In [1]:

```
"""
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"""

import os
import pandas as pd
import numpy as np
import zipfile
import tensorflow as tf
from tensorflow import keras
from tensorflow.keras.optimizers import Adam
from tensorflow.keras.models import Model
from tensorflow.keras.layers import (
    Input, Conv2D, MaxPool2D,
    AveragePooling2D, Flatten, GlobalAveragePooling2D,
    Dense, Dropout)
from keras.layers.merge import concatenate

from sklearn import metrics
import matplotlib.pyplot as plt
%matplotlib inline

TRAIN_PATH = "../input/covid19/"
EPOCHS = 100
BATCH_SIZE = 128
LEARNING_RATE = 0.001
INPUT_SIZE = (224, 224)

def load_data():
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    """
    Loads input data from directory
    Arguments: None
    Returns: Train and val generator
    """

    train_datagen =  keras.preprocessing.image.ImageDataGenerator(validation_split=0.2) # set validation split

    train_generator = train_datagen.flow_from_directory(
        TRAIN_PATH,
        target_size=INPUT_SIZE,
        batch_size=BATCH_SIZE,
        shuffle=False,
        class_mode='categorical',
        subset='training') # set as training data

    validation_generator = train_datagen.flow_from_directory(
        TRAIN_PATH,
        target_size=INPUT_SIZE,
        batch_size=BATCH_SIZE,
        shuffle=False,
        class_mode='categorical',
        subset='validation') # set as validation data

    return train_generator, validation_generator


def inception_module(x, filters_1x1, filters_3x3_reduce, filters_3x3,
                     filters_5x5_reduce, filters_5x5,filters_pool_proj,
                     name=None):
    """
```

```
    Represents an inception block
    Arguments:
        x                                   -- input
        filters_1x1                         -- number of filters of the 1x1 convolutional
                                               layer in the first path
        filters_3x3_reduce, filters_3x3     -- number of filters corresponding to the 1x1
                                               and 3x3 convolutional layers in the second path
        filters_5x5_reduce, filters_pool_proj -- number of filters corresponding to the 1x1 and
                                               5x5  convolutional layer in the third path
        filters_pool_proj                   -- number of filters of the 1x1 convolutional layer
    Returns: output layer
    """
    conv_1x1 = Conv2D(filters_1x1, (1, 1), padding='same', activation='relu')(x)

    conv_3x3 = Conv2D(filters_3x3_reduce, (1, 1), padding='same', activation='relu')(x)
    conv_3x3 = Conv2D(filters_3x3, (3, 3), padding='same', activation='relu')(conv_3x3)

    conv_5x5 = Conv2D(filters_5x5_reduce, (1, 1), padding='same', activation='relu')(x)
    conv_5x5 = Conv2D(filters_5x5, (5, 5), padding='same', activation='relu')(conv_5x5)

    pool_proj = MaxPool2D((3, 3), strides=(1, 1), padding='same')(x)
    pool_proj = Conv2D(filters_pool_proj, (1, 1), padding='same', activation='relu')(pool_proj)

    output = concatenate([conv_1x1, conv_3x3, conv_5x5, pool_proj], axis=3, name=name)

    return output


def load_model():
    """
    Creates a keras GoogleNet model
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    Arguments: None
    Returns: GoogleNet Model
    """

    input_layer = Input(shape=(224, 224, 3))

    x = Conv2D(64, (7, 7), padding='same', strides=(2, 2), activation='relu', name='conv_1_7x7/2')(input_layer
)
    x = MaxPool2D((3, 3), padding='same', strides=(2, 2), name='max_pool_1_3x3/2')(x)
    x = Conv2D(64, (1, 1), padding='same', strides=(1, 1), activation='relu', name='conv_2a_3x3/1')(x)
    x = Conv2D(192, (3, 3), padding='same', strides=(1, 1), activation='relu', name='conv_2b_3x3/1')(x)
    x = MaxPool2D((3, 3), padding='same', strides=(2, 2), name='max_pool_2_3x3/2')(x)

    x = inception_module(x,
                         filters_1x1=64,
                         filters_3x3_reduce=96,
                         filters_3x3=128,
                         filters_5x5_reduce=16,
                         filters_5x5=32,
                         filters_pool_proj=32,
                         name='inception_3a')

    x = inception_module(x,
                         filters_1x1=128,
                         filters_3x3_reduce=128,
                         filters_3x3=192,
                         filters_5x5_reduce=32,
                         filters_5x5=96,
                         filters_pool_proj=64,
                         name='inception_3b')
```

```
x = MaxPool2D((3, 3), padding='same', strides=(2, 2), name='max_pool_3_3x3/2')(x)

x = inception_module(x,
                     filters_1x1=192,
                     filters_3x3_reduce=96,
                     filters_3x3=208,
                     filters_5x5_reduce=16,
                     filters_5x5=48,
                     filters_pool_proj=64,
                     name='inception_4a')


x1 = AveragePooling2D((5, 5), strides=3)(x)
x1 = Conv2D(128, (1, 1), padding='same', activation='relu')(x1)
x1 = Flatten()(x1)
x1 = Dense(1024, activation='relu')(x1)
x1 = Dropout(0.7)(x1)
x1 = Dense(3, activation='softmax', name='auxilliary_output_1')(x1)

x = inception_module(x,
                     filters_1x1=160,
                     filters_3x3_reduce=112,
                     filters_3x3=224,
                     filters_5x5_reduce=24,
                     filters_5x5=64,
                     filters_pool_proj=64,
                     name='inception_4b')

x = inception_module(x,
                     filters_1x1=128,
                     filters_3x3_reduce=128,
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                    filters_3x3=256,
                    filters_5x5_reduce=24,
                    filters_5x5=64,
                    filters_pool_proj=64,
                    name='inception_4c')

x = inception_module(x,
                    filters_1x1=112,
                    filters_3x3_reduce=144,
                    filters_3x3=288,
                    filters_5x5_reduce=32,
                    filters_5x5=64,
                    filters_pool_proj=64,
                    name='inception_4d')


x2 = AveragePooling2D((5, 5), strides=3)(x)
x2 = Conv2D(128, (1, 1), padding='same', activation='relu')(x2)
x2 = Flatten()(x2)
x2 = Dense(1024, activation='relu')(x2)
x2 = Dropout(0.7)(x2)
x2 = Dense(3, activation='softmax', name='auxilliary_output_2')(x2)

x = inception_module(x,
                    filters_1x1=256,
                    filters_3x3_reduce=160,
                    filters_3x3=320,
                    filters_5x5_reduce=32,
                    filters_5x5=128,
                    filters_pool_proj=128,
                    name='inception_4e')
```

```
x = MaxPool2D((3, 3), padding='same', strides=(2, 2), name='max_pool_4_3x3/2')(x)

x = inception_module(x,
                     filters_1x1=256,
                     filters_3x3_reduce=160,
                     filters_3x3=320,
                     filters_5x5_reduce=32,
                     filters_5x5=128,
                     filters_pool_proj=128,
                     name='inception_5a')

x = inception_module(x,
                     filters_1x1=384,
                     filters_3x3_reduce=192,
                     filters_3x3=384,
                     filters_5x5_reduce=48,
                     filters_5x5=128,
                     filters_pool_proj=128,
                     name='inception_5b')

x = GlobalAveragePooling2D(name='avg_pool_5_3x3/1')(x)

x = Dropout(0.4)(x)

x = Dense(3, activation='softmax', name='output')(x)
model = Model(input_layer, [x, x1, x2], name='GoogLeNet')
model.summary()

opt = Adam(learning_rate=LEARNING_RATE)
model.compile(loss = keras.losses.categorical_crossentropy, optimizer=opt, metrics=['accuracy'])
```

```
    return model


def plot_curves(history):
    """
    Plots loss and accuracy and loss plots for
    training and validation datasets
    Arguments:
        history -- training history
    Returns: None
    """

    plt.plot(history.history['loss'], color='b', label="Training loss")
    plt.plot(history.history['val_loss'], color='r', label="Validation loss")
    plt.legend()
    plt.title('Training Loss VS Validation Loss')
    plt.show()

    plt.plot(history.history['output_accuracy'], color='b', label="Training accuracy")
    plt.plot(history.history['val_output_accuracy'], color='r',label="Validation accuracy")
    plt.title('Training Accuracy VS Validation Accuracy')
    plt.legend()
    plt.show()


def get_confusion_matrix(model, data_generator):
    """
    Calculates the accuracy and displays the
    confusion matrix for the input data
    Arguments:
        model           -- trained model
```

