from \_\_future\_\_ import absolute\_import, division, print\_function, unicode\_literals  
import tensorflow as tf  
  
# Extract dataset  
import os  
import tarfile  
  
import keras\_preprocessing  
from keras\_preprocessing.image import ImageDataGenerator # Data preprocessing and augmentation  
  
import sklearn  
import numpy as np

The default version of TensorFlow in Colab will soon switch to TensorFlow 2.x. We recommend you upgrade now or ensure your notebook will continue to use TensorFlow 1.x via the %tensorflow\_version 1.x magic: more info.

print(tf.\_\_version\_\_)

1.15.0

# Make folder for chest xray data  
!mkdir /content/data/  
  
# Make directory to save weights  
!mkdir /content/data/model  
  
# Make directory to logs for Tensorboard  
!mkdir /content/data/graph  
  
# Download dataset  
!wget --no-check-certificate \  
 https://s3.eu-central-1.amazonaws.com/public.unit8.co/data/chest\_xray.tar.gz \  
 -O /content/data/chest\_xray.tar.gz  
   
tar = tarfile.open("data/chest\_xray.tar.gz")  
tar.extractall(path='./data/')  
os.remove('data/chest\_xray.tar.gz')

--2019-10-31 04:30:59-- https://s3.eu-central-1.amazonaws.com/public.unit8.co/data/chest\_xray.tar.gz  
Resolving s3.eu-central-1.amazonaws.com (s3.eu-central-1.amazonaws.com)... 52.219.74.151  
Connecting to s3.eu-central-1.amazonaws.com (s3.eu-central-1.amazonaws.com)|52.219.74.151|:443... connected.  
HTTP request sent, awaiting response... 200 OK  
Length: 1225393795 (1.1G) [application/x-gzip]  
Saving to: ‘/content/data/chest\_xray.tar.gz’  
  
/content/data/chest 100%[===================>] 1.14G 30.0MB/s in 40s   
  
2019-10-31 04:31:39 (29.2 MB/s) - ‘/content/data/chest\_xray.tar.gz’ saved [1225393795/1225393795]

Change log: > training\_datagen –> ImageDataGenerator

trainable layer –> All except base

20 layers VGG16 model - base, flat, dense

**Optimizer = RMSprop(learning\_rate = 0.001)**

loss = categorical\_crosscentropy

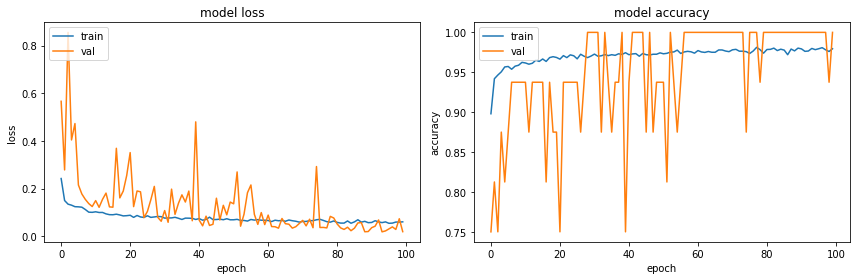
callback = [checkpoints]

epochs = 100

no class weight balancing

TRAINING\_DIR = "/content/data/chest\_xray/train"  
VALIDATION\_DIR = "/content/data/chest\_xray/val"  
TEST\_DIR = "/content/data/chest\_xray/test"  
  
# Data preprocessing  
training\_datagen = ImageDataGenerator(  
 preprocessing\_function=tf.keras.applications.vgg16.preprocess\_input,  
 rescale = 1./255,  
# rotation\_range=40,  
 # width\_shift\_range=0.2,  
 # height\_shift\_range=0.2,  
 shear\_range=0.2,  
 zoom\_range=0.2,  
 horizontal\_flip=True,  
 # vertical\_flip=True  
 fill\_mode='nearest'  
)  
  
validation\_datagen = ImageDataGenerator(  
 rescale = 1./255  
)  
  
test\_datagen = ImageDataGenerator(  
 rescale = 1./255  
)  
  
# Create training data batch  
train\_generator = training\_datagen.flow\_from\_directory(  
 TRAINING\_DIR,  
 target\_size=(150,150),  
 class\_mode='categorical'  
)  
  
validation\_generator = validation\_datagen.flow\_from\_directory(  
 VALIDATION\_DIR,  
 target\_size=(150,150),  
 class\_mode='categorical'  
)  
  
test\_generator = test\_datagen.flow\_from\_directory(  
 TEST\_DIR,  
 target\_size=(150,150),  
 class\_mode='categorical',  
 shuffle=False  
)  
  
train\_shape = train\_generator.image\_shape  
  
tf.keras.backend.clear\_session() # Destroys the current TF graph and creates a new one.  
  
base\_model = tf.keras.applications.VGG16(weights='imagenet', include\_top=False, input\_shape=train\_shape)  
  
# Define the machine learning model  
x = base\_model.output  
x = tf.keras.layers.Flatten()(x)  
x = tf.keras.layers.Dense(2, 'softmax')(x)  
  
model = tf.keras.Model(inputs=base\_model.input, outputs=x)  
  
# for layer in model.layers[0:20]:  
# layer.trainable = False  
  
for layer in base\_model.layers:  
 layer.trainable = False  
  
optimizer = tf.keras.optimizers.RMSprop(learning\_rate=0.001)  
  
model.compile(loss='categorical\_crossentropy',   
 optimizer=optimizer,   
 metrics=['accuracy'])  
  
# Callbacks stuff  
# Function to save the weights of the model after each epoch  
checkpoint = tf.keras.callbacks.ModelCheckpoint(  
 '/content/data/model/weights.epoch\_{epoch:02d}.hdf5',  
 monitor='val\_accuracy',  
 save\_best\_only=False,  
 save\_weights\_only=False,  
 mode='auto',  
 verbose=1  
)  
  
# Function to stop training early if there's no improvement  
early\_stopping\_monitor = tf.keras.callbacks.EarlyStopping(patience = 3, monitor = "val\_loss", mode="auto", verbose = 1)  
  
lr\_reduce = tf.keras.callbacks.ReduceLROnPlateau(monitor='val\_loss', factor=0.3, patience=2, verbose=1, mode='max')  
  
classweight = sklearn.utils.class\_weight.compute\_class\_weight('balanced', np.unique(train\_generator.labels), train\_generator.labels)  
print(classweight)  
  
batch\_size = 32  
epochs = 100  
  
# Training process  
history = model.fit\_generator(  
 generator=train\_generator,   
 # steps\_per\_epoch=train\_generator.samples//batch\_size,   
 epochs=epochs,  
 # callbacks=[early\_stopping\_monitor],  
 callbacks=[checkpoint],  
 # shuffle=True,   
 validation\_data=validation\_generator,   
 # validation\_steps= validation\_generator//batch\_size, #no because it's gonna be 0... if leave alone its len(generator) which is equal to 1.   
 # class\_weight=classweight,  
 verbose = 1  
)  
  
