1.13236427e-04
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1.98253110e-05 1.48473191e-04 6.39737045e-05 2.67284995e-05
4.29977372e-05 1.51909131e-04 1.80505929e-04 3.08210932e-04
2.26825607e-04 7.97288594e-05 9.52363989e-05 4.29513457e-05
5.10523641e-05 2.09242899e-05 6.18914710e-05 5.63330032e-05
1.90053997e-05 6.33332165e-05 5.60914486e-05 3.97748627e-05
1.83574355e-06 1.78109458e-05 5.12331644e-05 2.07487301e-05
3.00131378e-05 2.81950579e-05 4.41239914e-03 1.48228282e-04
8.43753296e-05 5.18359993e-05 9.11546085e-05 5.44237951e-03
1.05446445e-04 7.14217837e-04 6.95484108e-04 1.59877454e-04
1.04986575e-04 1.55470407e-04 5.15914580e-04 2.69758631e-04
5.53757884e-04 9.67251690e-05 1.41127763e-04 5.17273264e-04
1.65178091e-04 4.38820600e-04 7.76213055e-05 7.71105988e-04
8.71600205e-05 6.32327283e-04 2.78978841e-04 3.60339385e-04
1.25893086e-04 1.04214778e-04 5.29835888e-05 8.40803841e-05
```

```
---------------------------------------------------------------------------
AttributeError                            Traceback (most recent call last)
<ipython-input-17-83421ec204f5> in <module>
      7
      8 print(model.predict(test_image))
----> 9 print(model.predict_classes(test_image))
```

Testing a new image

In [18]:
```
test_image_path = 'D:/Harold/MyDNN/DataSet/Chest_xray_seperate/PNEUMONIA/person11_b
acteria_45.jpeg'
test_image = image.load_img(test_image_path, target_size=(224, 224))
x = image.img_to_array(test_image)
x = np.expand_dims(x, axis=0)
x = preprocess_input(x)
print (x.shape)


# if num_channel==1:
#     if (K.image_data_format() == 'channels_first'):
#         test_image= np.expand_dims(test_image, axis=0)
#         test_image= np.expand_dims(test_image, axis=0)
#         print (test_image.shape)
#     else:
#         test_image= np.expand_dims(test_image, axis=3)
#         test_image= np.expand_dims(test_image, axis=0)
#         print (test_image.shape)
# else:
#     if (K.image_data_format() == 'channels_first'):
#         test_image=np.rollaxis(test_image,2,0)
#         test_image= np.expand_dims(test_image, axis=0)
#         print (test_image.shape)
#     else:
#         test_image= np.expand_dims(test_image, axis=0)
#         print (test_image.shape)


# Predicting the test image
yhat = custom_resnet_model.predict(x)
print(yhat)
# print(custom_resnet_model.predict_classes(x))
label = decode_predictions(yhat)
# retrieve the most likely result, e.g. highest probability
label = label[0][0]
```

```
(1, 224, 224, 3)
[[0.04744451 0.95255554]]

---------------------------------------------------------------------------
ValueError                                Traceback (most recent call last)
<ipython-input-18-505048f79341> in <module>
     30 print(yhat)
     31 # print(custom_resnet_model.predict_classes(x))
---> 32 label = decode_predictions(yhat)
     33 # retrieve the most likely result, e.g. highest probability
     34 label = label[0][0]

D:\Anaconda3\lib\site-packages\tensorflow\python\keras\applications\inception_v
3.py in decode_predictions(preds, top)
    412 @keras_export('keras.applications.inception_v3.decode_predictions')
    413 def decode_predictions(preds, top=5):
--> 414   return imagenet_utils.decode_predictions(preds, top=top)
    415 
    416 

D:\Anaconda3\lib\site-packages\tensorflow\python\keras\applications\imagenet_uti
ls.py in decode_predictions(preds, top)
    149                      'a batch of predictions '
    150                      '(i.e. a 2D array of shape (samples, 1000)). '
--> 151                      'Found array with shape: ' + str(preds.shape))
    152   if CLASS_INDEX is None:
    153     fpath = data_utils.get_file(