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        data_generator  -- input data generator
    Returns: None
    """

    predictions = model.predict(data_generator, BATCH_SIZE)
    y_pred = np.argmax(predictions[0], axis=1)
    y_true = data_generator.classes
    class_names = ['COVID', 'Normal', 'Pneumonia']

    print("Score =", model.evaluate(data_generator, batch_size=BATCH_SIZE))
    print("Accuracy  = ", metrics.accuracy_score(y_true, y_pred))
    cm = metrics.confusion_matrix(y_true, y_pred)
    metrics.ConfusionMatrixDisplay(cm, display_labels=class_names).plot(cmap=plt.cm.Blues,
                                                                        xticks_rotation='vertical')
    plt.show()


def train_model(train_generator, val_generator):
    """
    Trains GoogleNet model and saves the
    trained weights to an H5 file.
    Arguments:
        train_generator   -- train data generator
        val_generator     -- validation data generator
    Returns: Trained model
    """

    # Loads the model
    model = load_model()
    earlystop = keras.callbacks.EarlyStopping(patience=10)
    callbacks = [earlystop]
```

```
    history = model.fit(
        train_generator,
        batch_size=BATCH_SIZE,
        epochs=EPOCHS,
        validation_data=val_generator,
        validation_steps=val_generator.samples//BATCH_SIZE,
        steps_per_epoch=train_generator.samples//BATCH_SIZE,
        callbacks=callbacks)

    plot_curves(history)
    model.save_weights("model.h5")
    print("Model saved successfully!")

    return model
```

In [2]:

```
train_generator, val_generator = load_data()
model = train_model(train_generator, val_generator)

print("Confusion matrix for train data:")
get_confusion_matrix(model, train_generator)

print("Confusion matrix for val/test data:")
get_confusion_matrix(model, val_generator)
```

```
de zero
2021-10-19 09:48:41.497770: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1510] Created device /job:l
ocalhost/replica:0/task:0/device:GPU:0 with 15403 MB memory:  -> device: 0, name: Tesla P100-PCIE-16GB, pc
i bus id: 0000:00:04.0, compute capability: 6.0
```

```
Model: "GoogLeNet"
__________________________________________________________________________________________________
Layer (type)                    Output Shape         Param #     Connected to
==================================================================================================
input_1 (InputLayer)            [(None, 224, 224, 3) 0
__________________________________________________________________________________________________
conv_1_7x7/2 (Conv2D)           (None, 112, 112, 64) 9472        input_1[0][0]
__________________________________________________________________________________________________
max_pool_1_3x3/2 (MaxPooling2D) (None, 56, 56, 64)   0           conv_1_7x7/2[0][0]
__________________________________________________________________________________________________
conv_2a_3x3/1 (Conv2D)          (None, 56, 56, 64)   4160        max_pool_1_3x3/2[0][0]
__________________________________________________________________________________________________
conv_2b_3x3/1 (Conv2D)          (None, 56, 56, 192)  110784      conv_2a_3x3/1[0][0]
__________________________________________________________________________________________________
max_pool_2_3x3/2 (MaxPooling2D) (None, 28, 28, 192)  0           conv_2b_3x3/1[0][0]
__________________________________________________________________________________________________
conv2d_1 (Conv2D)               (None, 28, 28, 96)   18528       max_pool_2_3x3/2[0][0]
__________________________________________________________________________________________________
conv2d_3 (Conv2D)               (None, 28, 28, 16)   3088        max_pool_2_3x3/2[0][0]
__________________________________________________________________________________________________
max_pooling2d (MaxPooling2D)    (None, 28, 28, 192)  0           max_pool_2_3x3/2[0][0]
__________________________________________________________________________________________________
conv2d (Conv2D)                 (None, 28, 28, 64)   12352       max_pool_2_3x3/2[0][0]
__________________________________________________________________________________________________
conv2d_2 (Conv2D)               (None, 28, 28, 128)  110720      conv2d_1[0][0]
__________________________________________________________________________________________________
conv2d_4 (Conv2D)               (None, 28, 28, 32)   12832       conv2d_3[0][0]
__________________________________________________________________________________________________
conv2d_5 (Conv2D)               (None, 28, 28, 32)   6176        max_pooling2d[0][0]
__________________________________________________________________________________________________
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```
inception_3a (Concatenate)      (None, 28, 28, 256)  0          conv2d[0][0]
                                                                conv2d_2[0][0]
                                                                conv2d_4[0][0]
                                                                conv2d_5[0][0]
__________________________________________________________________________________________
conv2d_7 (Conv2D)               (None, 28, 28, 128)  32896      inception_3a[0][0]
__________________________________________________________________________________________
conv2d_9 (Conv2D)               (None, 28, 28, 32)   8224       inception_3a[0][0]
__________________________________________________________________________________________
max_pooling2d_1 (MaxPooling2D)  (None, 28, 28, 256)  0          inception_3a[0][0]
__________________________________________________________________________________________
conv2d_6 (Conv2D)               (None, 28, 28, 128)  32896      inception_3a[0][0]
__________________________________________________________________________________________
conv2d_8 (Conv2D)               (None, 28, 28, 192)  221376     conv2d_7[0][0]
__________________________________________________________________________________________
conv2d_10 (Conv2D)              (None, 28, 28, 96)   76896      conv2d_9[0][0]
__________________________________________________________________________________________
conv2d_11 (Conv2D)              (None, 28, 28, 64)   16448      max_pooling2d_1[0][0]
__________________________________________________________________________________________
inception_3b (Concatenate)      (None, 28, 28, 480)  0          conv2d_6[0][0]
                                                                conv2d_8[0][0]
                                                                conv2d_10[0][0]
                                                                conv2d_11[0][0]
__________________________________________________________________________________________
max_pool_3_3x3/2 (MaxPooling2D) (None, 14, 14, 480)  0          inception_3b[0][0]
__________________________________________________________________________________________
conv2d_13 (Conv2D)              (None, 14, 14, 96)   46176      max_pool_3_3x3/2[0][0]
__________________________________________________________________________________________
conv2d_15 (Conv2D)              (None, 14, 14, 16)   7696       max_pool_3_3x3/2[0][0]
__________________________________________________________________________________________
max_pooling2d_2 (MaxPooling2D)  (None, 14, 14, 480)  0          max_pool_3_3x3/2[0][0]
```

