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

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')

mkdir: cannot create directory ‘/content/data/’: File exists  
mkdir: cannot create directory ‘/content/data/model’: File exists  
mkdir: cannot create directory ‘/content/data/graph’: File exists  
--2019-10-29 04:11:13-- 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)... 52.219.73.175  
Connecting to s3.eu-central-1.amazonaws.com (s3.eu-central-1.amazonaws.com)|52.219.73.175|: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 26.2MB/s in 46s   
  
2019-10-29 04:11:59 (25.5 MB/s) - ‘/content/data/chest\_xray.tar.gz’ saved [1225393795/1225393795]

Change log: > training\_datagen –> ImageDataGenerator

trainable layer –> All except base

24 layers VGG16 model

Optimizer = RMSprop(learning\_rate = 0.0001)

loss = categorical\_crosscentropy

callback = [checkpoints]

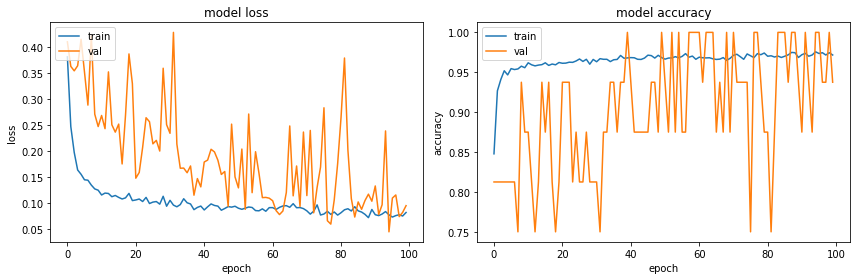
epochs = 100

**class weight balancing**

TRAINING\_DIR = "/content/data/chest\_xray/train"  
VALIDATION\_DIR = "/content/data/chest\_xray/val"  
TEST\_DIR = "/content/data/chest\_xray/test"  
  
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  
# TODO: Try grayscaling the image to see what will happen  
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)  
  
x = base\_model.output  
x = tf.keras.layers.Flatten()(x)  
x = tf.keras.layers.Dense(64, activation='relu')(x)  
x = tf.keras.layers.Dropout(0.33)(x)  
x = tf.keras.layers.BatchNormalization()(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=0.0001) # Lower learning rate by x10  
  
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  
)  
  