ValueError: `decode_predictions` expects a batch of predictions (i.e. a 2D array
of shape (samples, 1000)). Found array with shape: (1, 2)
```

Visualizing the intermediate layer

In [19]:

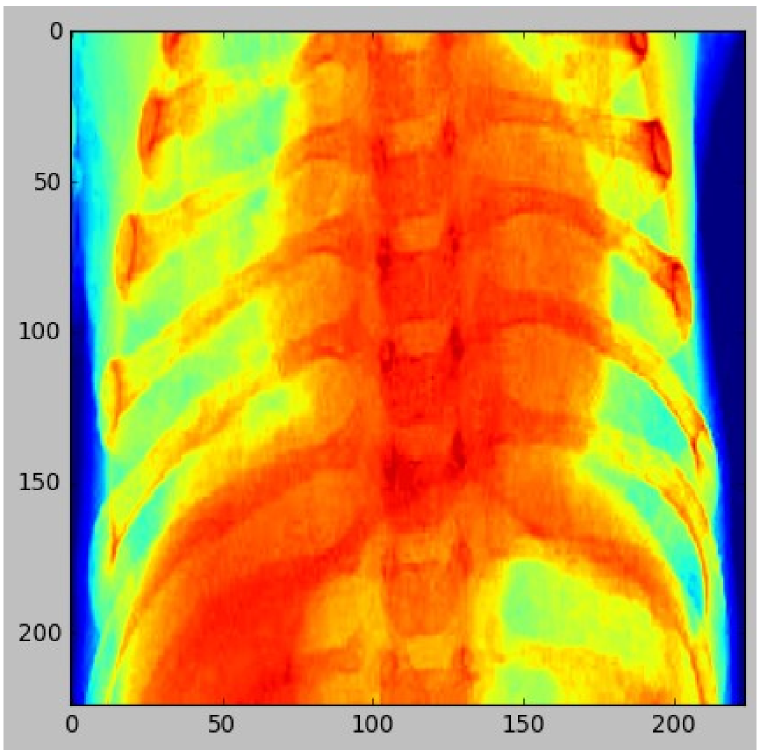
```
from keras.models import Model
layer_outputs = [layer.output for layer in model.layers]
activation_model = Model(inputs=custom_resnet_model.input, outputs=layer_outputs)
activations = custom_resnet_model.predict(X_train[10].reshape(1,224,224,3))
print(activations.shape)