```
__________________________________________________________________________________________________
conv2d_12 (Conv2D)              (None, 14, 14, 192)  92352       max_pool_3_3x3/2[0][0]
__________________________________________________________________________________________________
conv2d_14 (Conv2D)              (None, 14, 14, 208)  179920      conv2d_13[0][0]
__________________________________________________________________________________________________
conv2d_16 (Conv2D)              (None, 14, 14, 48)   19248       conv2d_15[0][0]
__________________________________________________________________________________________________
conv2d_17 (Conv2D)              (None, 14, 14, 64)   30784       max_pooling2d_2[0][0]
__________________________________________________________________________________________________
inception_4a (Concatenate)      (None, 14, 14, 512)  0           conv2d_12[0][0]
                                                                 conv2d_14[0][0]
                                                                 conv2d_16[0][0]
                                                                 conv2d_17[0][0]
__________________________________________________________________________________________________
conv2d_20 (Conv2D)              (None, 14, 14, 112)  57456       inception_4a[0][0]
__________________________________________________________________________________________________
conv2d_22 (Conv2D)              (None, 14, 14, 24)   12312       inception_4a[0][0]
__________________________________________________________________________________________________
max_pooling2d_3 (MaxPooling2D)  (None, 14, 14, 512)  0           inception_4a[0][0]
__________________________________________________________________________________________________
conv2d_19 (Conv2D)              (None, 14, 14, 160)  82080       inception_4a[0][0]
__________________________________________________________________________________________________
conv2d_21 (Conv2D)              (None, 14, 14, 224)  226016      conv2d_20[0][0]
__________________________________________________________________________________________________
conv2d_23 (Conv2D)              (None, 14, 14, 64)   38464       conv2d_22[0][0]
__________________________________________________________________________________________________
conv2d_24 (Conv2D)              (None, 14, 14, 64)   32832       max_pooling2d_3[0][0]
__________________________________________________________________________________________________
inception_4b (Concatenate)      (None, 14, 14, 512)  0           conv2d_19[0][0]
                                                                 conv2d_21[0][0]
                                                                 conv2d_23[0][0]
```

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                                                                 conv2d_24[0][0]
__________________________________________________________________________________________________
conv2d_26 (Conv2D)              (None, 14, 14, 128)  65664       inception_4b[0][0]
__________________________________________________________________________________________________
conv2d_28 (Conv2D)              (None, 14, 14, 24)   12312       inception_4b[0][0]
__________________________________________________________________________________________________
max_pooling2d_4 (MaxPooling2D)  (None, 14, 14, 512)  0           inception_4b[0][0]
__________________________________________________________________________________________________
conv2d_25 (Conv2D)              (None, 14, 14, 128)  65664       inception_4b[0][0]
__________________________________________________________________________________________________
conv2d_27 (Conv2D)              (None, 14, 14, 256)  295168      conv2d_26[0][0]
__________________________________________________________________________________________________
conv2d_29 (Conv2D)              (None, 14, 14, 64)   38464       conv2d_28[0][0]
__________________________________________________________________________________________________
conv2d_30 (Conv2D)              (None, 14, 14, 64)   32832       max_pooling2d_4[0][0]
__________________________________________________________________________________________________
inception_4c (Concatenate)      (None, 14, 14, 512)  0           conv2d_25[0][0]
                                                                 conv2d_27[0][0]
                                                                 conv2d_29[0][0]
                                                                 conv2d_30[0][0]
__________________________________________________________________________________________________
conv2d_32 (Conv2D)              (None, 14, 14, 144)  73872       inception_4c[0][0]
__________________________________________________________________________________________________
conv2d_34 (Conv2D)              (None, 14, 14, 32)   16416       inception_4c[0][0]
__________________________________________________________________________________________________
max_pooling2d_5 (MaxPooling2D)  (None, 14, 14, 512)  0           inception_4c[0][0]
__________________________________________________________________________________________________
conv2d_31 (Conv2D)              (None, 14, 14, 112)  57456       inception_4c[0][0]
__________________________________________________________________________________________________
conv2d_33 (Conv2D)              (None, 14, 14, 288)  373536      conv2d_32[0][0]
__________________________________________________________________________________________________
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conv2d_35 (Conv2D)              (None, 14, 14, 64)   51264       conv2d_34[0][0]
__________________________________________________________________________________________________
conv2d_36 (Conv2D)              (None, 14, 14, 64)   32832       max_pooling2d_5[0][0]
__________________________________________________________________________________________________
inception_4d (Concatenate)      (None, 14, 14, 528)  0           conv2d_31[0][0]
                                                                 conv2d_33[0][0]
                                                                 conv2d_35[0][0]
                                                                 conv2d_36[0][0]
__________________________________________________________________________________________________
conv2d_39 (Conv2D)              (None, 14, 14, 160)  84640       inception_4d[0][0]
__________________________________________________________________________________________________
conv2d_41 (Conv2D)              (None, 14, 14, 32)   16928       inception_4d[0][0]
__________________________________________________________________________________________________
max_pooling2d_6 (MaxPooling2D)  (None, 14, 14, 528)  0           inception_4d[0][0]
__________________________________________________________________________________________________
conv2d_38 (Conv2D)              (None, 14, 14, 256)  135424      inception_4d[0][0]
__________________________________________________________________________________________________
conv2d_40 (Conv2D)              (None, 14, 14, 320)  461120      conv2d_39[0][0]
__________________________________________________________________________________________________
conv2d_42 (Conv2D)              (None, 14, 14, 128)  102528      conv2d_41[0][0]
__________________________________________________________________________________________________
conv2d_43 (Conv2D)              (None, 14, 14, 128)  67712       max_pooling2d_6[0][0]
__________________________________________________________________________________________________
inception_4e (Concatenate)      (None, 14, 14, 832)  0           conv2d_38[0][0]
                                                                 conv2d_40[0][0]
                                                                 conv2d_42[0][0]
                                                                 conv2d_43[0][0]
__________________________________________________________________________________________________
max_pool_4_3x3/2 (MaxPooling2D) (None, 7, 7, 832)    0           inception_4e[0][0]
__________________________________________________________________________________________________
conv2d_45 (Conv2D)              (None, 7, 7, 160)    133280      max_pool_4_3x3/2[0][0]
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__________________________________________________________________________________________________
conv2d_47 (Conv2D)              (None, 7, 7, 32)     26656       max_pool_4_3x3/2[0][0]
__________________________________________________________________________________________________
max_pooling2d_7 (MaxPooling2D)  (None, 7, 7, 832)    0           max_pool_4_3x3/2[0][0]
__________________________________________________________________________________________________
conv2d_44 (Conv2D)              (None, 7, 7, 256)    213248      max_pool_4_3x3/2[0][0]
__________________________________________________________________________________________________
conv2d_46 (Conv2D)              (None, 7, 7, 320)    461120      conv2d_45[0][0]
__________________________________________________________________________________________________
conv2d_48 (Conv2D)              (None, 7, 7, 128)    102528      conv2d_47[0][0]
__________________________________________________________________________________________________
conv2d_49 (Conv2D)              (None, 7, 7, 128)    106624      max_pooling2d_7[0][0]
__________________________________________________________________________________________________
inception_5a (Concatenate)      (None, 7, 7, 832)    0           conv2d_44[0][0]
                                                                 conv2d_46[0][0]
                                                                 conv2d_48[0][0]
                                                                 conv2d_49[0][0]
__________________________________________________________________________________________________
conv2d_51 (Conv2D)              (None, 7, 7, 192)    159936      inception_5a[0][0]
__________________________________________________________________________________________________
conv2d_53 (Conv2D)              (None, 7, 7, 48)     39984       inception_5a[0][0]
__________________________________________________________________________________________________
max_pooling2d_8 (MaxPooling2D)  (None, 7, 7, 832)    0           inception_5a[0][0]
__________________________________________________________________________________________________
average_pooling2d (AveragePooli (None, 4, 4, 512)    0           inception_4a[0][0]
__________________________________________________________________________________________________
average_pooling2d_1 (AveragePoo (None, 4, 4, 528)    0           inception_4d[0][0]
__________________________________________________________________________________________________
conv2d_50 (Conv2D)              (None, 7, 7, 384)    319872      inception_5a[0][0]
__________________________________________________________________________________________________
conv2d_52 (Conv2D)              (None, 7, 7, 384)    663936      conv2d_51[0][0]
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__________________________________________________________________________________________________
conv2d_54 (Conv2D)              (None, 7, 7, 128)    153728      conv2d_53[0][0]
__________________________________________________________________________________________________
conv2d_55 (Conv2D)              (None, 7, 7, 128)    106624      max_pooling2d_8[0][0]
__________________________________________________________________________________________________
conv2d_18 (Conv2D)              (None, 4, 4, 128)    65664       average_pooling2d[0][0]
__________________________________________________________________________________________________
conv2d_37 (Conv2D)              (None, 4, 4, 128)    67712       average_pooling2d_1[0][0]
__________________________________________________________________________________________________
inception_5b (Concatenate)      (None, 7, 7, 1024)   0           conv2d_50[0][0]
                                                                 conv2d_52[0][0]
                                                                 conv2d_54[0][0]
                                                                 conv2d_55[0][0]
__________________________________________________________________________________________________
flatten (Flatten)               (None, 2048)         0           conv2d_18[0][0]
__________________________________________________________________________________________________
flatten_1 (Flatten)             (None, 2048)         0           conv2d_37[0][0]
__________________________________________________________________________________________________
avg_pool_5_3x3/1 (GlobalAverage (None, 1024)         0           inception_5b[0][0]
__________________________________________________________________________________________________
dense (Dense)                   (None, 1024)         2098176     flatten[0][0]
__________________________________________________________________________________________________
dense_1 (Dense)                 (None, 1024)         2098176     flatten_1[0][0]
__________________________________________________________________________________________________
dropout_2 (Dropout)             (None, 1024)         0           avg_pool_5_3x3/1[0][0]
__________________________________________________________________________________________________
dropout (Dropout)               (None, 1024)         0           dense[0][0]
__________________________________________________________________________________________________
dropout_1 (Dropout)             (None, 1024)         0           dense_1[0][0]
__________________________________________________________________________________________________
output (Dense)                  (None, 3)            3075        dropout_2[0][0]
```

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__________________________________________________________________________________________________
auxilliary_output_1 (Dense)     (None, 3)            3075        dropout[0][0]
__________________________________________________________________________________________________
auxilliary_output_2 (Dense)     (None, 3)            3075        dropout_1[0][0]
==================================================================================================
Total params: 10,312,505
Trainable params: 10,312,505
Non-trainable params: 0
__________________________________________________________________________________________________


2021-10-19 09:48:43.564332: I tensorflow/compiler/mlir/mlir_graph_optimization_pass.cc:185] None of the ML
IR Optimization Passes are enabled (registered 2)


Epoch 1/100


2021-10-19 09:48:48.911158: I tensorflow/stream_executor/cuda/cuda_dnn.cc:369] Loaded cuDNN version 8005
```

```
94/94 [==============================] - 146s 1s/step - loss: 10.4544 - output_loss: 2.7401 - auxilliary_o
utput_1_loss: 3.6297 - auxilliary_output_2_loss: 4.0847 - output_accuracy: 0.5730 - auxilliary_output_1_ac
curacy: 0.5526 - auxilliary_output_2_accuracy: 0.6082 - val_loss: 2.9125 - val_output_loss: 0.9392 - val_a
uxilliary_output_1_loss: 0.9952 - val_auxilliary_output_2_loss: 0.9781 - val_output_accuracy: 0.2626 - val
_auxilliary_output_1_accuracy: 0.2456 - val_auxilliary_output_2_accuracy: 0.2456
Epoch 2/100
94/94 [==============================] - 66s 705ms/step - loss: 4.2064 - output_loss: 1.0540 - auxilliary_
output_1_loss: 1.5898 - auxilliary_output_2_loss: 1.5626 - output_accuracy: 0.6350 - auxilliary_output_1_a
ccuracy: 0.6073 - auxilliary_output_2_accuracy: 0.6292 - val_loss: 2.8147 - val_output_loss: 0.8589 - val_
auxilliary_output_1_loss: 0.9932 - val_auxilliary_output_2_loss: 0.9626 - val_output_accuracy: 0.6923 - va
l_auxilliary_output_1_accuracy: 0.2456 - val_auxilliary_output_2_accuracy: 0.2456
Epoch 3/100
94/94 [==============================] - 66s 707ms/step - loss: 2.8171 - output_loss: 0.8671 - auxilliary_
output_1_loss: 1.0495 - auxilliary_output_2_loss: 0.9005 - output_accuracy: 0.6691 - auxilliary_output_1_a
ccuracy: 0.6084 - auxilliary_output_2_accuracy: 0.5723 - val_loss: 3.0545 - val_output_loss: 0.7702 - val_
auxilliary_output_1_loss: 1.4307 - val_auxilliary_output_2_loss: 0.8536 - val_output_accuracy: 0.6923 - va
l_auxilliary_output_1_accuracy: 0.6923 - val_auxilliary_output_2_accuracy: 0.6923
Epoch 4/100
94/94 [==============================] - 67s 712ms/step - loss: 11.5128 - output_loss: 1.6595 - auxilliary
_output_1_loss: 4.7425 - auxilliary_output_2_loss: 5.1109 - output_accuracy: 0.6346 - auxilliary_output_1_
accuracy: 0.5710 - auxilliary_output_2_accuracy: 0.6093 - val_loss: 2.3050 - val_output_loss: 0.7713 - val
_auxilliary_output_1_loss: 0.7298 - val_auxilliary_output_2_loss: 0.8039 - val_output_accuracy: 0.6923 - v
al_auxilliary_output_1_accuracy: 0.6923 - val_auxilliary_output_2_accuracy: 0.6923
Epoch 5/100
94/94 [==============================] - 67s 710ms/step - loss: 6.4662 - output_loss: 1.3789 - auxilliary_
output_1_loss: 2.2838 - auxilliary_output_2_loss: 2.8035 - output_accuracy: 0.6805 - auxilliary_output_1_a
ccuracy: 0.6596 - auxilliary_output_2_accuracy: 0.6763 - val_loss: 2.5897 - val_output_loss: 0.8612 - val_
auxilliary_output_1_loss: 0.8369 - val_auxilliary_output_2_loss: 0.8915 - val_output_accuracy: 0.6923 - va
l_auxilliary_output_1_accuracy: 0.6912 - val_auxilliary_output_2_accuracy: 0.6923
Epoch 6/100
```

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94/94 [==============================] - 67s 714ms/step - loss: 3.5878 - output_loss: 0.8899 - auxilliary_
output_1_loss: 1.7354 - auxilliary_output_2_loss: 0.9625 - output_accuracy: 0.6775 - auxilliary_output_1_a
ccuracy: 0.5918 - auxilliary_output_2_accuracy: 0.6629 - val_loss: 2.3038 - val_output_loss: 0.7728 - val_
auxilliary_output_1_loss: 0.7460 - val_auxilliary_output_2_loss: 0.7850 - val_output_accuracy: 0.6923 - va
l_auxilliary_output_1_accuracy: 0.6923 - val_auxilliary_output_2_accuracy: 0.6923
Epoch 7/100
94/94 [==============================] - 67s 713ms/step - loss: 2.3564 - output_loss: 0.8313 - auxilliary_
output_1_loss: 0.7299 - auxilliary_output_2_loss: 0.7952 - output_accuracy: 0.6691 - auxilliary_output_1_a
ccuracy: 0.6789 - auxilliary_output_2_accuracy: 0.6658 - val_loss: 2.0938 - val_output_loss: 0.7285 - val_
auxilliary_output_1_loss: 0.6771 - val_auxilliary_output_2_loss: 0.6882 - val_output_accuracy: 0.6923 - va
l_auxilliary_output_1_accuracy: 0.6797 - val_auxilliary_output_2_accuracy: 0.6970
Epoch 8/100
94/94 [==============================] - 69s 729ms/step - loss: 1.9594 - output_loss: 0.7121 - auxilliary_
output_1_loss: 0.6096 - auxilliary_output_2_loss: 0.6376 - output_accuracy: 0.6962 - auxilliary_output_1_a
ccuracy: 0.6894 - auxilliary_output_2_accuracy: 0.6937 - val_loss: 1.8732 - val_output_loss: 0.6575 - val_
auxilliary_output_1_loss: 0.5925 - val_auxilliary_output_2_loss: 0.6233 - val_output_accuracy: 0.6923 - va
l_auxilliary_output_1_accuracy: 0.7255 - val_auxilliary_output_2_accuracy: 0.7096
Epoch 9/100
94/94 [==============================] - 69s 734ms/step - loss: 1.7716 - output_loss: 0.6315 - auxilliary_
output_1_loss: 0.5588 - auxilliary_output_2_loss: 0.5814 - output_accuracy: 0.6964 - auxilliary_output_1_a
ccuracy: 0.7395 - auxilliary_output_2_accuracy: 0.7193 - val_loss: 1.7408 - val_output_loss: 0.5853 - val_
auxilliary_output_1_loss: 0.5698 - val_auxilliary_output_2_loss: 0.5858 - val_output_accuracy: 0.7249 - va
l_auxilliary_output_1_accuracy: 0.7853 - val_auxilliary_output_2_accuracy: 0.7310
Epoch 10/100
94/94 [==============================] - 71s 755ms/step - loss: 1.7185 - output_loss: 0.6030 - auxilliary_
output_1_loss: 0.5485 - auxilliary_output_2_loss: 0.5670 - output_accuracy: 0.7214 - auxilliary_output_1_a
ccuracy: 0.7543 - auxilliary_output_2_accuracy: 0.7278 - val_loss: 1.8768 - val_output_loss: 0.6606 - val_
auxilliary_output_1_loss: 0.5941 - val_auxilliary_output_2_loss: 0.6221 - val_output_accuracy: 0.7364 - va
l_auxilliary_output_1_accuracy: 0.7745 - val_auxilliary_output_2_accuracy: 0.7480
Epoch 11/100
94/94 [==============================] - 72s 771ms/step - loss: 1.6171 - output_loss: 0.5741 - auxilliary_
```