# test\_loss, test\_acc = model.evaluate\_generator(generator=test\_generator, verbose=1)

Found 5216 images belonging to 2 classes.  
Found 16 images belonging to 2 classes.  
Found 624 images belonging to 2 classes.  
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/tensorflow\_core/python/ops/resource\_variable\_ops.py:1630: calling BaseResourceVariable.\_\_init\_\_ (from tensorflow.python.ops.resource\_variable\_ops) with constraint is deprecated and will be removed in a future version.  
Instructions for updating:  
If using Keras pass \*\_constraint arguments to layers.  
Downloading data from https://github.com/fchollet/deep-learning-models/releases/download/v0.1/vgg16\_weights\_tf\_dim\_ordering\_tf\_kernels\_notop.h5  
58892288/58889256 [==============================] - 1s 0us/step  
[1.9448173 0.67303226]  
Epoch 1/100  
162/163 [============================>.] - ETA: 0s - loss: 0.3802 - acc: 0.8480Epoch 1/100  
 1/163 [..............................] - ETA: 4:49 - loss: 0.4098 - acc: 0.8125  
Epoch 00001: saving model to /content/data/model/weights.epoch\_01.hdf5  
163/163 [==============================] - 101s 620ms/step - loss: 0.3808 - acc: 0.8478 - val\_loss: 0.4098 - val\_acc: 0.8125  
Epoch 2/100  
162/163 [============================>.] - ETA: 0s - loss: 0.2467 - acc: 0.9267Epoch 1/100  
 1/163 [..............................] - ETA: 58s - loss: 0.3625 - acc: 0.8125  
Epoch 00002: saving model to /content/data/model/weights.epoch\_02.hdf5  
163/163 [==============================] - 97s 593ms/step - loss: 0.2467 - acc: 0.9268 - val\_loss: 0.3625 - val\_acc: 0.8125  
Epoch 3/100  
162/163 [============================>.] - ETA: 0s - loss: 0.1974 - acc: 0.9408Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.3540 - acc: 0.8125  
Epoch 00003: saving model to /content/data/model/weights.epoch\_03.hdf5  
163/163 [==============================] - 94s 575ms/step - loss: 0.1969 - acc: 0.9410 - val\_loss: 0.3540 - val\_acc: 0.8125  
Epoch 4/100  
162/163 [============================>.] - ETA: 0s - loss: 0.1631 - acc: 0.9518Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.3638 - acc: 0.8125  
Epoch 00004: saving model to /content/data/model/weights.epoch\_04.hdf5  
163/163 [==============================] - 85s 524ms/step - loss: 0.1632 - acc: 0.9519 - val\_loss: 0.3638 - val\_acc: 0.8125  
Epoch 5/100  
162/163 [============================>.] - ETA: 0s - loss: 0.1548 - acc: 0.9468Epoch 1/100  
 1/163 [..............................] - ETA: 54s - loss: 0.4146 - acc: 0.8125  
Epoch 00005: saving model to /content/data/model/weights.epoch\_05.hdf5  
163/163 [==============================] - 88s 538ms/step - loss: 0.1548 - acc: 0.9467 - val\_loss: 0.4146 - val\_acc: 0.8125  
Epoch 6/100  
162/163 [============================>.] - ETA: 0s - loss: 0.1441 - acc: 0.9545Epoch 1/100  
 1/163 [..............................] - ETA: 59s - loss: 0.3516 - acc: 0.8125  
Epoch 00006: saving model to /content/data/model/weights.epoch\_06.hdf5  
163/163 [==============================] - 90s 551ms/step - loss: 0.1443 - acc: 0.9546 - val\_loss: 0.3516 - val\_acc: 0.8125  
Epoch 7/100  
162/163 [============================>.] - ETA: 0s - loss: 0.1440 - acc: 0.9531Epoch 1/100  
 1/163 [..............................] - ETA: 58s - loss: 0.2880 - acc: 0.8125  
Epoch 00007: saving model to /content/data/model/weights.epoch\_07.hdf5  
163/163 [==============================] - 90s 553ms/step - loss: 0.1435 - acc: 0.9534 - val\_loss: 0.2880 - val\_acc: 0.8125  
Epoch 8/100  
162/163 [============================>.] - ETA: 0s - loss: 0.1331 - acc: 0.9545Epoch 1/100  
 1/163 [..............................] - ETA: 57s - loss: 0.4213 - acc: 0.7500  
Epoch 00008: saving model to /content/data/model/weights.epoch\_08.hdf5  
163/163 [==============================] - 90s 555ms/step - loss: 0.1340 - acc: 0.9542 - val\_loss: 0.4213 - val\_acc: 0.7500  
Epoch 9/100  
162/163 [============================>.] - ETA: 0s - loss: 0.1265 - acc: 0.9578Epoch 1/100  
 1/163 [..............................] - ETA: 1:01 - loss: 0.2705 - acc: 0.9375  
Epoch 00009: saving model to /content/data/model/weights.epoch\_09.hdf5  
163/163 [==============================] - 90s 552ms/step - loss: 0.1267 - acc: 0.9576 - val\_loss: 0.2705 - val\_acc: 0.9375  
Epoch 10/100  
162/163 [============================>.] - ETA: 0s - loss: 0.1240 - acc: 0.9560Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.2467 - acc: 0.8750  
Epoch 00010: saving model to /content/data/model/weights.epoch\_10.hdf5  
163/163 [==============================] - 91s 560ms/step - loss: 0.1242 - acc: 0.9557 - val\_loss: 0.2467 - val\_acc: 0.8750  
Epoch 11/100  
162/163 [============================>.] - ETA: 0s - loss: 0.1154 - acc: 0.9616Epoch 1/100  
 1/163 [..............................] - ETA: 57s - loss: 0.2680 - acc: 0.8750  
Epoch 00011: saving model to /content/data/model/weights.epoch\_11.hdf5  
163/163 [==============================] - 91s 558ms/step - loss: 0.1150 - acc: 0.9618 - val\_loss: 0.2680 - val\_acc: 0.8750  
Epoch 12/100  
162/163 [============================>.] - ETA: 0s - loss: 0.1187 - acc: 0.9593Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.2426 - acc: 0.8125  
Epoch 00012: saving model to /content/data/model/weights.epoch\_12.hdf5  
163/163 [==============================] - 91s 557ms/step - loss: 0.1187 - acc: 0.9594 - val\_loss: 0.2426 - val\_acc: 0.8125  
Epoch 13/100  
162/163 [============================>.] - ETA: 0s - loss: 0.1176 - acc: 0.9579Epoch 1/100  
 1/163 [..............................] - ETA: 57s - loss: 0.3519 - acc: 0.7500  
Epoch 00013: saving model to /content/data/model/weights.epoch\_13.hdf5  
163/163 [==============================] - 91s 555ms/step - loss: 0.1179 - acc: 0.9580 - val\_loss: 0.3519 - val\_acc: 0.7500  
Epoch 14/100  
162/163 [============================>.] - ETA: 0s - loss: 0.1119 - acc: 0.9589Epoch 1/100  
 1/163 [..............................] - ETA: 1:02 - loss: 0.2501 - acc: 0.8125  
Epoch 00014: saving model to /content/data/model/weights.epoch\_14.hdf5  
163/163 [==============================] - 91s 557ms/step - loss: 0.1117 - acc: 0.9590 - val\_loss: 0.2501 - val\_acc: 0.8125  
Epoch 15/100  
162/163 [============================>.] - ETA: 0s - loss: 0.1129 - acc: 0.9601Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.2360 - acc: 0.9375  
Epoch 00015: saving model to /content/data/model/weights.epoch\_15.hdf5  
163/163 [==============================] - 92s 563ms/step - loss: 0.1141 - acc: 0.9595 - val\_loss: 0.2360 - val\_acc: 0.9375  
Epoch 16/100  
162/163 [============================>.] - ETA: 0s - loss: 0.1100 - acc: 0.9620Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.2514 - acc: 0.8750  
Epoch 00016: saving model to /content/data/model/weights.epoch\_16.hdf5  
163/163 [==============================] - 91s 559ms/step - loss: 0.1104 - acc: 0.9618 - val\_loss: 0.2514 - val\_acc: 0.8750  
Epoch 17/100  
162/163 [============================>.] - ETA: 0s - loss: 0.1072 - acc: 0.9589Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.1747 - acc: 0.9375  
Epoch 00017: saving model to /content/data/model/weights.epoch\_17.hdf5  
163/163 [==============================] - 92s 561ms/step - loss: 0.1073 - acc: 0.9586 - val\_loss: 0.1747 - val\_acc: 0.9375  
Epoch 18/100  
162/163 [============================>.] - ETA: 0s - loss: 0.1099 - acc: 0.9601Epoch 1/100  
 1/163 [..............................] - ETA: 1:02 - loss: 0.2693 - acc: 0.8125  
Epoch 00018: saving model to /content/data/model/weights.epoch\_18.hdf5  
163/163 [==============================] - 92s 563ms/step - loss: 0.1095 - acc: 0.9603 - val\_loss: 0.2693 - val\_acc: 0.8125  
Epoch 19/100  
162/163 [============================>.] - ETA: 0s - loss: 0.1177 - acc: 0.9597Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.3865 - acc: 0.7500  
Epoch 00019: saving model to /content/data/model/weights.epoch\_19.hdf5  
163/163 [==============================] - 91s 557ms/step - loss: 0.1181 - acc: 0.9594 - val\_loss: 0.3865 - val\_acc: 0.7500  
Epoch 20/100  
162/163 [============================>.] - ETA: 0s - loss: 0.1034 - acc: 0.9624Epoch 1/100  
 1/163 [..............................] - ETA: 59s - loss: 0.3293 - acc: 0.8125  
Epoch 00020: saving model to /content/data/model/weights.epoch\_20.hdf5  
163/163 [==============================] - 91s 560ms/step - loss: 0.1042 - acc: 0.9622 - val\_loss: 0.3293 - val\_acc: 0.8125  
Epoch 21/100  
162/163 [============================>.] - ETA: 0s - loss: 0.1057 - acc: 0.9612Epoch 1/100  
 1/163 [..............................] - ETA: 58s - loss: 0.1473 - acc: 0.9375  
Epoch 00021: saving model to /content/data/model/weights.epoch\_21.hdf5  
163/163 [==============================] - 91s 561ms/step - loss: 0.1054 - acc: 0.9613 - val\_loss: 0.1473 - val\_acc: 0.9375  
Epoch 22/100  
162/163 [============================>.] - ETA: 0s - loss: 0.1071 - acc: 0.9614Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.1585 - acc: 0.9375  
Epoch 00022: saving model to /content/data/model/weights.epoch\_22.hdf5  
163/163 [==============================] - 91s 558ms/step - loss: 0.1072 - acc: 0.9615 - val\_loss: 0.1585 - val\_acc: 0.9375  
Epoch 23/100  
162/163 [============================>.] - ETA: 0s - loss: 0.1027 - acc: 0.9624Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.2068 - acc: 0.9375  
Epoch 00023: saving model to /content/data/model/weights.epoch\_23.hdf5  
163/163 [==============================] - 92s 562ms/step - loss: 0.1024 - acc: 0.9626 - val\_loss: 0.2068 - val\_acc: 0.9375  
Epoch 24/100  
162/163 [============================>.] - ETA: 0s - loss: 0.1106 - acc: 0.9624Epoch 1/100  
 1/163 [..............................] - ETA: 1:01 - loss: 0.2637 - acc: 0.8125  
Epoch 00024: saving model to /content/data/model/weights.epoch\_24.hdf5  
163/163 [==============================] - 91s 559ms/step - loss: 0.1104 - acc: 0.9624 - val\_loss: 0.2637 - val\_acc: 0.8125  
Epoch 25/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0990 - acc: 0.9639Epoch 1/100  
 1/163 [..............................] - ETA: 58s - loss: 0.2560 - acc: 0.8750  
Epoch 00025: saving model to /content/data/model/weights.epoch\_25.hdf5  
163/163 [==============================] - 92s 563ms/step - loss: 0.0986 - acc: 0.9641 - val\_loss: 0.2560 - val\_acc: 0.8750  
Epoch 26/100  
162/163 [============================>.] - ETA: 0s - loss: 0.1015 - acc: 0.9666Epoch 1/100  
 1/163 [..............................] - ETA: 58s - loss: 0.2135 - acc: 0.8125  
Epoch 00026: saving model to /content/data/model/weights.epoch\_26.hdf5  
163/163 [==============================] - 92s 563ms/step - loss: 0.1013 - acc: 0.9666 - val\_loss: 0.2135 - val\_acc: 0.8125  
Epoch 27/100  
162/163 [============================>.] - ETA: 0s - loss: 0.1028 - acc: 0.9633Epoch 1/100  
 1/163 [..............................] - ETA: 57s - loss: 0.2201 - acc: 0.8125  
Epoch 00027: saving model to /content/data/model/weights.epoch\_27.hdf5  
163/163 [==============================] - 92s 563ms/step - loss: 0.1024 - acc: 0.9636 - val\_loss: 0.2201 - val\_acc: 0.8125  
Epoch 28/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0967 - acc: 0.9664Epoch 1/100  
 1/163 [..............................] - ETA: 57s - loss: 0.1996 - acc: 0.8750  
Epoch 00028: saving model to /content/data/model/weights.epoch\_28.hdf5  
163/163 [==============================] - 92s 562ms/step - loss: 0.0974 - acc: 0.9663 - val\_loss: 0.1996 - val\_acc: 0.8750  
Epoch 29/100  
162/163 [============================>.] - ETA: 0s - loss: 0.1130 - acc: 0.9599Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.3590 - acc: 0.8125  
Epoch 00029: saving model to /content/data/model/weights.epoch\_29.hdf5  
163/163 [==============================] - 91s 561ms/step - loss: 0.1125 - acc: 0.9601 - val\_loss: 0.3590 - val\_acc: 0.8125  
Epoch 30/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0935 - acc: 0.9660Epoch 1/100  
 1/163 [..............................] - ETA: 54s - loss: 0.2503 - acc: 0.8125  
Epoch 00030: saving model to /content/data/model/weights.epoch\_30.hdf5  
163/163 [==============================] - 91s 560ms/step - loss: 0.0934 - acc: 0.9661 - val\_loss: 0.2503 - val\_acc: 0.8125  
Epoch 31/100  
162/163 [============================>.] - ETA: 0s - loss: 0.1051 - acc: 0.9630Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.2337 - acc: 0.8125  
Epoch 00031: saving model to /content/data/model/weights.epoch\_31.hdf5  
163/163 [==============================] - 89s 547ms/step - loss: 0.1047 - acc: 0.9632 - val\_loss: 0.2337 - val\_acc: 0.8125  
Epoch 32/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0945 - acc: 0.9676Epoch 1/100  
 1/163 [..............................] - ETA: 1:00 - loss: 0.4280 - acc: 0.7500  
Epoch 00032: saving model to /content/data/model/weights.epoch\_32.hdf5  
163/163 [==============================] - 87s 536ms/step - loss: 0.0955 - acc: 0.9670 - val\_loss: 0.4280 - val\_acc: 0.7500  
Epoch 33/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0925 - acc: 0.9662Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.2131 - acc: 0.8750  
Epoch 00033: saving model to /content/data/model/weights.epoch\_33.hdf5  
163/163 [==============================] - 89s 547ms/step - loss: 0.0923 - acc: 0.9663 - val\_loss: 0.2131 - val\_acc: 0.8750  
Epoch 34/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0964 - acc: 0.9662Epoch 1/100  
 1/163 [..............................] - ETA: 57s - loss: 0.1665 - acc: 0.8750  
Epoch 00034: saving model to /content/data/model/weights.epoch\_34.hdf5  
163/163 [==============================] - 89s 547ms/step - loss: 0.0965 - acc: 0.9663 - val\_loss: 0.1665 - val\_acc: 0.8750  
Epoch 35/100  
162/163 [============================>.] - ETA: 0s - loss: 0.1082 - acc: 0.9632Epoch 1/100  
 1/163 [..............................] - ETA: 57s - loss: 0.1668 - acc: 0.9375  
Epoch 00035: saving model to /content/data/model/weights.epoch\_35.hdf5  
163/163 [==============================] - 90s 549ms/step - loss: 0.1078 - acc: 0.9634 - val\_loss: 0.1668 - val\_acc: 0.9375  
Epoch 36/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0995 - acc: 0.9659Epoch 1/100  
 1/163 [..............................] - ETA: 57s - loss: 0.1578 - acc: 0.9375  
Epoch 00036: saving model to /content/data/model/weights.epoch\_36.hdf5  
163/163 [==============================] - 90s 551ms/step - loss: 0.1000 - acc: 0.9657 - val\_loss: 0.1578 - val\_acc: 0.9375  
Epoch 37/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0978 - acc: 0.9659Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.1709 - acc: 0.8750  
Epoch 00037: saving model to /content/data/model/weights.epoch\_37.hdf5  
163/163 [==============================] - 90s 550ms/step - loss: 0.0977 - acc: 0.9661 - val\_loss: 0.1709 - val\_acc: 0.8750  
Epoch 38/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0869 - acc: 0.9711Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.1146 - acc: 0.9375  
Epoch 00038: saving model to /content/data/model/weights.epoch\_38.hdf5  
163/163 [==============================] - 89s 546ms/step - loss: 0.0868 - acc: 0.9711 - val\_loss: 0.1146 - val\_acc: 0.9375  
Epoch 39/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0909 - acc: 0.9678Epoch 1/100  
 1/163 [..............................] - ETA: 57s - loss: 0.1466 - acc: 0.9375  
Epoch 00039: saving model to /content/data/model/weights.epoch\_39.hdf5  
163/163 [==============================] - 90s 553ms/step - loss: 0.0911 - acc: 0.9676 - val\_loss: 0.1466 - val\_acc: 0.9375  
Epoch 40/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0933 - acc: 0.9682Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.1306 - acc: 1.0000  
Epoch 00040: saving model to /content/data/model/weights.epoch\_40.hdf5  
163/163 [==============================] - 89s 546ms/step - loss: 0.0937 - acc: 0.9680 - val\_loss: 0.1306 - val\_acc: 1.0000  
Epoch 41/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0853 - acc: 0.9686Epoch 1/100  
 1/163 [..............................] - ETA: 59s - loss: 0.1785 - acc: 0.9375  
Epoch 00041: saving model to /content/data/model/weights.epoch\_41.hdf5  
163/163 [==============================] - 90s 554ms/step - loss: 0.0862 - acc: 0.9684 - val\_loss: 0.1785 - val\_acc: 0.9375  
Epoch 42/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0926 - acc: 0.9680Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.1822 - acc: 0.8750  
Epoch 00042: saving model to /content/data/model/weights.epoch\_42.hdf5  
163/163 [==============================] - 90s 555ms/step - loss: 0.0923 - acc: 0.9682 - val\_loss: 0.1822 - val\_acc: 0.8750  
Epoch 43/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0979 - acc: 0.9662Epoch 1/100  
 1/163 [..............................] - ETA: 57s - loss: 0.2030 - acc: 0.8750  
Epoch 00043: saving model to /content/data/model/weights.epoch\_43.hdf5  
163/163 [==============================] - 89s 549ms/step - loss: 0.0978 - acc: 0.9663 - val\_loss: 0.2030 - val\_acc: 0.8750  
Epoch 44/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0952 - acc: 0.9659Epoch 1/100  
 1/163 [..............................] - ETA: 54s - loss: 0.1978 - acc: 0.8750  
Epoch 00044: saving model to /content/data/model/weights.epoch\_44.hdf5  
163/163 [==============================] - 88s 541ms/step - loss: 0.0948 - acc: 0.9661 - val\_loss: 0.1978 - val\_acc: 0.8750  
Epoch 45/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0936 - acc: 0.9678Epoch 1/100  
 1/163 [..............................] - ETA: 58s - loss: 0.1818 - acc: 0.8750  
Epoch 00045: saving model to /content/data/model/weights.epoch\_45.hdf5  
163/163 [==============================] - 88s 542ms/step - loss: 0.0936 - acc: 0.9678 - val\_loss: 0.1818 - val\_acc: 0.8750  
Epoch 46/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0861 - acc: 0.9713Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.1545 - acc: 0.8750  
Epoch 00046: saving model to /content/data/model/weights.epoch\_46.hdf5  
163/163 [==============================] - 90s 549ms/step - loss: 0.0857 - acc: 0.9714 - val\_loss: 0.1545 - val\_acc: 0.8750  
Epoch 47/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0890 - acc: 0.9709Epoch 1/100  
 1/163 [..............................] - ETA: 54s - loss: 0.1602 - acc: 0.9375  
Epoch 00047: saving model to /content/data/model/weights.epoch\_47.hdf5  
163/163 [==============================] - 89s 548ms/step - loss: 0.0890 - acc: 0.9709 - val\_loss: 0.1602 - val\_acc: 0.9375  
Epoch 48/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0929 - acc: 0.9678Epoch 1/100  
 1/163 [..............................] - ETA: 59s - loss: 0.0931 - acc: 0.9375  
Epoch 00048: saving model to /content/data/model/weights.epoch\_48.hdf5  
163/163 [==============================] - 90s 550ms/step - loss: 0.0927 - acc: 0.9678 - val\_loss: 0.0931 - val\_acc: 0.9375  
Epoch 49/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0920 - acc: 0.9711Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.2514 - acc: 0.8750  
Epoch 00049: saving model to /content/data/model/weights.epoch\_49.hdf5  
163/163 [==============================] - 90s 553ms/step - loss: 0.0916 - acc: 0.9712 - val\_loss: 0.2514 - val\_acc: 0.8750  
Epoch 50/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0924 - acc: 0.9693Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.1498 - acc: 1.0000  
Epoch 00050: saving model to /content/data/model/weights.epoch\_50.hdf5  
163/163 [==============================] - 90s 550ms/step - loss: 0.0933 - acc: 0.9684 - val\_loss: 0.1498 - val\_acc: 1.0000  
Epoch 51/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0896 - acc: 0.9662Epoch 1/100  
 1/163 [..............................] - ETA: 53s - loss: 0.1287 - acc: 0.9375  
Epoch 00051: saving model to /content/data/model/weights.epoch\_51.hdf5  
163/163 [==============================] - 89s 548ms/step - loss: 0.0895 - acc: 0.9664 - val\_loss: 0.1287 - val\_acc: 0.9375  
Epoch 52/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0868 - acc: 0.9682Epoch 1/100  
 1/163 [..............................] - ETA: 58s - loss: 0.2034 - acc: 0.8750  
Epoch 00052: saving model to /content/data/model/weights.epoch\_52.hdf5  
163/163 [==============================] - 91s 557ms/step - loss: 0.0875 - acc: 0.9678 - val\_loss: 0.2034 - val\_acc: 0.8750  
Epoch 53/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0898 - acc: 0.9680Epoch 1/100  
 1/163 [..............................] - ETA: 54s - loss: 0.0875 - acc: 1.0000  
Epoch 00053: saving model to /content/data/model/weights.epoch\_53.hdf5  
163/163 [==============================] - 91s 555ms/step - loss: 0.0896 - acc: 0.9680 - val\_loss: 0.0875 - val\_acc: 1.0000  
Epoch 54/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0914 - acc: 0.9697Epoch 1/100  
 1/163 [..............................] - ETA: 58s - loss: 0.2708 - acc: 0.8750  
Epoch 00054: saving model to /content/data/model/weights.epoch\_54.hdf5  
163/163 [==============================] - 90s 550ms/step - loss: 0.0919 - acc: 0.9695 - val\_loss: 0.2708 - val\_acc: 0.8750  
Epoch 55/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0914 - acc: 0.9680Epoch 1/100  
 1/163 [..............................] - ETA: 58s - loss: 0.1194 - acc: 1.0000  
Epoch 00055: saving model to /content/data/model/weights.epoch\_55.hdf5  
163/163 [==============================] - 89s 548ms/step - loss: 0.0910 - acc: 0.9682 - val\_loss: 0.1194 - val\_acc: 1.0000  
Epoch 56/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0851 - acc: 0.9699Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.1983 - acc: 0.8750  
Epoch 00056: saving model to /content/data/model/weights.epoch\_56.hdf5  
163/163 [==============================] - 90s 550ms/step - loss: 0.0850 - acc: 0.9699 - val\_loss: 0.1983 - val\_acc: 0.8750  
Epoch 57/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0849 - acc: 0.9732Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.1570 - acc: 0.8750  
Epoch 00057: saving model to /content/data/model/weights.epoch\_57.hdf5  
163/163 [==============================] - 89s 549ms/step - loss: 0.0845 - acc: 0.9734 - val\_loss: 0.1570 - val\_acc: 0.8750  
Epoch 58/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0887 - acc: 0.9688Epoch 1/100  
 1/163 [..............................] - ETA: 58s - loss: 0.1099 - acc: 1.0000  
Epoch 00058: saving model to /content/data/model/weights.epoch\_58.hdf5  
163/163 [==============================] - 89s 546ms/step - loss: 0.0883 - acc: 0.9689 - val\_loss: 0.1099 - val\_acc: 1.0000  
Epoch 59/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0835 - acc: 0.9705Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.1104 - acc: 1.0000  
Epoch 00059: saving model to /content/data/model/weights.epoch\_59.hdf5  
163/163 [==============================] - 89s 546ms/step - loss: 0.0837 - acc: 0.9703 - val\_loss: 0.1104 - val\_acc: 1.0000  
Epoch 60/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0908 - acc: 0.9662Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.1089 - acc: 1.0000  
Epoch 00060: saving model to /content/data/model/weights.epoch\_60.hdf5  
163/163 [==============================] - 89s 548ms/step - loss: 0.0907 - acc: 0.9663 - val\_loss: 0.1089 - val\_acc: 1.0000  
Epoch 61/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0908 - acc: 0.9689Epoch 1/100  
 1/163 [..............................] - ETA: 58s - loss: 0.1040 - acc: 1.0000  
Epoch 00061: saving model to /content/data/model/weights.epoch\_61.hdf5  
163/163 [==============================] - 90s 549ms/step - loss: 0.0907 - acc: 0.9689 - val\_loss: 0.1040 - val\_acc: 1.0000  
Epoch 62/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0866 - acc: 0.9686Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.0850 - acc: 0.9375  
Epoch 00062: saving model to /content/data/model/weights.epoch\_62.hdf5  
163/163 [==============================] - 90s 550ms/step - loss: 0.0872 - acc: 0.9682 - val\_loss: 0.0850 - val\_acc: 0.9375  
Epoch 63/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0908 - acc: 0.9680Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.0773 - acc: 1.0000  
Epoch 00063: saving model to /content/data/model/weights.epoch\_63.hdf5  
163/163 [==============================] - 90s 554ms/step - loss: 0.0912 - acc: 0.9680 - val\_loss: 0.0773 - val\_acc: 1.0000  
Epoch 64/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0943 - acc: 0.9680Epoch 1/100  
 1/163 [..............................] - ETA: 58s - loss: 0.0843 - acc: 1.0000  
Epoch 00064: saving model to /content/data/model/weights.epoch\_64.hdf5  
163/163 [==============================] - 90s 550ms/step - loss: 0.0939 - acc: 0.9682 - val\_loss: 0.0843 - val\_acc: 1.0000  
Epoch 65/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0948 - acc: 0.9666Epoch 1/100  
 1/163 [..............................] - ETA: 58s - loss: 0.1199 - acc: 1.0000  
Epoch 00065: saving model to /content/data/model/weights.epoch\_65.hdf5  
163/163 [==============================] - 90s 551ms/step - loss: 0.0945 - acc: 0.9668 - val\_loss: 0.1199 - val\_acc: 1.0000  
Epoch 66/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0889 - acc: 0.9664Epoch 1/100  
 1/163 [..............................] - ETA: 58s - loss: 0.2478 - acc: 0.8750  
Epoch 00066: saving model to /content/data/model/weights.epoch\_66.hdf5  
163/163 [==============================] - 91s 555ms/step - loss: 0.0914 - acc: 0.9661 - val\_loss: 0.2478 - val\_acc: 0.8750  
Epoch 67/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0983 - acc: 0.9664Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.1133 - acc: 0.9375  
Epoch 00067: saving model to /content/data/model/weights.epoch\_67.hdf5  
163/163 [==============================] - 90s 552ms/step - loss: 0.0983 - acc: 0.9664 - val\_loss: 0.1133 - val\_acc: 0.9375  
Epoch 68/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0903 - acc: 0.9688Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.1708 - acc: 0.8750  
Epoch 00068: saving model to /content/data/model/weights.epoch\_68.hdf5  
163/163 [==============================] - 90s 553ms/step - loss: 0.0905 - acc: 0.9684 - val\_loss: 0.1708 - val\_acc: 0.8750  
Epoch 69/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0911 - acc: 0.9649Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.0929 - acc: 1.0000  
Epoch 00069: saving model to /content/data/model/weights.epoch\_69.hdf5  
163/163 [==============================] - 90s 549ms/step - loss: 0.0908 - acc: 0.9649 - val\_loss: 0.0929 - val\_acc: 1.0000  
Epoch 70/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0886 - acc: 0.9674Epoch 1/100  
 1/163 [..............................] - ETA: 57s - loss: 0.2361 - acc: 0.8750  
Epoch 00070: saving model to /content/data/model/weights.epoch\_70.hdf5  
163/163 [==============================] - 90s 549ms/step - loss: 0.0888 - acc: 0.9674 - val\_loss: 0.2361 - val\_acc: 0.8750  
Epoch 71/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0844 - acc: 0.9713Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.1138 - acc: 1.0000  
Epoch 00071: saving model to /content/data/model/weights.epoch\_71.hdf5  
163/163 [==============================] - 89s 546ms/step - loss: 0.0845 - acc: 0.9712 - val\_loss: 0.1138 - val\_acc: 1.0000  
Epoch 72/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0767 - acc: 0.9730Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.2393 - acc: 0.9375  
Epoch 00072: saving model to /content/data/model/weights.epoch\_72.hdf5  
163/163 [==============================] - 89s 545ms/step - loss: 0.0781 - acc: 0.9726 - val\_loss: 0.2393 - val\_acc: 0.9375  
Epoch 73/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0840 - acc: 0.9695Epoch 1/100  
 1/163 [..............................] - ETA: 58s - loss: 0.0807 - acc: 0.9375  
Epoch 00073: saving model to /content/data/model/weights.epoch\_73.hdf5  
163/163 [==============================] - 90s 551ms/step - loss: 0.0838 - acc: 0.9695 - val\_loss: 0.0807 - val\_acc: 0.9375  
Epoch 74/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0964 - acc: 0.9660Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.1297 - acc: 0.9375  
Epoch 00074: saving model to /content/data/model/weights.epoch\_74.hdf5  
163/163 [==============================] - 89s 549ms/step - loss: 0.0959 - acc: 0.9663 - val\_loss: 0.1297 - val\_acc: 0.9375  
Epoch 75/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0766 - acc: 0.9730Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.1688 - acc: 0.9375  
Epoch 00075: saving model to /content/data/model/weights.epoch\_75.hdf5  
163/163 [==============================] - 89s 548ms/step - loss: 0.0765 - acc: 0.9730 - val\_loss: 0.1688 - val\_acc: 0.9375  
Epoch 76/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0785 - acc: 0.9707Epoch 1/100  
 1/163 [..............................] - ETA: 57s - loss: 0.2829 - acc: 0.7500  
Epoch 00076: saving model to /content/data/model/weights.epoch\_76.hdf5  
163/163 [==============================] - 90s 550ms/step - loss: 0.0784 - acc: 0.9707 - val\_loss: 0.2829 - val\_acc: 0.7500  
Epoch 77/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0839 - acc: 0.9682Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.0655 - acc: 1.0000  
Epoch 00077: saving model to /content/data/model/weights.epoch\_77.hdf5  
163/163 [==============================] - 91s 556ms/step - loss: 0.0836 - acc: 0.9684 - val\_loss: 0.0655 - val\_acc: 1.0000  
Epoch 78/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0780 - acc: 0.9732Epoch 1/100  
 1/163 [..............................] - ETA: 57s - loss: 0.0590 - acc: 1.0000  
Epoch 00078: saving model to /content/data/model/weights.epoch\_78.hdf5  
163/163 [==============================] - 90s 553ms/step - loss: 0.0777 - acc: 0.9734 - val\_loss: 0.0590 - val\_acc: 1.0000  
Epoch 79/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0826 - acc: 0.9718Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.1054 - acc: 0.9375  
Epoch 00079: saving model to /content/data/model/weights.epoch\_79.hdf5  
163/163 [==============================] - 90s 553ms/step - loss: 0.0823 - acc: 0.9720 - val\_loss: 0.1054 - val\_acc: 0.9375  
Epoch 80/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0765 - acc: 0.9740Epoch 1/100  
 1/163 [..............................] - ETA: 58s - loss: 0.1753 - acc: 0.8750  
Epoch 00080: saving model to /content/data/model/weights.epoch\_80.hdf5  
163/163 [==============================] - 90s 553ms/step - loss: 0.0763 - acc: 0.9741 - val\_loss: 0.1753 - val\_acc: 0.8750  
Epoch 81/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0812 - acc: 0.9699Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.2651 - acc: 0.8750  
Epoch 00081: saving model to /content/data/model/weights.epoch\_81.hdf5  
163/163 [==============================] - 90s 551ms/step - loss: 0.0809 - acc: 0.9701 - val\_loss: 0.2651 - val\_acc: 0.8750  
Epoch 82/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0869 - acc: 0.9705Epoch 1/100  
 1/163 [..............................] - ETA: 58s - loss: 0.3787 - acc: 0.7500  
Epoch 00082: saving model to /content/data/model/weights.epoch\_82.hdf5  
163/163 [==============================] - 89s 545ms/step - loss: 0.0865 - acc: 0.9707 - val\_loss: 0.3787 - val\_acc: 0.7500  
Epoch 83/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0887 - acc: 0.9691Epoch 1/100  
 1/163 [..............................] - ETA: 58s - loss: 0.2015 - acc: 0.8750  
Epoch 00083: saving model to /content/data/model/weights.epoch\_83.hdf5  
163/163 [==============================] - 89s 547ms/step - loss: 0.0885 - acc: 0.9691 - val\_loss: 0.2015 - val\_acc: 0.8750  
Epoch 84/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0846 - acc: 0.9701Epoch 1/100  
 1/163 [..............................] - ETA: 59s - loss: 0.1080 - acc: 1.0000  
Epoch 00084: saving model to /content/data/model/weights.epoch\_84.hdf5  
163/163 [==============================] - 89s 548ms/step - loss: 0.0842 - acc: 0.9703 - val\_loss: 0.1080 - val\_acc: 1.0000  
Epoch 85/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0929 - acc: 0.9684Epoch 1/100  
 1/163 [..............................] - ETA: 57s - loss: 0.0726 - acc: 1.0000  
Epoch 00085: saving model to /content/data/model/weights.epoch\_85.hdf5  
163/163 [==============================] - 89s 548ms/step - loss: 0.0924 - acc: 0.9686 - val\_loss: 0.0726 - val\_acc: 1.0000  
Epoch 86/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0847 - acc: 0.9701Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.1016 - acc: 1.0000  
Epoch 00086: saving model to /content/data/model/weights.epoch\_86.hdf5  
163/163 [==============================] - 89s 547ms/step - loss: 0.0845 - acc: 0.9701 - val\_loss: 0.1016 - val\_acc: 1.0000  
Epoch 87/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0818 - acc: 0.9722Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.0875 - acc: 0.9375  
Epoch 00087: saving model to /content/data/model/weights.epoch\_87.hdf5  
163/163 [==============================] - 89s 548ms/step - loss: 0.0822 - acc: 0.9718 - val\_loss: 0.0875 - val\_acc: 0.9375  
Epoch 88/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0775 - acc: 0.9751Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.1044 - acc: 1.0000  
Epoch 00088: saving model to /content/data/model/weights.epoch\_88.hdf5  
163/163 [==============================] - 90s 550ms/step - loss: 0.0777 - acc: 0.9749 - val\_loss: 0.1044 - val\_acc: 1.0000  
Epoch 89/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0717 - acc: 0.9743Epoch 1/100  
 1/163 [..............................] - ETA: 57s - loss: 0.1166 - acc: 1.0000  
Epoch 00089: saving model to /content/data/model/weights.epoch\_89.hdf5  
163/163 [==============================] - 89s 546ms/step - loss: 0.0714 - acc: 0.9745 - val\_loss: 0.1166 - val\_acc: 1.0000  
Epoch 90/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0875 - acc: 0.9684Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.1030 - acc: 0.9375  
Epoch 00090: saving model to /content/data/model/weights.epoch\_90.hdf5  
163/163 [==============================] - 89s 544ms/step - loss: 0.0871 - acc: 0.9686 - val\_loss: 0.1030 - val\_acc: 0.9375  
Epoch 91/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0774 - acc: 0.9718Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.1324 - acc: 0.8750  
Epoch 00091: saving model to /content/data/model/weights.epoch\_91.hdf5  
163/163 [==============================] - 90s 550ms/step - loss: 0.0770 - acc: 0.9720 - val\_loss: 0.1324 - val\_acc: 0.8750  
Epoch 92/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0756 - acc: 0.9736Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.0777 - acc: 1.0000  
Epoch 00092: saving model to /content/data/model/weights.epoch\_92.hdf5  
163/163 [==============================] - 90s 551ms/step - loss: 0.0753 - acc: 0.9737 - val\_loss: 0.0777 - val\_acc: 1.0000  
Epoch 93/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0778 - acc: 0.9707Epoch 1/100  
 1/163 [..............................] - ETA: 57s - loss: 0.0962 - acc: 0.9375  
Epoch 00093: saving model to /content/data/model/weights.epoch\_93.hdf5  
163/163 [==============================] - 89s 548ms/step - loss: 0.0783 - acc: 0.9701 - val\_loss: 0.0962 - val\_acc: 0.9375  
Epoch 94/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0835 - acc: 0.9715Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.2383 - acc: 0.8750  
Epoch 00094: saving model to /content/data/model/weights.epoch\_94.hdf5  
163/163 [==============================] - 90s 550ms/step - loss: 0.0831 - acc: 0.9716 - val\_loss: 0.2383 - val\_acc: 0.8750  
Epoch 95/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0758 - acc: 0.9757Epoch 1/100  
 1/163 [..............................] - ETA: 58s - loss: 0.0441 - acc: 1.0000  
Epoch 00095: saving model to /content/data/model/weights.epoch\_95.hdf5  
163/163 [==============================] - 90s 552ms/step - loss: 0.0769 - acc: 0.9757 - val\_loss: 0.0441 - val\_acc: 1.0000  
Epoch 96/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0728 - acc: 0.9734Epoch 1/100  
 1/163 [..............................] - ETA: 58s - loss: 0.1091 - acc: 1.0000  
Epoch 00096: saving model to /content/data/model/weights.epoch\_96.hdf5  
163/163 [==============================] - 89s 549ms/step - loss: 0.0725 - acc: 0.9735 - val\_loss: 0.1091 - val\_acc: 1.0000  
Epoch 97/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0753 - acc: 0.9745Epoch 1/100  
 1/163 [..............................] - ETA: 57s - loss: 0.1151 - acc: 0.9375  
Epoch 00097: saving model to /content/data/model/weights.epoch\_97.hdf5  
163/163 [==============================] - 90s 553ms/step - loss: 0.0753 - acc: 0.9745 - val\_loss: 0.1151 - val\_acc: 0.9375  
Epoch 98/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0771 - acc: 0.9716Epoch 1/100  
 1/163 [..............................] - ETA: 58s - loss: 0.0734 - acc: 0.9375  
Epoch 00098: saving model to /content/data/model/weights.epoch\_98.hdf5  
163/163 [==============================] - 90s 555ms/step - loss: 0.0771 - acc: 0.9716 - val\_loss: 0.0734 - val\_acc: 0.9375  
Epoch 99/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0748 - acc: 0.9745Epoch 1/100  
 1/163 [..............................] - ETA: 55s - loss: 0.0815 - acc: 1.0000  
Epoch 00099: saving model to /content/data/model/weights.epoch\_99.hdf5  
163/163 [==============================] - 93s 571ms/step - loss: 0.0745 - acc: 0.9745 - val\_loss: 0.0815 - val\_acc: 1.0000  
Epoch 100/100  
162/163 [============================>.] - ETA: 0s - loss: 0.0805 - acc: 0.9720Epoch 1/100  
 1/163 [..............................] - ETA: 56s - loss: 0.0945 - acc: 0.9375  
Epoch 00100: saving model to /content/data/model/weights.epoch\_100.hdf5  
163/163 [==============================] - 92s 564ms/step - loss: 0.0813 - acc: 0.9716 - val\_loss: 0.0945 - val\_acc: 0.9375

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)



png

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]))

Loading the best model  
epoch: 95, val\_loss: 0.04409787803888321, val\_acc: 1.0

test\_loss, test\_acc = model.evaluate\_generator(generator=test\_generator, verbose=1)

20/20 [==============================] - 8s 419ms/step - loss: 0.2661 - acc: 0.9135

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)))

20/20 [==============================] - 8s 390ms/step  
CONFUSION MATRIX ------------------  
[[197 37]  
 [ 17 373]]  
  
TEST METRICS ----------------------  
Accuracy: 91.34615384615384%  
Precision: 90.97560975609757%  
Recall: 95.64102564102565%  
F1-score: 93.25  
  
TRAIN METRIC ----------------------  
Train acc: 97.16257452964781%