def display_activation(activations, col_size, row_size, act_index):
    activation = activations[0, act_index]
    activation_index=1
    fig, ax = plt.subplots(row_size, col_size, figsize=(row_size*2.5,col_size*1))
    for row in range(0,row_size):
        for col in range(0,col_size):
            ax[row][col].imshow(activation[0, :, :, activation_index], cmap='gray')
            activation_index += 1
plt.imshow(test_image)
plt.imshow(X_train[10][:,:,0]);
display_activation(activations, 8, 4, 1)
```

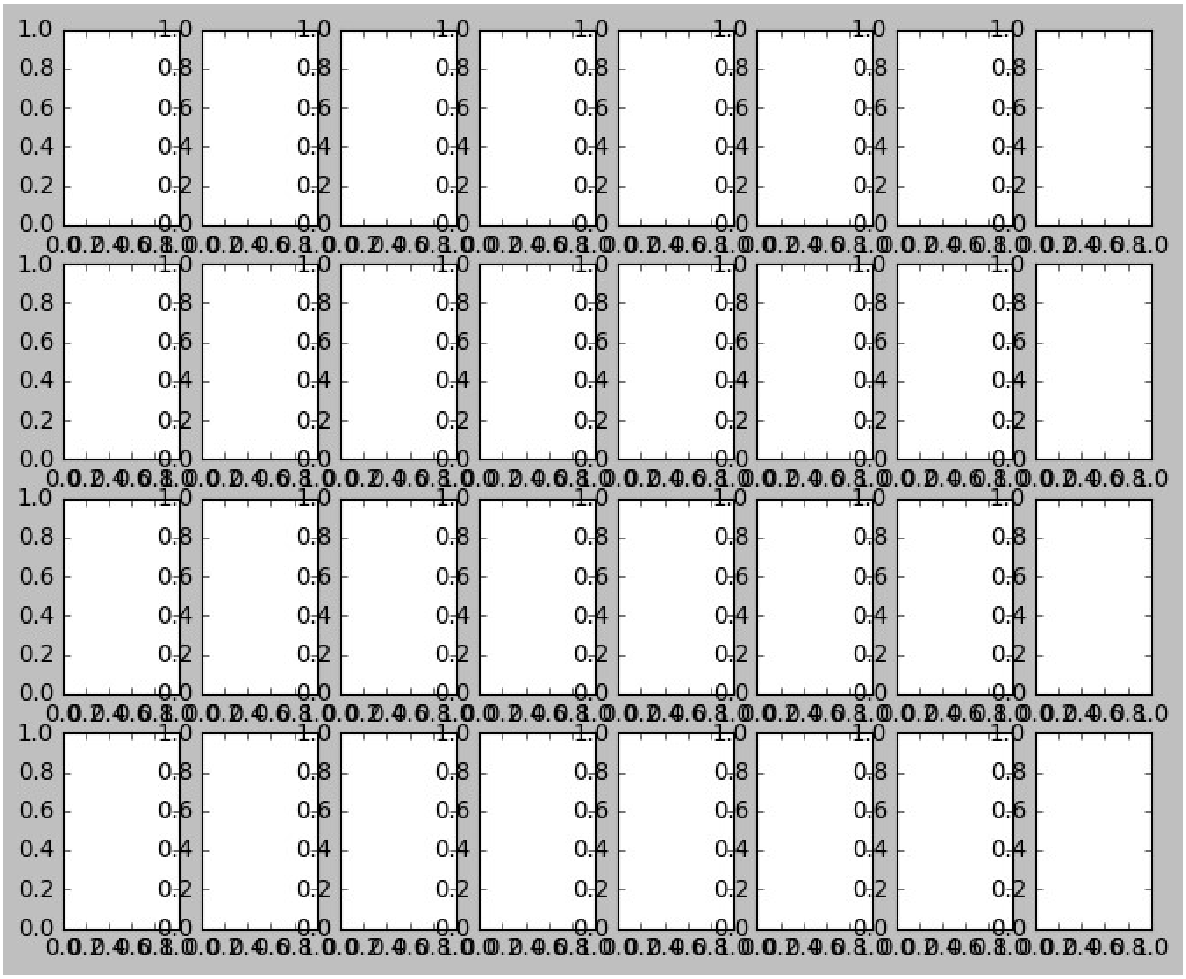
```
(1, 2)