## Graph loss and acc  
import matplotlib.pyplot as plt  
def plot\_learning\_curves(history):  
 plt.figure(figsize=(12,4))  
   
 plt.subplot(1,2,1)  
 plt.plot(history.history['loss'])  
 plt.plot(history.history['val\_loss'])  
 plt.title('model loss')  
 plt.ylabel('loss')  
 plt.xlabel('epoch')  
 plt.legend(['train', 'val'], loc='upper left')  
   
 plt.subplot(1,2,2)  
 plt.plot(history.history['acc'])  
 plt.plot(history.history['val\_acc'])  
 plt.title('model accuracy')  
 plt.ylabel('accuracy')  
 plt.xlabel('epoch')  
 plt.legend(['train', 'val'], loc='upper left')  
   
 plt.tight\_layout()  
   
plot\_learning\_curves(history)  
  
  
## Evaualate  
test\_loss, test\_acc = model.evaluate\_generator(generator=test\_generator, verbose=1)  
  
## Load best weight  
idx = np.argmin(history.history['val\_loss'])   
model.load\_weights("/content/data/model/weights.epoch\_{:02d}.hdf5".format(idx + 1))  
  
print("Loading the best model")  
print("epoch: {}, val\_loss: {}, val\_acc: {}".format(idx + 1, history.history['val\_loss'][idx], history.history['val\_acc'][idx]))  
  
## Evaluate the best weight  
test\_loss, test\_acc = model.evaluate\_generator(generator=test\_generator, verbose=1)  
  
## Test analytics  
from sklearn.metrics import accuracy\_score, confusion\_matrix  
  
test\_generator.reset()  
test\_preds = model.predict\_generator(test\_generator, verbose=1)  
test\_preds = np.argmax(test\_preds,axis=1)  
  
acc = accuracy\_score(test\_generator.classes, test\_preds)\*100  
cm = confusion\_matrix(test\_generator.classes, test\_preds)  
tn, fp, fn, tp = cm.ravel()  
  
print('CONFUSION MATRIX ------------------')  
print(cm)  
# plot\_confusion\_matrix(cm, target\_names=['NORMAL', 'PNEUMONIA'], normalize=False)  
  
  
print('\nTEST METRICS ----------------------')  
precision = tp/(tp+fp)\*100  
recall = tp/(tp+fn)\*100  
print('Accuracy: {}%'.format(acc))  
print('Precision: {}%'.format(precision))  
print('Recall: {}%'.format(recall))  
print('F1-score: {}'.format(2\*precision\*recall/(precision+recall)))  
  
print('\nTRAIN METRIC ----------------------')  
print('Train acc: {}%'.format(np.round((history.history['acc'][-1])\*100, 14)))

Found 5216 images belonging to 2 classes.  
Found 16 images belonging to 2 classes.  
Found 624 images belonging to 2 classes.  
[1.9448173 0.67303226]  
Epoch 1/100  
162/163 [============================>.] - ETA: 0s - loss: 0.2429 - acc: 0.8978Epoch 1/100  
 1/163 [..............................] - ETA: 4:07 - loss: 0.5661 - acc: 0.7500  
Epoch 00001: saving model to /content/data/model/weights.epoch\_01.hdf5  
163/163 [==============================] - 89s 547ms/step - loss: 0.2419 - acc: 0.8980 - val\_loss: 0.5661 - val\_acc: 0.7500  
Epoch 2/100  
162/163 [============================>.] - ETA: 0s - loss: 0.1500 - acc: 0.9417Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.2780 - acc: 0.8125  
Epoch 00002: saving model to /content/data/model/weights.epoch\_02.hdf5  
163/163 [==============================] - 88s 537ms/step - loss: 0.1495 - acc: 0.9419 - val\_loss: 0.2780 - val\_acc: 0.8125  
Epoch 3/100  
162/163 [============================>.] - ETA: 0s - loss: 0.1334 - acc: 0.9466Epoch 1/100  
 1/163 [..............................] - ETA: 54s - loss: 0.8554 - acc: 0.7500  
Epoch 00003: saving model to /content/data/model/weights.epoch\_03.hdf5  
163/163 [==============================] - 87s 537ms/step - loss: 0.1343 - acc: 0.9465 - val\_loss: 0.8554 - val\_acc: 0.7500  
Epoch 4/100  
162/163 [============================>.] - ETA: 0s - loss: 0.1295 - acc: 0.9508Epoch 1/100  
 1/163 [..............................] - ETA: 58s - loss: 0.4039 - acc: 0.8750  
Epoch 00004: saving model to /content/data/model/weights.epoch\_04.hdf5  
163/163 [==============================] - 87s 534ms/step - loss: 0.1301 - acc: 0.9505 - val\_loss: 0.4039 - val\_acc: 0.8750  
Epoch 5/100  
162/163 [============================>.] - ETA: 0s - loss: 0.1242 - acc: 0.9564Epoch 1/100  
 1/163 [..............................] - ETA: 53s - loss: 0.4727 - acc: 0.8125  
Epoch 00005: saving model to /content/data/model/weights.epoch\_05.hdf5  
163/163 [==============================] - 86s 530ms/step - loss: 0.1237 - acc: 0.9567 - val\_loss: 0.4727 - val\_acc: 0.8125  
Epoch 6/100  
162/163 [============================>.] - ETA: 0s - loss: 0.1231 - acc: 0.9574Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.2148 - acc: 0.8750  
Epoch 00006: saving model to /content/data/model/weights.epoch\_06.hdf5  
163/163 [==============================] - 87s 533ms/step - loss: 0.1231 - acc: 0.9572 - val\_loss: 0.2148 - val\_acc: 0.8750  
Epoch 7/100  
162/163 [============================>.] - ETA: 0s - loss: 0.1223 - acc: 0.9535Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.1770 - acc: 0.9375  
Epoch 00007: saving model to /content/data/model/weights.epoch\_07.hdf5  
163/163 [==============================] - 87s 536ms/step - loss: 0.1216 - acc: 0.9538 - val\_loss: 0.1770 - val\_acc: 0.9375  
Epoch 8/100  
162/163 [============================>.] - ETA: 0s - loss: 0.1123 - acc: 0.9576Epoch 1/100  
 1/163 [..............................] - ETA: 53s - loss: 0.1544 - acc: 0.9375  
Epoch 00008: saving model to /content/data/model/weights.epoch\_08.hdf5  
163/163 [==============================] - 86s 527ms/step - loss: 0.1119 - acc: 0.9576 - val\_loss: 0.1544 - val\_acc: 0.9375  
Epoch 9/100  
162/163 [============================>.] - ETA: 0s - loss: 0.1011 - acc: 0.9585Epoch 1/100  
 1/163 [..............................] - ETA: 53s - loss: 0.1367 - acc: 0.9375  
Epoch 00009: saving model to /content/data/model/weights.epoch\_09.hdf5  
163/163 [==============================] - 87s 535ms/step - loss: 0.1007 - acc: 0.9588 - val\_loss: 0.1367 - val\_acc: 0.9375  
Epoch 10/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0992 - acc: 0.9626Epoch 1/100  
 1/163 [..............................] - ETA: 54s - loss: 0.1243 - acc: 0.9375  
Epoch 00010: saving model to /content/data/model/weights.epoch\_10.hdf5  
163/163 [==============================] - 87s 533ms/step - loss: 0.1000 - acc: 0.9624 - val\_loss: 0.1243 - val\_acc: 0.9375  
Epoch 11/100  
162/163 [============================>.] - ETA: 0s - loss: 0.1025 - acc: 0.9616Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.1493 - acc: 0.9375  
Epoch 00011: saving model to /content/data/model/weights.epoch\_11.hdf5  
163/163 [==============================] - 87s 534ms/step - loss: 0.1022 - acc: 0.9617 - val\_loss: 0.1493 - val\_acc: 0.9375  
Epoch 12/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0990 - acc: 0.9601Epoch 1/100  
 1/163 [..............................] - ETA: 54s - loss: 0.1211 - acc: 0.8750  
Epoch 00012: saving model to /content/data/model/weights.epoch\_12.hdf5  
163/163 [==============================] - 87s 535ms/step - loss: 0.0993 - acc: 0.9601 - val\_loss: 0.1211 - val\_acc: 0.8750  
Epoch 13/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0991 - acc: 0.9612Epoch 1/100  
 1/163 [..............................] - ETA: 54s - loss: 0.1547 - acc: 0.9375  
Epoch 00013: saving model to /content/data/model/weights.epoch\_13.hdf5  
163/163 [==============================] - 87s 535ms/step - loss: 0.0995 - acc: 0.9613 - val\_loss: 0.1547 - val\_acc: 0.9375  
Epoch 14/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0935 - acc: 0.9651Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.1807 - acc: 0.9375  
Epoch 00014: saving model to /content/data/model/weights.epoch\_14.hdf5  
163/163 [==============================] - 86s 530ms/step - loss: 0.0935 - acc: 0.9651 - val\_loss: 0.1807 - val\_acc: 0.9375  
Epoch 15/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0903 - acc: 0.9637Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.1229 - acc: 0.9375  
Epoch 00015: saving model to /content/data/model/weights.epoch\_15.hdf5  
163/163 [==============================] - 87s 531ms/step - loss: 0.0902 - acc: 0.9636 - val\_loss: 0.1229 - val\_acc: 0.9375  
Epoch 16/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0904 - acc: 0.9664Epoch 1/100  
 1/163 [..............................] - ETA: 59s - loss: 0.1215 - acc: 0.9375  
Epoch 00016: saving model to /content/data/model/weights.epoch\_16.hdf5  
163/163 [==============================] - 87s 532ms/step - loss: 0.0899 - acc: 0.9666 - val\_loss: 0.1215 - val\_acc: 0.9375  
Epoch 17/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0922 - acc: 0.9637Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.3688 - acc: 0.8125  
Epoch 00017: saving model to /content/data/model/weights.epoch\_17.hdf5  
163/163 [==============================] - 87s 532ms/step - loss: 0.0922 - acc: 0.9636 - val\_loss: 0.3688 - val\_acc: 0.8125  
Epoch 18/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0894 - acc: 0.9682Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.1606 - acc: 0.9375  
Epoch 00018: saving model to /content/data/model/weights.epoch\_18.hdf5  
163/163 [==============================] - 85s 524ms/step - loss: 0.0890 - acc: 0.9684 - val\_loss: 0.1606 - val\_acc: 0.9375  
Epoch 19/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0851 - acc: 0.9695Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.1894 - acc: 0.8750  
Epoch 00019: saving model to /content/data/model/weights.epoch\_19.hdf5  
163/163 [==============================] - 87s 533ms/step - loss: 0.0850 - acc: 0.9695 - val\_loss: 0.1894 - val\_acc: 0.8750  
Epoch 20/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0860 - acc: 0.9688Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.2548 - acc: 0.8750  
Epoch 00020: saving model to /content/data/model/weights.epoch\_20.hdf5  
163/163 [==============================] - 86s 529ms/step - loss: 0.0860 - acc: 0.9686 - val\_loss: 0.2548 - val\_acc: 0.8750  
Epoch 21/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0882 - acc: 0.9662Epoch 1/100  
 1/163 [..............................] - ETA: 57s - loss: 0.3508 - acc: 0.7500  
Epoch 00021: saving model to /content/data/model/weights.epoch\_21.hdf5  
163/163 [==============================] - 87s 532ms/step - loss: 0.0877 - acc: 0.9664 - val\_loss: 0.3508 - val\_acc: 0.7500  
Epoch 22/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0787 - acc: 0.9709Epoch 1/100  
 1/163 [..............................] - ETA: 58s - loss: 0.1240 - acc: 0.9375  
Epoch 00022: saving model to /content/data/model/weights.epoch\_22.hdf5  
163/163 [==============================] - 86s 529ms/step - loss: 0.0788 - acc: 0.9709 - val\_loss: 0.1240 - val\_acc: 0.9375  
Epoch 23/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0871 - acc: 0.9682Epoch 1/100  
 1/163 [..............................] - ETA: 57s - loss: 0.1897 - acc: 0.9375  
Epoch 00023: saving model to /content/data/model/weights.epoch\_23.hdf5  
163/163 [==============================] - 87s 533ms/step - loss: 0.0867 - acc: 0.9684 - val\_loss: 0.1897 - val\_acc: 0.9375  
Epoch 24/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0806 - acc: 0.9720Epoch 1/100  
 1/163 [..............................] - ETA: 59s - loss: 0.1861 - acc: 0.9375  
Epoch 00024: saving model to /content/data/model/weights.epoch\_24.hdf5  
163/163 [==============================] - 87s 535ms/step - loss: 0.0806 - acc: 0.9718 - val\_loss: 0.1861 - val\_acc: 0.9375  
Epoch 25/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0777 - acc: 0.9709Epoch 1/100  
 1/163 [..............................] - ETA: 57s - loss: 0.0779 - acc: 0.9375  
Epoch 00025: saving model to /content/data/model/weights.epoch\_25.hdf5  
163/163 [==============================] - 87s 536ms/step - loss: 0.0786 - acc: 0.9707 - val\_loss: 0.0779 - val\_acc: 0.9375  
Epoch 26/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0848 - acc: 0.9674Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.1038 - acc: 0.9375  
Epoch 00026: saving model to /content/data/model/weights.epoch\_26.hdf5  
163/163 [==============================] - 87s 536ms/step - loss: 0.0855 - acc: 0.9668 - val\_loss: 0.1038 - val\_acc: 0.9375  
Epoch 27/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0792 - acc: 0.9724Epoch 1/100  
 1/163 [..............................] - ETA: 54s - loss: 0.1531 - acc: 0.8750  
Epoch 00027: saving model to /content/data/model/weights.epoch\_27.hdf5  
163/163 [==============================] - 87s 535ms/step - loss: 0.0788 - acc: 0.9726 - val\_loss: 0.1531 - val\_acc: 0.8750  
Epoch 28/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0796 - acc: 0.9703Epoch 1/100  
 1/163 [..............................] - ETA: 53s - loss: 0.2089 - acc: 0.9375  
Epoch 00028: saving model to /content/data/model/weights.epoch\_28.hdf5  
163/163 [==============================] - 87s 534ms/step - loss: 0.0806 - acc: 0.9701 - val\_loss: 0.2089 - val\_acc: 0.9375  
Epoch 29/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0831 - acc: 0.9682Epoch 1/100  
 1/163 [..............................] - ETA: 59s - loss: 0.0790 - acc: 1.0000  
Epoch 00029: saving model to /content/data/model/weights.epoch\_29.hdf5  
163/163 [==============================] - 87s 533ms/step - loss: 0.0826 - acc: 0.9684 - val\_loss: 0.0790 - val\_acc: 1.0000  
Epoch 30/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0822 - acc: 0.9701Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.0625 - acc: 1.0000  
Epoch 00030: saving model to /content/data/model/weights.epoch\_30.hdf5  
163/163 [==============================] - 87s 532ms/step - loss: 0.0818 - acc: 0.9703 - val\_loss: 0.0625 - val\_acc: 1.0000  
Epoch 31/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0761 - acc: 0.9726Epoch 1/100  
 1/163 [..............................] - ETA: 54s - loss: 0.1074 - acc: 1.0000  
Epoch 00031: saving model to /content/data/model/weights.epoch\_31.hdf5  
163/163 [==============================] - 87s 537ms/step - loss: 0.0757 - acc: 0.9728 - val\_loss: 0.1074 - val\_acc: 1.0000  
Epoch 32/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0763 - acc: 0.9703Epoch 1/100  
 1/163 [..............................] - ETA: 57s - loss: 0.0581 - acc: 1.0000  
Epoch 00032: saving model to /content/data/model/weights.epoch\_32.hdf5  
163/163 [==============================] - 88s 538ms/step - loss: 0.0763 - acc: 0.9701 - val\_loss: 0.0581 - val\_acc: 1.0000  
Epoch 33/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0768 - acc: 0.9707Epoch 1/100  
 1/163 [..............................] - ETA: 57s - loss: 0.1973 - acc: 0.8750  
Epoch 00033: saving model to /content/data/model/weights.epoch\_33.hdf5  
163/163 [==============================] - 87s 536ms/step - loss: 0.0766 - acc: 0.9707 - val\_loss: 0.1973 - val\_acc: 0.8750  
Epoch 34/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0793 - acc: 0.9722Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.0914 - acc: 1.0000  
Epoch 00034: saving model to /content/data/model/weights.epoch\_34.hdf5  
163/163 [==============================] - 87s 537ms/step - loss: 0.0792 - acc: 0.9722 - val\_loss: 0.0914 - val\_acc: 1.0000  
Epoch 35/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0749 - acc: 0.9709Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.1380 - acc: 0.9375  
Epoch 00035: saving model to /content/data/model/weights.epoch\_35.hdf5  
163/163 [==============================] - 87s 535ms/step - loss: 0.0749 - acc: 0.9709 - val\_loss: 0.1380 - val\_acc: 0.9375  
Epoch 36/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0703 - acc: 0.9718Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.1734 - acc: 0.8750  
Epoch 00036: saving model to /content/data/model/weights.epoch\_36.hdf5  
163/163 [==============================] - 87s 537ms/step - loss: 0.0700 - acc: 0.9720 - val\_loss: 0.1734 - val\_acc: 0.8750  
Epoch 37/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0755 - acc: 0.9715Epoch 1/100  
 1/163 [..............................] - ETA: 54s - loss: 0.1433 - acc: 0.9375  
Epoch 00037: saving model to /content/data/model/weights.epoch\_37.hdf5  
163/163 [==============================] - 88s 541ms/step - loss: 0.0757 - acc: 0.9712 - val\_loss: 0.1433 - val\_acc: 0.9375  
Epoch 38/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0751 - acc: 0.9732Epoch 1/100  
 1/163 [..............................] - ETA: 57s - loss: 0.1892 - acc: 0.9375  
Epoch 00038: saving model to /content/data/model/weights.epoch\_38.hdf5  
163/163 [==============================] - 88s 537ms/step - loss: 0.0754 - acc: 0.9732 - val\_loss: 0.1892 - val\_acc: 0.9375  
Epoch 39/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0752 - acc: 0.9722Epoch 1/100  
 1/163 [..............................] - ETA: 58s - loss: 0.0646 - acc: 1.0000  
Epoch 00039: saving model to /content/data/model/weights.epoch\_39.hdf5  
163/163 [==============================] - 87s 534ms/step - loss: 0.0748 - acc: 0.9724 - val\_loss: 0.0646 - val\_acc: 1.0000  
Epoch 40/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0698 - acc: 0.9745Epoch 1/100  
 1/163 [..............................] - ETA: 57s - loss: 0.4798 - acc: 0.7500  
Epoch 00040: saving model to /content/data/model/weights.epoch\_40.hdf5  
163/163 [==============================] - 87s 535ms/step - loss: 0.0700 - acc: 0.9745 - val\_loss: 0.4798 - val\_acc: 0.7500  
Epoch 41/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0742 - acc: 0.9718Epoch 1/100  
 1/163 [..............................] - ETA: 58s - loss: 0.0673 - acc: 0.9375  
Epoch 00041: saving model to /content/data/model/weights.epoch\_41.hdf5  
163/163 [==============================] - 87s 536ms/step - loss: 0.0738 - acc: 0.9720 - val\_loss: 0.0673 - val\_acc: 0.9375  
Epoch 42/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0669 - acc: 0.9730Epoch 1/100  
 1/163 [..............................] - ETA: 59s - loss: 0.0433 - acc: 1.0000  
Epoch 00042: saving model to /content/data/model/weights.epoch\_42.hdf5  
163/163 [==============================] - 87s 536ms/step - loss: 0.0669 - acc: 0.9730 - val\_loss: 0.0433 - val\_acc: 1.0000  
Epoch 43/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0704 - acc: 0.9732Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.0838 - acc: 1.0000  
Epoch 00043: saving model to /content/data/model/weights.epoch\_43.hdf5  
163/163 [==============================] - 88s 538ms/step - loss: 0.0701 - acc: 0.9734 - val\_loss: 0.0838 - val\_acc: 1.0000  
Epoch 44/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0802 - acc: 0.9699Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.0449 - acc: 1.0000  
Epoch 00044: saving model to /content/data/model/weights.epoch\_44.hdf5  
163/163 [==============================] - 87s 534ms/step - loss: 0.0798 - acc: 0.9701 - val\_loss: 0.0449 - val\_acc: 1.0000  
Epoch 45/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0697 - acc: 0.9734Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.0499 - acc: 1.0000  
Epoch 00045: saving model to /content/data/model/weights.epoch\_45.hdf5  
163/163 [==============================] - 87s 533ms/step - loss: 0.0695 - acc: 0.9735 - val\_loss: 0.0499 - val\_acc: 1.0000  
Epoch 46/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0701 - acc: 0.9720Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.1592 - acc: 0.8750  
Epoch 00046: saving model to /content/data/model/weights.epoch\_46.hdf5  
163/163 [==============================] - 88s 541ms/step - loss: 0.0698 - acc: 0.9720 - val\_loss: 0.1592 - val\_acc: 0.8750  
Epoch 47/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0718 - acc: 0.9715Epoch 1/100  
 1/163 [..............................] - ETA: 59s - loss: 0.0679 - acc: 1.0000  
Epoch 00047: saving model to /content/data/model/weights.epoch\_47.hdf5  
163/163 [==============================] - 89s 544ms/step - loss: 0.0714 - acc: 0.9716 - val\_loss: 0.0679 - val\_acc: 1.0000  
Epoch 48/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0682 - acc: 0.9728Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.1295 - acc: 0.8750  
Epoch 00048: saving model to /content/data/model/weights.epoch\_48.hdf5  
163/163 [==============================] - 87s 531ms/step - loss: 0.0689 - acc: 0.9726 - val\_loss: 0.1295 - val\_acc: 0.8750  
Epoch 49/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0733 - acc: 0.9726Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.0895 - acc: 0.9375  
Epoch 00049: saving model to /content/data/model/weights.epoch\_49.hdf5  
163/163 [==============================] - 87s 535ms/step - loss: 0.0731 - acc: 0.9726 - val\_loss: 0.0895 - val\_acc: 0.9375  
Epoch 50/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0686 - acc: 0.9743Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.1431 - acc: 0.9375  
Epoch 00050: saving model to /content/data/model/weights.epoch\_50.hdf5  
163/163 [==============================] - 86s 531ms/step - loss: 0.0686 - acc: 0.9743 - val\_loss: 0.1431 - val\_acc: 0.9375  
Epoch 51/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0688 - acc: 0.9734Epoch 1/100  
 1/163 [..............................] - ETA: 57s - loss: 0.1358 - acc: 0.9375  
Epoch 00051: saving model to /content/data/model/weights.epoch\_51.hdf5  
163/163 [==============================] - 86s 526ms/step - loss: 0.0687 - acc: 0.9732 - val\_loss: 0.1358 - val\_acc: 0.9375  
Epoch 52/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0702 - acc: 0.9740Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.2695 - acc: 0.8125  
Epoch 00052: saving model to /content/data/model/weights.epoch\_52.hdf5  
163/163 [==============================] - 87s 536ms/step - loss: 0.0705 - acc: 0.9737 - val\_loss: 0.2695 - val\_acc: 0.8125  
Epoch 53/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0664 - acc: 0.9751Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.0418 - acc: 1.0000  
Epoch 00053: saving model to /content/data/model/weights.epoch\_53.hdf5  
163/163 [==============================] - 87s 535ms/step - loss: 0.0661 - acc: 0.9753 - val\_loss: 0.0418 - val\_acc: 1.0000  
Epoch 54/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0659 - acc: 0.9755Epoch 1/100  
 1/163 [..............................] - ETA: 59s - loss: 0.0923 - acc: 0.9375  
Epoch 00054: saving model to /content/data/model/weights.epoch\_54.hdf5  
163/163 [==============================] - 87s 536ms/step - loss: 0.0659 - acc: 0.9755 - val\_loss: 0.0923 - val\_acc: 0.9375  
Epoch 55/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0629 - acc: 0.9778Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.1823 - acc: 0.8750  
Epoch 00055: saving model to /content/data/model/weights.epoch\_55.hdf5  
163/163 [==============================] - 88s 540ms/step - loss: 0.0633 - acc: 0.9778 - val\_loss: 0.1823 - val\_acc: 0.8750  
Epoch 56/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0696 - acc: 0.9738Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.2149 - acc: 0.9375  
Epoch 00056: saving model to /content/data/model/weights.epoch\_56.hdf5  
163/163 [==============================] - 88s 540ms/step - loss: 0.0699 - acc: 0.9735 - val\_loss: 0.2149 - val\_acc: 0.9375  
Epoch 57/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0674 - acc: 0.9755Epoch 1/100  
 1/163 [..............................] - ETA: 53s - loss: 0.0913 - acc: 1.0000  
Epoch 00057: saving model to /content/data/model/weights.epoch\_57.hdf5  
163/163 [==============================] - 87s 536ms/step - loss: 0.0674 - acc: 0.9755 - val\_loss: 0.0913 - val\_acc: 1.0000  
Epoch 58/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0683 - acc: 0.9765Epoch 1/100  
 1/163 [..............................] - ETA: 57s - loss: 0.0494 - acc: 1.0000  
Epoch 00058: saving model to /content/data/model/weights.epoch\_58.hdf5  
163/163 [==============================] - 88s 539ms/step - loss: 0.0694 - acc: 0.9762 - val\_loss: 0.0494 - val\_acc: 1.0000  
Epoch 59/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0671 - acc: 0.9755Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.0989 - acc: 1.0000  
Epoch 00059: saving model to /content/data/model/weights.epoch\_59.hdf5  
163/163 [==============================] - 87s 536ms/step - loss: 0.0669 - acc: 0.9757 - val\_loss: 0.0989 - val\_acc: 1.0000  
Epoch 60/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0672 - acc: 0.9738Epoch 1/100  
 1/163 [..............................] - ETA: 54s - loss: 0.0486 - acc: 1.0000  
Epoch 00060: saving model to /content/data/model/weights.epoch\_60.hdf5  
163/163 [==============================] - 86s 530ms/step - loss: 0.0669 - acc: 0.9739 - val\_loss: 0.0486 - val\_acc: 1.0000  
Epoch 61/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0659 - acc: 0.9770Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.0884 - acc: 1.0000  
Epoch 00061: saving model to /content/data/model/weights.epoch\_61.hdf5  
163/163 [==============================] - 87s 534ms/step - loss: 0.0656 - acc: 0.9772 - val\_loss: 0.0884 - val\_acc: 1.0000  
Epoch 62/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0616 - acc: 0.9753Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.0403 - acc: 1.0000  
Epoch 00062: saving model to /content/data/model/weights.epoch\_62.hdf5  
163/163 [==============================] - 88s 537ms/step - loss: 0.0612 - acc: 0.9755 - val\_loss: 0.0403 - val\_acc: 1.0000  
Epoch 63/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0672 - acc: 0.9747Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.0395 - acc: 1.0000  
Epoch 00063: saving model to /content/data/model/weights.epoch\_63.hdf5  
163/163 [==============================] - 87s 533ms/step - loss: 0.0669 - acc: 0.9749 - val\_loss: 0.0395 - val\_acc: 1.0000  
Epoch 64/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0650 - acc: 0.9759Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.0335 - acc: 1.0000  
Epoch 00064: saving model to /content/data/model/weights.epoch\_64.hdf5  
163/163 [==============================] - 86s 531ms/step - loss: 0.0646 - acc: 0.9760 - val\_loss: 0.0335 - val\_acc: 1.0000  
Epoch 65/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0661 - acc: 0.9749Epoch 1/100  
 1/163 [..............................] - ETA: 54s - loss: 0.0741 - acc: 1.0000  
Epoch 00065: saving model to /content/data/model/weights.epoch\_65.hdf5  
163/163 [==============================] - 86s 528ms/step - loss: 0.0658 - acc: 0.9751 - val\_loss: 0.0741 - val\_acc: 1.0000  
Epoch 66/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0625 - acc: 0.9751Epoch 1/100  
 1/163 [..............................] - ETA: 54s - loss: 0.0522 - acc: 1.0000  
Epoch 00066: saving model to /content/data/model/weights.epoch\_66.hdf5  
163/163 [==============================] - 87s 534ms/step - loss: 0.0625 - acc: 0.9751 - val\_loss: 0.0522 - val\_acc: 1.0000  
Epoch 67/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0681 - acc: 0.9778Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.0501 - acc: 1.0000  
Epoch 00067: saving model to /content/data/model/weights.epoch\_67.hdf5  
163/163 [==============================] - 87s 531ms/step - loss: 0.0678 - acc: 0.9780 - val\_loss: 0.0501 - val\_acc: 1.0000  
Epoch 68/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0651 - acc: 0.9778Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.0337 - acc: 1.0000  
Epoch 00068: saving model to /content/data/model/weights.epoch\_68.hdf5  
163/163 [==============================] - 87s 532ms/step - loss: 0.0648 - acc: 0.9780 - val\_loss: 0.0337 - val\_acc: 1.0000  
Epoch 69/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0629 - acc: 0.9765Epoch 1/100  
 1/163 [..............................] - ETA: 54s - loss: 0.0396 - acc: 1.0000  
Epoch 00069: saving model to /content/data/model/weights.epoch\_69.hdf5  
163/163 [==============================] - 87s 534ms/step - loss: 0.0626 - acc: 0.9766 - val\_loss: 0.0396 - val\_acc: 1.0000  
Epoch 70/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0592 - acc: 0.9757Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.0529 - acc: 1.0000  
Epoch 00070: saving model to /content/data/model/weights.epoch\_70.hdf5  
163/163 [==============================] - 87s 536ms/step - loss: 0.0589 - acc: 0.9758 - val\_loss: 0.0529 - val\_acc: 1.0000  
Epoch 71/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0620 - acc: 0.9780Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.0662 - acc: 1.0000  
Epoch 00071: saving model to /content/data/model/weights.epoch\_71.hdf5  
163/163 [==============================] - 87s 532ms/step - loss: 0.0617 - acc: 0.9781 - val\_loss: 0.0662 - val\_acc: 1.0000  
Epoch 72/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0620 - acc: 0.9786Epoch 1/100  
 1/163 [..............................] - ETA: 54s - loss: 0.0431 - acc: 1.0000  
Epoch 00072: saving model to /content/data/model/weights.epoch\_72.hdf5  
163/163 [==============================] - 87s 533ms/step - loss: 0.0618 - acc: 0.9787 - val\_loss: 0.0431 - val\_acc: 1.0000  
Epoch 73/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0648 - acc: 0.9765Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.0710 - acc: 1.0000  
Epoch 00073: saving model to /content/data/model/weights.epoch\_73.hdf5  
163/163 [==============================] - 87s 536ms/step - loss: 0.0648 - acc: 0.9764 - val\_loss: 0.0710 - val\_acc: 1.0000  
Epoch 74/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0655 - acc: 0.9763Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.0354 - acc: 1.0000  
Epoch 00074: saving model to /content/data/model/weights.epoch\_74.hdf5  
163/163 [==============================] - 87s 535ms/step - loss: 0.0651 - acc: 0.9764 - val\_loss: 0.0354 - val\_acc: 1.0000  
Epoch 75/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0682 - acc: 0.9761Epoch 1/100  
 1/163 [..............................] - ETA: 57s - loss: 0.2922 - acc: 0.8750  
Epoch 00075: saving model to /content/data/model/weights.epoch\_75.hdf5  
163/163 [==============================] - 87s 532ms/step - loss: 0.0687 - acc: 0.9758 - val\_loss: 0.2922 - val\_acc: 0.8750  
Epoch 76/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0711 - acc: 0.9734Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.0363 - acc: 1.0000  
Epoch 00076: saving model to /content/data/model/weights.epoch\_76.hdf5  
163/163 [==============================] - 86s 530ms/step - loss: 0.0707 - acc: 0.9735 - val\_loss: 0.0363 - val\_acc: 1.0000  
Epoch 77/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0657 - acc: 0.9769Epoch 1/100  
 1/163 [..............................] - ETA: 54s - loss: 0.0367 - acc: 1.0000  
Epoch 00077: saving model to /content/data/model/weights.epoch\_77.hdf5  
163/163 [==============================] - 87s 533ms/step - loss: 0.0660 - acc: 0.9766 - val\_loss: 0.0367 - val\_acc: 1.0000  
Epoch 78/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0610 - acc: 0.9811Epoch 1/100  
 1/163 [..............................] - ETA: 54s - loss: 0.0346 - acc: 1.0000  
Epoch 00078: saving model to /content/data/model/weights.epoch\_78.hdf5  
163/163 [==============================] - 87s 531ms/step - loss: 0.0608 - acc: 0.9812 - val\_loss: 0.0346 - val\_acc: 1.0000  
Epoch 79/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0591 - acc: 0.9782Epoch 1/100  
 1/163 [..............................] - ETA: 54s - loss: 0.0830 - acc: 0.9375  
Epoch 00079: saving model to /content/data/model/weights.epoch\_79.hdf5  
163/163 [==============================] - 86s 530ms/step - loss: 0.0587 - acc: 0.9783 - val\_loss: 0.0830 - val\_acc: 0.9375  
Epoch 80/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0641 - acc: 0.9738Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.0763 - acc: 1.0000  
Epoch 00080: saving model to /content/data/model/weights.epoch\_80.hdf5  
163/163 [==============================] - 87s 536ms/step - loss: 0.0637 - acc: 0.9739 - val\_loss: 0.0763 - val\_acc: 1.0000  
Epoch 81/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0575 - acc: 0.9786Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.0510 - acc: 1.0000  
Epoch 00081: saving model to /content/data/model/weights.epoch\_81.hdf5  
163/163 [==============================] - 87s 537ms/step - loss: 0.0578 - acc: 0.9785 - val\_loss: 0.0510 - val\_acc: 1.0000  
Epoch 82/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0547 - acc: 0.9788Epoch 1/100  
 1/163 [..............................] - ETA: 54s - loss: 0.0347 - acc: 1.0000  
Epoch 00082: saving model to /content/data/model/weights.epoch\_82.hdf5  
163/163 [==============================] - 87s 535ms/step - loss: 0.0548 - acc: 0.9787 - val\_loss: 0.0347 - val\_acc: 1.0000  
Epoch 83/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0550 - acc: 0.9801Epoch 1/100  
 1/163 [..............................] - ETA: 57s - loss: 0.0282 - acc: 1.0000  
Epoch 00083: saving model to /content/data/model/weights.epoch\_83.hdf5  
163/163 [==============================] - 87s 535ms/step - loss: 0.0548 - acc: 0.9803 - val\_loss: 0.0282 - val\_acc: 1.0000  
Epoch 84/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0636 - acc: 0.9772Epoch 1/100  
 1/163 [..............................] - ETA: 58s - loss: 0.0374 - acc: 1.0000  
Epoch 00084: saving model to /content/data/model/weights.epoch\_84.hdf5  
163/163 [==============================] - 88s 542ms/step - loss: 0.0637 - acc: 0.9772 - val\_loss: 0.0374 - val\_acc: 1.0000  
Epoch 85/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0544 - acc: 0.9788Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.0228 - acc: 1.0000  
Epoch 00085: saving model to /content/data/model/weights.epoch\_85.hdf5  
163/163 [==============================] - 88s 539ms/step - loss: 0.0542 - acc: 0.9789 - val\_loss: 0.0228 - val\_acc: 1.0000  
Epoch 86/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0602 - acc: 0.9776Epoch 1/100  
 1/163 [..............................] - ETA: 53s - loss: 0.0334 - acc: 1.0000  
Epoch 00086: saving model to /content/data/model/weights.epoch\_86.hdf5  
163/163 [==============================] - 87s 534ms/step - loss: 0.0599 - acc: 0.9778 - val\_loss: 0.0334 - val\_acc: 1.0000  
Epoch 87/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0678 - acc: 0.9726Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.0555 - acc: 1.0000  
Epoch 00087: saving model to /content/data/model/weights.epoch\_87.hdf5  
163/163 [==============================] - 88s 538ms/step - loss: 0.0689 - acc: 0.9720 - val\_loss: 0.0555 - val\_acc: 1.0000  
Epoch 88/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0592 - acc: 0.9790Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.0570 - acc: 1.0000  
Epoch 00088: saving model to /content/data/model/weights.epoch\_88.hdf5  
163/163 [==============================] - 89s 547ms/step - loss: 0.0589 - acc: 0.9791 - val\_loss: 0.0570 - val\_acc: 1.0000  
Epoch 89/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0624 - acc: 0.9767Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.0185 - acc: 1.0000  
Epoch 00089: saving model to /content/data/model/weights.epoch\_89.hdf5  
163/163 [==============================] - 88s 542ms/step - loss: 0.0622 - acc: 0.9768 - val\_loss: 0.0185 - val\_acc: 1.0000  
Epoch 90/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0569 - acc: 0.9801Epoch 1/100  
 1/163 [..............................] - ETA: 54s - loss: 0.0194 - acc: 1.0000  
Epoch 00090: saving model to /content/data/model/weights.epoch\_90.hdf5  
163/163 [==============================] - 88s 542ms/step - loss: 0.0566 - acc: 0.9803 - val\_loss: 0.0194 - val\_acc: 1.0000  
Epoch 91/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0576 - acc: 0.9792Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.0355 - acc: 1.0000  
Epoch 00091: saving model to /content/data/model/weights.epoch\_91.hdf5  
163/163 [==============================] - 88s 543ms/step - loss: 0.0575 - acc: 0.9793 - val\_loss: 0.0355 - val\_acc: 1.0000  
Epoch 92/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0651 - acc: 0.9761Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.0418 - acc: 1.0000  
Epoch 00092: saving model to /content/data/model/weights.epoch\_92.hdf5  
163/163 [==============================] - 89s 544ms/step - loss: 0.0648 - acc: 0.9762 - val\_loss: 0.0418 - val\_acc: 1.0000  
Epoch 93/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0603 - acc: 0.9765Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.0679 - acc: 1.0000  
Epoch 00093: saving model to /content/data/model/weights.epoch\_93.hdf5  
163/163 [==============================] - 89s 548ms/step - loss: 0.0601 - acc: 0.9766 - val\_loss: 0.0679 - val\_acc: 1.0000  
Epoch 94/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0567 - acc: 0.9799Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.0181 - acc: 1.0000  
Epoch 00094: saving model to /content/data/model/weights.epoch\_94.hdf5  
163/163 [==============================] - 89s 546ms/step - loss: 0.0568 - acc: 0.9799 - val\_loss: 0.0181 - val\_acc: 1.0000  
Epoch 95/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0600 - acc: 0.9784Epoch 1/100  
 1/163 [..............................] - ETA: 1:00 - loss: 0.0219 - acc: 1.0000  
Epoch 00095: saving model to /content/data/model/weights.epoch\_95.hdf5  
163/163 [==============================] - 89s 547ms/step - loss: 0.0599 - acc: 0.9783 - val\_loss: 0.0219 - val\_acc: 1.0000  
Epoch 96/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0541 - acc: 0.9794Epoch 1/100  
 1/163 [..............................] - ETA: 57s - loss: 0.0304 - acc: 1.0000  
Epoch 00096: saving model to /content/data/model/weights.epoch\_96.hdf5  
163/163 [==============================] - 89s 545ms/step - loss: 0.0540 - acc: 0.9795 - val\_loss: 0.0304 - val\_acc: 1.0000  
Epoch 97/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0550 - acc: 0.9807Epoch 1/100  
 1/163 [..............................] - ETA: 59s - loss: 0.0389 - acc: 1.0000  
Epoch 00097: saving model to /content/data/model/weights.epoch\_97.hdf5  
163/163 [==============================] - 89s 547ms/step - loss: 0.0547 - acc: 0.9808 - val\_loss: 0.0389 - val\_acc: 1.0000  
Epoch 98/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0595 - acc: 0.9780Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.0282 - acc: 1.0000  
Epoch 00098: saving model to /content/data/model/weights.epoch\_98.hdf5  
163/163 [==============================] - 89s 548ms/step - loss: 0.0592 - acc: 0.9781 - val\_loss: 0.0282 - val\_acc: 1.0000  
Epoch 99/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0593 - acc: 0.9759Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.0730 - acc: 0.9375  
Epoch 00099: saving model to /content/data/model/weights.epoch\_99.hdf5  
163/163 [==============================] - 90s 551ms/step - loss: 0.0591 - acc: 0.9760 - val\_loss: 0.0730 - val\_acc: 0.9375  
Epoch 100/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0603 - acc: 0.9794Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.0189 - acc: 1.0000  
Epoch 00100: saving model to /content/data/model/weights.epoch\_100.hdf5  
163/163 [==============================] - 90s 550ms/step - loss: 0.0601 - acc: 0.9795 - val\_loss: 0.0189 - val\_acc: 1.0000  
20/20 [==============================] - 8s 383ms/step - loss: 0.3198 - acc: 0.9087  
Loading the best model  
epoch: 94, val\_loss: 0.01814509741961956, val\_acc: 1.0  
20/20 [==============================] - 7s 363ms/step - loss: 0.3109 - acc: 0.9167  
20/20 [==============================] - 8s 394ms/step  
CONFUSION MATRIX ------------------  
[[201 33]  
 [ 19 371]]  
  
TEST METRICS ----------------------  
Accuracy: 91.66666666666666%  
Precision: 91.83168316831683%  
Recall: 95.12820512820512%  
F1-score: 93.45088161209067  
  
TRAIN METRIC ----------------------  
Train acc: 97.94861674308775%



png

## Load best weight  
idx = np.argmin(history.history['acc'])   
model.load\_weights("/content/data/model/weights.epoch\_{:02d}.hdf5".format(idx + 1))  
  
print("Loading the best model")  
print("epoch: {}, val\_loss: {}, val\_acc: {}".format(idx + 1, history.history['val\_loss'][idx], history.history['val\_acc'][idx]))  
  
## Evaluate the best weight  
test\_loss, test\_acc = model.evaluate\_generator(generator=test\_generator, verbose=1)  
  
## Test analytics  
from sklearn.metrics import accuracy\_score, confusion\_matrix  
  
test\_generator.reset()  
test\_preds = model.predict\_generator(test\_generator, verbose=1)  
test\_preds = np.argmax(test\_preds,axis=1)  
  
acc = accuracy\_score(test\_generator.classes, test\_preds)\*100  
cm = confusion\_matrix(test\_generator.classes, test\_preds)  
tn, fp, fn, tp = cm.ravel()  
  
print('CONFUSION MATRIX ------------------')  
print(cm)  
# plot\_confusion\_matrix(cm, target\_names=['NORMAL', 'PNEUMONIA'], normalize=False)  
  
  
print('\nTEST METRICS ----------------------')  
precision = tp/(tp+fp)\*100  
recall = tp/(tp+fn)\*100  
print('Accuracy: {}%'.format(acc))  
print('Precision: {}%'.format(precision))  
print('Recall: {}%'.format(recall))  
print('F1-score: {}'.format(2\*precision\*recall/(precision+recall)))  
  
print('\nTRAIN METRIC ----------------------')  
print('Train acc: {}%'.format(np.round((history.history['acc'][-1])\*100, 14)))

Loading the best model  
epoch: 1, val\_loss: 0.5660557150840759, val\_acc: 0.75  
20/20 [==============================] - 7s 349ms/step - loss: 0.3333 - acc: 0.8622  
20/20 [==============================] - 7s 365ms/step  
CONFUSION MATRIX ------------------  
[[154 80]  
 [ 6 384]]  
  
TEST METRICS ----------------------  
Accuracy: 86.21794871794873%  
Precision: 82.75862068965517%  
Recall: 98.46153846153847%  
F1-score: 89.9297423887588  
  
TRAIN METRIC ----------------------  
Train acc: 97.94861674308775%