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output_1_loss: 0.5176 - auxilliary_output_2_loss: 0.5253 - output_accuracy: 0.7162 - auxilliary_output_1_a
ccuracy: 0.7742 - auxilliary_output_2_accuracy: 0.7636 - val_loss: 1.7763 - val_output_loss: 0.5977 - val_
auxilliary_output_1_loss: 0.5852 - val_auxilliary_output_2_loss: 0.5934 - val_output_accuracy: 0.7385 - va
l_auxilliary_output_1_accuracy: 0.7626 - val_auxilliary_output_2_accuracy: 0.7401
Epoch 12/100
94/94 [==============================] - 72s 767ms/step - loss: 1.5291 - output_loss: 0.5458 - auxilliary_
output_1_loss: 0.4855 - auxilliary_output_2_loss: 0.4978 - output_accuracy: 0.7211 - auxilliary_output_1_a
ccuracy: 0.7848 - auxilliary_output_2_accuracy: 0.7729 - val_loss: 1.6041 - val_output_loss: 0.5643 - val_
auxilliary_output_1_loss: 0.5223 - val_auxilliary_output_2_loss: 0.5175 - val_output_accuracy: 0.7446 - va
l_auxilliary_output_1_accuracy: 0.8268 - val_auxilliary_output_2_accuracy: 0.8268
Epoch 13/100
94/94 [==============================] - 73s 775ms/step - loss: 1.3763 - output_loss: 0.4946 - auxilliary_
output_1_loss: 0.4333 - auxilliary_output_2_loss: 0.4485 - output_accuracy: 0.7771 - auxilliary_output_1_a
ccuracy: 0.8294 - auxilliary_output_2_accuracy: 0.8195 - val_loss: 1.6276 - val_output_loss: 0.6236 - val_
auxilliary_output_1_loss: 0.4946 - val_auxilliary_output_2_loss: 0.5094 - val_output_accuracy: 0.7680 - va
l_auxilliary_output_1_accuracy: 0.8516 - val_auxilliary_output_2_accuracy: 0.8325
Epoch 14/100
94/94 [==============================] - 70s 742ms/step - loss: 1.2973 - output_loss: 0.4998 - auxilliary_
output_1_loss: 0.3859 - auxilliary_output_2_loss: 0.4116 - output_accuracy: 0.7820 - auxilliary_output_1_a
ccuracy: 0.8409 - auxilliary_output_2_accuracy: 0.8288 - val_loss: 1.3575 - val_output_loss: 0.5236 - val_
auxilliary_output_1_loss: 0.4053 - val_auxilliary_output_2_loss: 0.4286 - val_output_accuracy: 0.7469 - va
l_auxilliary_output_1_accuracy: 0.8655 - val_auxilliary_output_2_accuracy: 0.8461
Epoch 15/100
94/94 [==============================] - 68s 726ms/step - loss: 1.3400 - output_loss: 0.5016 - auxilliary_
output_1_loss: 0.4178 - auxilliary_output_2_loss: 0.4206 - output_accuracy: 0.7811 - auxilliary_output_1_a
ccuracy: 0.8229 - auxilliary_output_2_accuracy: 0.8192 - val_loss: 1.4256 - val_output_loss: 0.5284 - val_
auxilliary_output_1_loss: 0.4367 - val_auxilliary_output_2_loss: 0.4604 - val_output_accuracy: 0.7863 - va
l_auxilliary_output_1_accuracy: 0.8400 - val_auxilliary_output_2_accuracy: 0.8125
Epoch 16/100
94/94 [==============================] - 73s 770ms/step - loss: 1.3080 - output_loss: 0.4789 - auxilliary_
output_1_loss: 0.4059 - auxilliary_output_2_loss: 0.4232 - output_accuracy: 0.7866 - auxilliary_output_1_a
```

```
ccuracy: 0.8301 - auxilliary_output_2_accuracy: 0.8190 - val_loss: 1.4450 - val_output_loss: 0.5480 - val_
auxilliary_output_1_loss: 0.4400 - val_auxilliary_output_2_loss: 0.4569 - val_output_accuracy: 0.7993 - va
l_auxilliary_output_1_accuracy: 0.8332 - val_auxilliary_output_2_accuracy: 0.8207
Epoch 17/100
94/94 [==============================] - 73s 775ms/step - loss: 1.1820 - output_loss: 0.4326 - auxilliary_
output_1_loss: 0.3670 - auxilliary_output_2_loss: 0.3825 - output_accuracy: 0.8143 - auxilliary_output_1_a
ccuracy: 0.8522 - auxilliary_output_2_accuracy: 0.8431 - val_loss: 1.4444 - val_output_loss: 0.5240 - val_
auxilliary_output_1_loss: 0.4648 - val_auxilliary_output_2_loss: 0.4556 - val_output_accuracy: 0.7846 - va
l_auxilliary_output_1_accuracy: 0.8091 - val_auxilliary_output_2_accuracy: 0.8200
Epoch 18/100
94/94 [==============================] - 71s 754ms/step - loss: 1.1653 - output_loss: 0.4263 - auxilliary_
output_1_loss: 0.3650 - auxilliary_output_2_loss: 0.3740 - output_accuracy: 0.8228 - auxilliary_output_1_a
ccuracy: 0.8524 - auxilliary_output_2_accuracy: 0.8483 - val_loss: 1.3411 - val_output_loss: 0.5086 - val_
auxilliary_output_1_loss: 0.4078 - val_auxilliary_output_2_loss: 0.4247 - val_output_accuracy: 0.8482 - va
l_auxilliary_output_1_accuracy: 0.8679 - val_auxilliary_output_2_accuracy: 0.8590
Epoch 19/100
94/94 [==============================] - 68s 719ms/step - loss: 1.1365 - output_loss: 0.4476 - auxilliary_
output_1_loss: 0.3344 - auxilliary_output_2_loss: 0.3545 - output_accuracy: 0.8321 - auxilliary_output_1_a
ccuracy: 0.8662 - auxilliary_output_2_accuracy: 0.8606 - val_loss: 1.2713 - val_output_loss: 0.4421 - val_
auxilliary_output_1_loss: 0.4014 - val_auxilliary_output_2_loss: 0.4278 - val_output_accuracy: 0.8196 - va
l_auxilliary_output_1_accuracy: 0.8529 - val_auxilliary_output_2_accuracy: 0.8322
Epoch 20/100
94/94 [==============================] - 68s 723ms/step - loss: 1.1609 - output_loss: 0.4169 - auxilliary_
output_1_loss: 0.3574 - auxilliary_output_2_loss: 0.3866 - output_accuracy: 0.8386 - auxilliary_output_1_a
ccuracy: 0.8622 - auxilliary_output_2_accuracy: 0.8535 - val_loss: 1.2725 - val_output_loss: 0.4531 - val_
auxilliary_output_1_loss: 0.4079 - val_auxilliary_output_2_loss: 0.4116 - val_output_accuracy: 0.8346 - va
l_auxilliary_output_1_accuracy: 0.8594 - val_auxilliary_output_2_accuracy: 0.8505
Epoch 21/100
94/94 [==============================] - 68s 725ms/step - loss: 0.9767 - output_loss: 0.3589 - auxilliary_
output_1_loss: 0.3015 - auxilliary_output_2_loss: 0.3163 - output_accuracy: 0.8595 - auxilliary_output_1_a
ccuracy: 0.8820 - auxilliary_output_2_accuracy: 0.8779 - val_loss: 1.2807 - val_output_loss: 0.4669 - val_
```

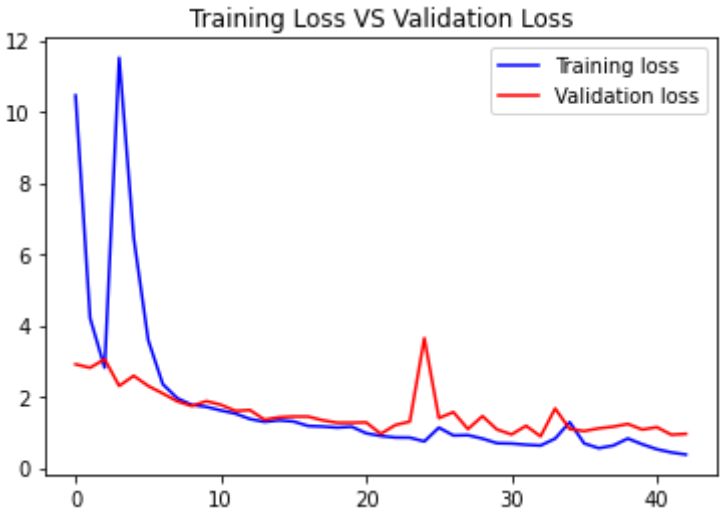
```
auxilliary_output_1_loss: 0.4034 - val_auxilliary_output_2_loss: 0.4104 - val_output_accuracy: 0.8295 - va
l_auxilliary_output_1_accuracy: 0.8954 - val_auxilliary_output_2_accuracy: 0.8781
Epoch 22/100
94/94 [==============================] - 68s 721ms/step - loss: 0.9016 - output_loss: 0.3349 - auxilliary_
output_1_loss: 0.2746 - auxilliary_output_2_loss: 0.2921 - output_accuracy: 0.8696 - auxilliary_output_1_a
ccuracy: 0.8922 - auxilliary_output_2_accuracy: 0.8885 - val_loss: 0.9594 - val_output_loss: 0.3227 - val_
auxilliary_output_1_loss: 0.3181 - val_auxilliary_output_2_loss: 0.3186 - val_output_accuracy: 0.8947 - va
l_auxilliary_output_1_accuracy: 0.9049 - val_auxilliary_output_2_accuracy: 0.8984
Epoch 23/100
94/94 [==============================] - 68s 719ms/step - loss: 0.8581 - output_loss: 0.3158 - auxilliary_
output_1_loss: 0.2603 - auxilliary_output_2_loss: 0.2820 - output_accuracy: 0.8769 - auxilliary_output_1_a
ccuracy: 0.9012 - auxilliary_output_2_accuracy: 0.8930 - val_loss: 1.2069 - val_output_loss: 0.3849 - val_
auxilliary_output_1_loss: 0.4161 - val_auxilliary_output_2_loss: 0.4058 - val_output_accuracy: 0.8641 - va
l_auxilliary_output_1_accuracy: 0.8512 - val_auxilliary_output_2_accuracy: 0.8668
Epoch 24/100
94/94 [==============================] - 68s 719ms/step - loss: 0.8547 - output_loss: 0.3082 - auxilliary_
output_1_loss: 0.2682 - auxilliary_output_2_loss: 0.2783 - output_accuracy: 0.8786 - auxilliary_output_1_a
ccuracy: 0.8968 - auxilliary_output_2_accuracy: 0.8914 - val_loss: 1.3040 - val_output_loss: 0.4884 - val_
auxilliary_output_1_loss: 0.4003 - val_auxilliary_output_2_loss: 0.4153 - val_output_accuracy: 0.8815 - va
l_auxilliary_output_1_accuracy: 0.8906 - val_auxilliary_output_2_accuracy: 0.8961
Epoch 25/100
94/94 [==============================] - 67s 714ms/step - loss: 0.7474 - output_loss: 0.2633 - auxilliary_
output_1_loss: 0.2360 - auxilliary_output_2_loss: 0.2481 - output_accuracy: 0.9010 - auxilliary_output_1_a
ccuracy: 0.9132 - auxilliary_output_2_accuracy: 0.9086 - val_loss: 3.6459 - val_output_loss: 1.9100 - val_
auxilliary_output_1_loss: 0.8462 - val_auxilliary_output_2_loss: 0.8897 - val_output_accuracy: 0.7548 - va
l_auxilliary_output_1_accuracy: 0.7721 - val_auxilliary_output_2_accuracy: 0.7704
Epoch 26/100
94/94 [==============================] - 67s 710ms/step - loss: 1.1348 - output_loss: 0.4410 - auxilliary_
output_1_loss: 0.3344 - auxilliary_output_2_loss: 0.3594 - output_accuracy: 0.8393 - auxilliary_output_1_a
ccuracy: 0.8707 - auxilliary_output_2_accuracy: 0.8614 - val_loss: 1.4021 - val_output_loss: 0.5212 - val_
auxilliary_output_1_loss: 0.4201 - val_auxilliary_output_2_loss: 0.4607 - val_output_accuracy: 0.8244 - va
```

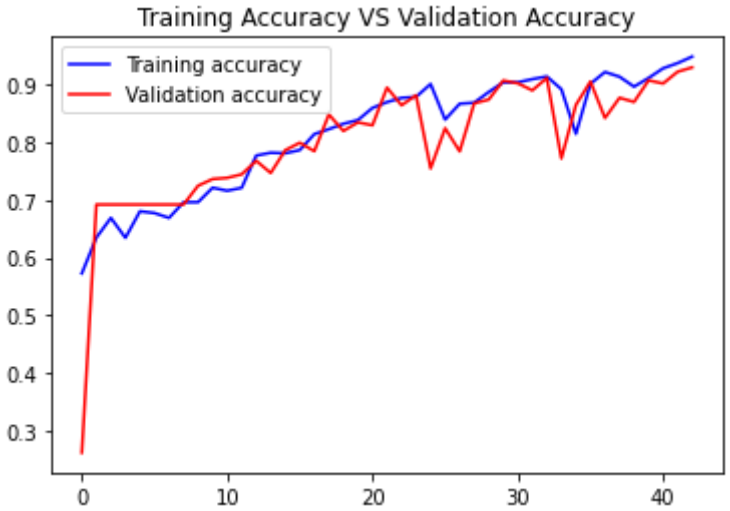
```
l_auxilliary_output_1_accuracy: 0.8913 - val_auxilliary_output_2_accuracy: 0.8804
Epoch 27/100
94/94 [==============================] - 67s 710ms/step - loss: 0.9151 - output_loss: 0.3422 - auxilliary_
output_1_loss: 0.2763 - auxilliary_output_2_loss: 0.2966 - output_accuracy: 0.8668 - auxilliary_output_1_a
ccuracy: 0.8941 - auxilliary_output_2_accuracy: 0.8861 - val_loss: 1.5706 - val_output_loss: 0.5607 - val_
auxilliary_output_1_loss: 0.5141 - val_auxilliary_output_2_loss: 0.4958 - val_output_accuracy: 0.7843 - va
l_auxilliary_output_1_accuracy: 0.8091 - val_auxilliary_output_2_accuracy: 0.8190
Epoch 28/100
94/94 [==============================] - 67s 708ms/step - loss: 0.9238 - output_loss: 0.3296 - auxilliary_
output_1_loss: 0.2894 - auxilliary_output_2_loss: 0.3048 - output_accuracy: 0.8686 - auxilliary_output_1_a
ccuracy: 0.8841 - auxilliary_output_2_accuracy: 0.8762 - val_loss: 1.0947 - val_output_loss: 0.3808 - val_
auxilliary_output_1_loss: 0.3568 - val_auxilliary_output_2_loss: 0.3571 - val_output_accuracy: 0.8675 - va
l_auxilliary_output_1_accuracy: 0.8835 - val_auxilliary_output_2_accuracy: 0.8862
Epoch 29/100
94/94 [==============================] - 67s 711ms/step - loss: 0.8259 - output_loss: 0.2960 - auxilliary_
output_1_loss: 0.2596 - auxilliary_output_2_loss: 0.2703 - output_accuracy: 0.8871 - auxilliary_output_1_a
ccuracy: 0.8993 - auxilliary_output_2_accuracy: 0.8970 - val_loss: 1.4568 - val_output_loss: 0.5047 - val_
auxilliary_output_1_loss: 0.4585 - val_auxilliary_output_2_loss: 0.4936 - val_output_accuracy: 0.8740 - va
l_auxilliary_output_1_accuracy: 0.8668 - val_auxilliary_output_2_accuracy: 0.8607
Epoch 30/100
94/94 [==============================] - 67s 710ms/step - loss: 0.6984 - output_loss: 0.2500 - auxilliary_
output_1_loss: 0.2152 - auxilliary_output_2_loss: 0.2331 - output_accuracy: 0.9039 - auxilliary_output_1_a
ccuracy: 0.9187 - auxilliary_output_2_accuracy: 0.9117 - val_loss: 1.0828 - val_output_loss: 0.3679 - val_
auxilliary_output_1_loss: 0.3604 - val_auxilliary_output_2_loss: 0.3544 - val_output_accuracy: 0.9069 - va
l_auxilliary_output_1_accuracy: 0.9073 - val_auxilliary_output_2_accuracy: 0.9113
Epoch 31/100
94/94 [==============================] - 66s 705ms/step - loss: 0.6892 - output_loss: 0.2488 - auxilliary_
output_1_loss: 0.2136 - auxilliary_output_2_loss: 0.2268 - output_accuracy: 0.9038 - auxilliary_output_1_a
ccuracy: 0.9187 - auxilliary_output_2_accuracy: 0.9125 - val_loss: 0.9428 - val_output_loss: 0.3267 - val_
auxilliary_output_1_loss: 0.3079 - val_auxilliary_output_2_loss: 0.3082 - val_output_accuracy: 0.9022 - va
l_auxilliary_output_1_accuracy: 0.9120 - val_auxilliary_output_2_accuracy: 0.9076
```

```
Epoch 32/100
94/94 [==============================] - 67s 710ms/step - loss: 0.6543 - output_loss: 0.2318 - auxilliary_
output_1_loss: 0.2091 - auxilliary_output_2_loss: 0.2134 - output_accuracy: 0.9094 - auxilliary_output_1_a
ccuracy: 0.9166 - auxilliary_output_2_accuracy: 0.9148 - val_loss: 1.1860 - val_output_loss: 0.4169 - val_
auxilliary_output_1_loss: 0.3772 - val_auxilliary_output_2_loss: 0.3919 - val_output_accuracy: 0.8899 - va
l_auxilliary_output_1_accuracy: 0.9005 - val_auxilliary_output_2_accuracy: 0.8967
Epoch 33/100
94/94 [==============================] - 67s 711ms/step - loss: 0.6329 - output_loss: 0.2194 - auxilliary_
output_1_loss: 0.1965 - auxilliary_output_2_loss: 0.2170 - output_accuracy: 0.9140 - auxilliary_output_1_a
ccuracy: 0.9241 - auxilliary_output_2_accuracy: 0.9196 - val_loss: 0.8897 - val_output_loss: 0.3060 - val_
auxilliary_output_1_loss: 0.2906 - val_auxilliary_output_2_loss: 0.2932 - val_output_accuracy: 0.9113 - va
l_auxilliary_output_1_accuracy: 0.9198 - val_auxilliary_output_2_accuracy: 0.9178
Epoch 34/100
94/94 [==============================] - 68s 723ms/step - loss: 0.8270 - output_loss: 0.2902 - auxilliary_
output_1_loss: 0.2682 - auxilliary_output_2_loss: 0.2685 - output_accuracy: 0.8920 - auxilliary_output_1_a
ccuracy: 0.8988 - auxilliary_output_2_accuracy: 0.8975 - val_loss: 1.6724 - val_output_loss: 0.5224 - val_
auxilliary_output_1_loss: 0.6542 - val_auxilliary_output_2_loss: 0.4958 - val_output_accuracy: 0.7721 - va
l_auxilliary_output_1_accuracy: 0.6416 - val_auxilliary_output_2_accuracy: 0.7857
Epoch 35/100
94/94 [==============================] - 74s 783ms/step - loss: 1.2889 - output_loss: 0.4009 - auxilliary_
output_1_loss: 0.4983 - auxilliary_output_2_loss: 0.3896 - output_accuracy: 0.8147 - auxilliary_output_1_a
ccuracy: 0.8248 - auxilliary_output_2_accuracy: 0.8320 - val_loss: 1.0953 - val_output_loss: 0.3817 - val_
auxilliary_output_1_loss: 0.3559 - val_auxilliary_output_2_loss: 0.3577 - val_output_accuracy: 0.8648 - va
l_auxilliary_output_1_accuracy: 0.8869 - val_auxilliary_output_2_accuracy: 0.8723
Epoch 36/100
94/94 [==============================] - 76s 804ms/step - loss: 0.6913 - output_loss: 0.2439 - auxilliary_
output_1_loss: 0.2199 - auxilliary_output_2_loss: 0.2275 - output_accuracy: 0.9014 - auxilliary_output_1_a
ccuracy: 0.9152 - auxilliary_output_2_accuracy: 0.9136 - val_loss: 1.0381 - val_output_loss: 0.3595 - val_
auxilliary_output_1_loss: 0.3257 - val_auxilliary_output_2_loss: 0.3529 - val_output_accuracy: 0.9052 - va
l_auxilliary_output_1_accuracy: 0.9086 - val_auxilliary_output_2_accuracy: 0.9049
Epoch 37/100
```

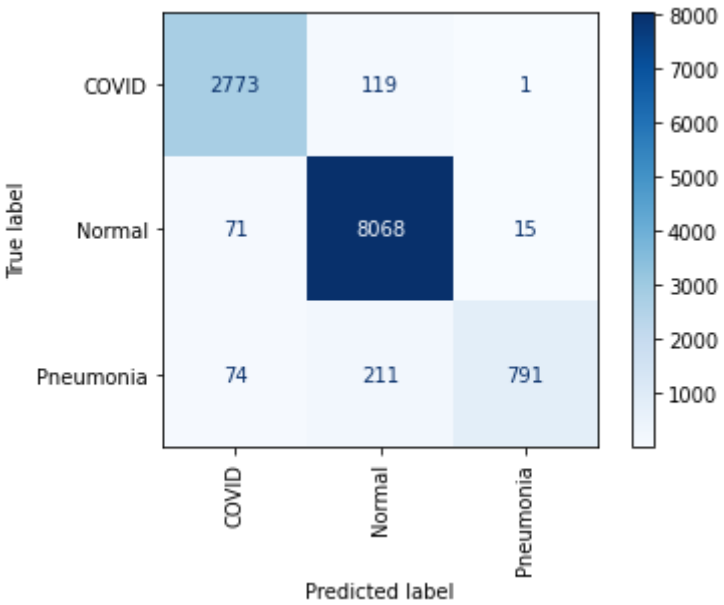
```
94/94 [==============================] - 75s 799ms/step - loss: 0.5583 - output_loss: 0.1961 - auxilliary_
output_1_loss: 0.1764 - auxilliary_output_2_loss: 0.1858 - output_accuracy: 0.9217 - auxilliary_output_1_a
ccuracy: 0.9335 - auxilliary_output_2_accuracy: 0.9301 - val_loss: 1.1141 - val_output_loss: 0.3846 - val_
auxilliary_output_1_loss: 0.3536 - val_auxilliary_output_2_loss: 0.3758 - val_output_accuracy: 0.8421 - va
l_auxilliary_output_1_accuracy: 0.9076 - val_auxilliary_output_2_accuracy: 0.8451
Epoch 38/100
94/94 [==============================] - 70s 739ms/step - loss: 0.6315 - output_loss: 0.2245 - auxilliary_
output_1_loss: 0.2032 - auxilliary_output_2_loss: 0.2038 - output_accuracy: 0.9135 - auxilliary_output_1_a
ccuracy: 0.9256 - auxilliary_output_2_accuracy: 0.9219 - val_loss: 1.1620 - val_output_loss: 0.3888 - val_
auxilliary_output_1_loss: 0.3907 - val_auxilliary_output_2_loss: 0.3825 - val_output_accuracy: 0.8770 - va
l_auxilliary_output_1_accuracy: 0.8825 - val_auxilliary_output_2_accuracy: 0.8638
Epoch 39/100
94/94 [==============================] - 67s 710ms/step - loss: 0.8293 - output_loss: 0.2853 - auxilliary_
output_1_loss: 0.2745 - auxilliary_output_2_loss: 0.2695 - output_accuracy: 0.8964 - auxilliary_output_1_a
ccuracy: 0.8998 - auxilliary_output_2_accuracy: 0.8983 - val_loss: 1.2375 - val_output_loss: 0.4359 - val_
auxilliary_output_1_loss: 0.4079 - val_auxilliary_output_2_loss: 0.3937 - val_output_accuracy: 0.8699 - va
l_auxilliary_output_1_accuracy: 0.8818 - val_auxilliary_output_2_accuracy: 0.8753
Epoch 40/100
94/94 [==============================] - 67s 710ms/step - loss: 0.6668 - output_loss: 0.2406 - auxilliary_
output_1_loss: 0.2053 - auxilliary_output_2_loss: 0.2210 - output_accuracy: 0.9114 - auxilliary_output_1_a
ccuracy: 0.9236 - auxilliary_output_2_accuracy: 0.9214 - val_loss: 1.0799 - val_output_loss: 0.3690 - val_
auxilliary_output_1_loss: 0.3494 - val_auxilliary_output_2_loss: 0.3616 - val_output_accuracy: 0.9073 - va
l_auxilliary_output_1_accuracy: 0.9103 - val_auxilliary_output_2_accuracy: 0.8978
Epoch 41/100
94/94 [==============================] - 67s 712ms/step - loss: 0.5282 - output_loss: 0.1885 - auxilliary_
output_1_loss: 0.1627 - auxilliary_output_2_loss: 0.1770 - output_accuracy: 0.9281 - auxilliary_output_1_a
ccuracy: 0.9390 - auxilliary_output_2_accuracy: 0.9352 - val_loss: 1.1469 - val_output_loss: 0.3996 - val_
auxilliary_output_1_loss: 0.3599 - val_auxilliary_output_2_loss: 0.3874 - val_output_accuracy: 0.9018 - va
l_auxilliary_output_1_accuracy: 0.9151 - val_auxilliary_output_2_accuracy: 0.9052
Epoch 42/100
94/94 [==============================] - 67s 717ms/step - loss: 0.4387 - output_loss: 0.1632 - auxilliary_
```

```
output_1_loss: 0.1315 - auxilliary_output_2_loss: 0.1441 - output_accuracy: 0.9371 - auxilliary_output_1_a
ccuracy: 0.9516 - auxilliary_output_2_accuracy: 0.9457 - val_loss: 0.9355 - val_output_loss: 0.3220 - val_
auxilliary_output_1_loss: 0.2999 - val_auxilliary_output_2_loss: 0.3136 - val_output_accuracy: 0.9222 - va
l_auxilliary_output_1_accuracy: 0.9321 - val_auxilliary_output_2_accuracy: 0.9300
Epoch 43/100
94/94 [==============================] - 78s 830ms/step - loss: 0.3792 - output_loss: 0.1400 - auxilliary_
output_1_loss: 0.1138 - auxilliary_output_2_loss: 0.1254 - output_accuracy: 0.9484 - auxilliary_output_1_a
ccuracy: 0.9576 - auxilliary_output_2_accuracy: 0.9537 - val_loss: 0.9593 - val_output_loss: 0.3252 - val_
auxilliary_output_1_loss: 0.3111 - val_auxilliary_output_2_loss: 0.3230 - val_output_accuracy: 0.9297 - va
l_auxilliary_output_1_accuracy: 0.9293 - val_auxilliary_output_2_accuracy: 0.9293
```

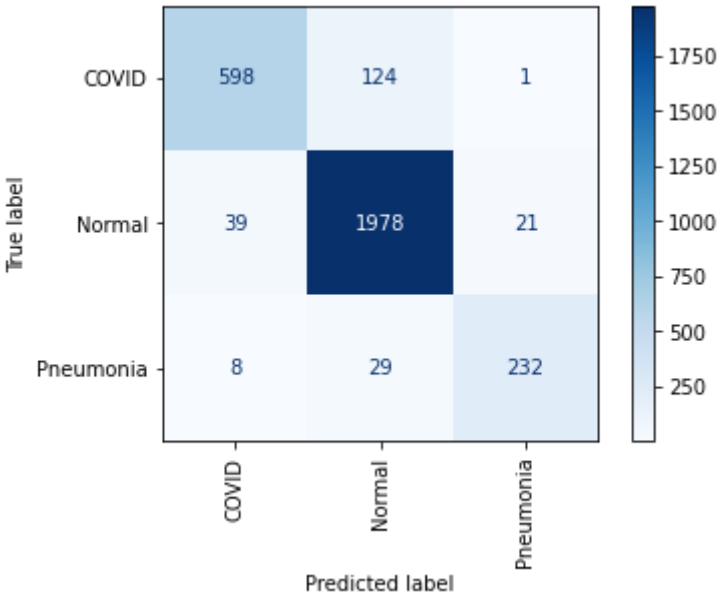





```
Model saved successfully!
Confusion matrix for train data:
95/95 [==============================] - 52s 544ms/step - loss: 0.2735 - output_loss: 0.1026 - auxilliary_
output_1_loss: 0.0816 - auxilliary_output_2_loss: 0.0893 - output_accuracy: 0.9595 - auxilliary_output_1_a
ccuracy: 0.9677 - auxilliary_output_2_accuracy: 0.9666
Score = [0.2734605371952057, 0.10262028872966766, 0.08156668394804001, 0.08927353471517563, 0.959498465061
1877, 0.9676647782325745, 0.9665924310684204]
Accuracy  =  0.9594984739750887
```




```
Confusion matrix for val/test data:
24/24 [==============================] - 13s 534ms/step - loss: 0.9628 - output_loss: 0.3269 - auxilliary_
output_1_loss: 0.3118 - auxilliary_output_2_loss: 0.3242 - output_accuracy: 0.9267 - auxilliary_output_1_a
ccuracy: 0.9277 - auxilliary_output_2_accuracy: 0.9277
Score = [0.9628267884254456, 0.3268653452396393, 0.31176432967185974, 0.3241971433162689, 0.92673265933990
48, 0.9277227520942688, 0.9277227520942688]
Accuracy  =  0.9267326732673268
```


COVID
Normal
Pneumonia
True label
598
124
1
39
1978
21
8
29
232
COVID
Normal
Pneumonia
Predicted label
1750
1500
1250
1000
750
500
250