---------------------------------------------------------------------------
IndexError                                Traceback (most recent call last)
<ipython-input-19-32e8200fb41b> in <module>
     14 plt.imshow(test_image)
     15 plt.imshow(X_train[10][:,:,0]);
---> 16 display_activation(activations, 8, 4, 1)

<ipython-input-19-32e8200fb41b> in display_activation(activations, col_size, row
_size, act_index)
     10     for row in range(0,row_size):
     11         for col in range(0,col_size):
---> 12             ax[row][col].imshow(activation[0, :, :, activation_index], c
map='gray')
     13             activation_index += 1
     14 plt.imshow(test_image)

IndexError: invalid index to scalar variable.
```





Confusion matrix

In [20]:
```
Y_pred = custom_resnet_model.predict(X_test)
print(Y_pred)
y_pred = np.argmax(Y_pred, axis=1)
print(y_pred)
#y_pred = model.predict_classes(X_test)
#print(y_pred)
target_names = ['class 0(Normal)', 'class 1(Pneumonia)']
print(classification_report(np.argmax(y_test,axis=1), y_pred,target_names=target_na
mes))
print(confusion_matrix(np.argmax(y_test,axis=1), y_pred))
```

```
[[0.01631579 0.9836842 ]
 [0.83765393 0.16234608]
 [0.01476637 0.9852336 ]
 ...
 [0.015543   0.98445696]
 [0.10139033 0.89860964]
 [0.8255221  0.17447793]]
[1 0 1 ... 1 1 0]
                    precision    recall  f1-score   support

   class 0(Normal)       0.88      0.79      0.83       312
class 1(Pneumonia)       0.93      0.96      0.94       860

          accuracy                           0.91      1172
         macro avg       0.90      0.88      0.89      1172
      weighted avg       0.91      0.91      0.91      1172

[[247  65]
 [ 35 825]]
```

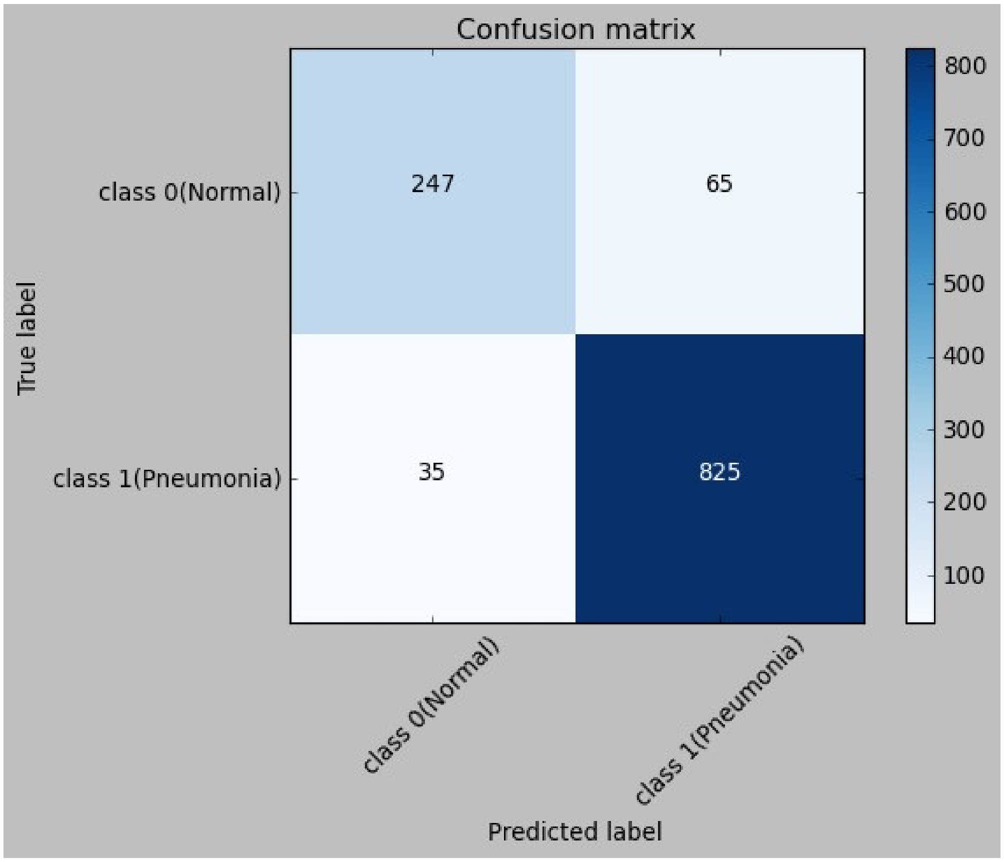
Compute confusion matrix

In [21]:
```
# Compute confusion matrix
cnf_matrix = (confusion_matrix(np.argmax(y_test,axis=1), y_pred))

np.set_printoptions(precision=2)

# Plot non-normalized confusion matrix
plot_confusion_matrix(cnf_matrix, classes=target_names,
                      title='Confusion matrix')
```

```
Confusion matrix, without normalization
[[247  65]
 [ 35 825]]
```



In [ ]:

In [ ]:

In [ ]: