data_aug_adam_acc_96_65

October 10, 2021

1 Covid Classifier Model

1.0.1 Goals

Classify: - Normal CXR - Viral Pneumonia CXR - COVID CXR

1.1 Create Directories for Dataset

Separate the data to use later as generators.

[ ]:
```python
# Matriz de confusion, cambiar learnings rates (learning rates dinamicos),␣
 ↪dropouts 0.3 & 0.2, Batch Normalization
# K-Fold o avg de modelos
import os

BASE_PATH = '/home/hivini/learn/research/new-covid'
ORIGINAL_DATASET_DIR = os.path.join(BASE_PATH, 'COVID-19_Radiography_Dataset')
ORIGINAL_VIRAL_DIR = os.path.join(ORIGINAL_DATASET_DIR, 'Viral Pneumonia')
ORIGINAL_COVID_DIR = os.path.join(ORIGINAL_DATASET_DIR, 'COVID')
ORIGINAL_NORMAL_DIR = os.path.join(ORIGINAL_DATASET_DIR, 'Normal')
DATASET_DIR = os.path.join(BASE_PATH, 'small_dataset')
TRAIN_DIR = os.path.join(DATASET_DIR, 'train')
VALIDATION_DIR = os.path.join(DATASET_DIR, 'validation')
TEST_DIR = os.path.join(DATASET_DIR, 'test')
TRAIN_VIRAL_DIR = os.path.join(TRAIN_DIR, 'viral_pneumonia')
TRAIN_COVID_DIR = os.path.join(TRAIN_DIR, 'covid')
TRAIN_NORMAL_DIR = os.path.join(TRAIN_DIR, 'normal')
VALIDATION_VIRAL_DIR = os.path.join(VALIDATION_DIR, 'viral_pneumonia')
VALIDATION_COVID_DIR = os.path.join(VALIDATION_DIR, 'covid')
VALIDATION_NORMAL_DIR = os.path.join(VALIDATION_DIR, 'normal')
TEST_VIRAL_DIR = os.path.join(TEST_DIR, 'viral_pneumonia')
TEST_COVID_DIR = os.path.join(TEST_DIR, 'covid')
TEST_NORMAL_DIR = os.path.join(TEST_DIR, 'normal')


def createDir(path: str) -> None:
    if not os.path.exists(path):
        os.mkdir(path)
```

```
createDir(DATASET_DIR)
createDir(TRAIN_DIR)
createDir(VALIDATION_DIR)
createDir(TEST_DIR)
createDir(TRAIN_VIRAL_DIR)
createDir(TRAIN_COVID_DIR)
createDir(TRAIN_NORMAL_DIR)
createDir(VALIDATION_VIRAL_DIR)
createDir(VALIDATION_COVID_DIR)
createDir(VALIDATION_NORMAL_DIR)
createDir(TEST_VIRAL_DIR)
createDir(TEST_COVID_DIR)
createDir(TEST_NORMAL_DIR)
```

[ ]:

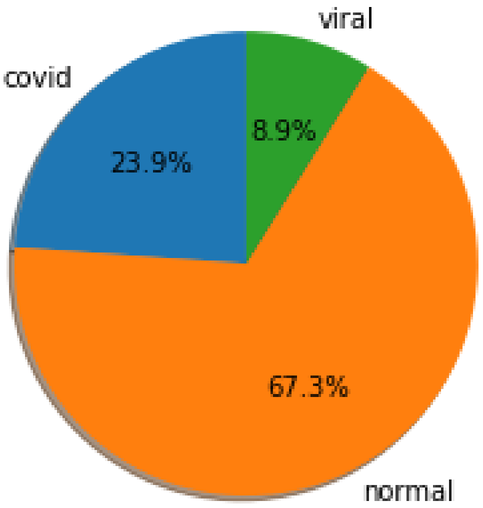
```
import numpy as np
import shutil



def generate_sets(source: str):
    allFiles = os.listdir(source)
    np.random.shuffle(allFiles)
    return np.split(np.array(allFiles), [int(len(allFiles)*0.7),␣
 ↪int(len(allFiles)*0.85)])



def saveAndSeparateFiles(src_dir: str, train_dir: str, val_dir: str, test_dir):
    train_fnames, val_fnames, test_fnames = generate_sets(src_dir)
    for fname in train_fnames:
        src = os.path.join(src_dir, fname)
        dst = os.path.join(train_dir, fname)
        shutil.copyfile(src, dst)

    for fname in val_fnames:
        src = os.path.join(src_dir, fname)
        dst = os.path.join(val_dir, fname)
        shutil.copyfile(src, dst)

    for fname in test_fnames:
        src = os.path.join(src_dir, fname)
        dst = os.path.join(test_dir, fname)
        shutil.copyfile(src, dst)

create = False
if create:
    saveAndSeparateFiles(ORIGINAL_NORMAL_DIR, TRAIN_NORMAL_DIR,
                         VALIDATION_NORMAL_DIR, TEST_NORMAL_DIR)
    saveAndSeparateFiles(ORIGINAL_COVID_DIR, TRAIN_COVID_DIR,
                        VALIDATION_COVID_DIR, TEST_COVID_DIR)
    saveAndSeparateFiles(ORIGINAL_VIRAL_DIR, TRAIN_VIRAL_DIR,
                        VALIDATION_VIRAL_DIR, TEST_VIRAL_DIR)
```

1.2 Counting our images

[ ]:

```
import tensorflow as tf
import matplotlib.pyplot as plt
normal_train = tf.io.gfile.glob(TRAIN_NORMAL_DIR + '/*')
viral_train = tf.io.gfile.glob(TRAIN_VIRAL_DIR + '/*')
covid_train = tf.io.gfile.glob(TRAIN_COVID_DIR + '/*')

# Plotting Distribution of Each Classes
image_count = {'covid': len(covid_train), 'normal': len(
    normal_train), 'viral': len(viral_train)}
fig1, ax1 = plt.subplots()
ax1.pie(image_count.values(),
        labels=image_count.keys(),
        shadow=True,
        autopct='%1.1f%%',
        startangle=90)
plt.show()
```

```
2021-10-10 18:47:07.927874: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcudart.so.10.1
```



1.3 Create our Covnet Model

In this case we are doing a multi class classification, our total clases are 3: - Viral CXR - Covid CXR - Normal CXR

Our neural network will output neurons as 3 classes that will calculate the probability of being one using the softmax function.

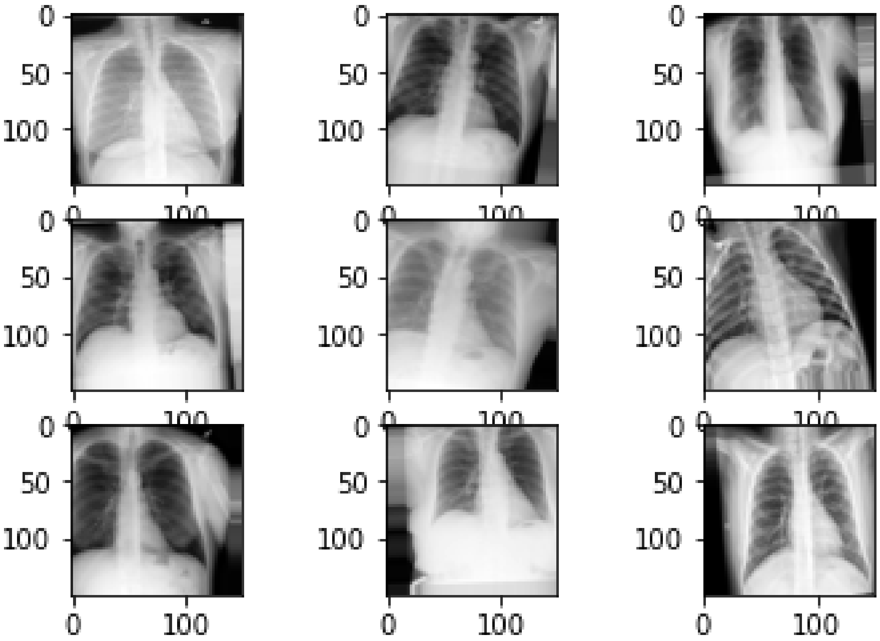
[ ]:

```
from keras.preprocessing.image import ImageDataGenerator

train_datagen = ImageDataGenerator(
    rescale=1./255,
    featurewise_center=False,  # set input mean to 0 over the dataset
    samplewise_center=False,  # set each sample mean to 0
    featurewise_std_normalization=False,  # divide inputs by std of the dataset
    samplewise_std_normalization=False,  # divide each input by its std
    zca_whitening=False,  # apply ZCA whitening
    # randomly rotate images in the range (degrees, 0 to 180)
    rotation_range=10,
    zoom_range=0.1,  # Randomly zoom image
    # randomly shift images horizontally (fraction of total width)
    width_shift_range=0.1,
    # randomly shift images vertically (fraction of total height)
    height_shift_range=0.1,
    horizontal_flip=False,  # randomly flip images
    vertical_flip=False  # randomly flip images
)

# train_datagen = ImageDataGenerator(rescale=1./255)
test_datagen = ImageDataGenerator(rescale=1./255)
evaluate_datagen = ImageDataGenerator(rescale=1./255)

train_generator = train_datagen.flow_from_directory(
    TRAIN_DIR,
    target_size=(150, 150),
    batch_size=32,
    class_mode='categorical',
    color_mode='grayscale'
)

print(train_generator.class_indices)

validation_generator = test_datagen.flow_from_directory(
    VALIDATION_DIR,
    target_size=(150, 150),
    batch_size=32,
    class_mode='categorical',
    color_mode='grayscale'
)

print(validation_generator.class_indices)

test_generator = evaluate_datagen.flow_from_directory(
    TEST_DIR,
    target_size=(150, 150),
    batch_size=32,
    class_mode='categorical',
    color_mode='grayscale'
)

print(test_generator.class_indices)
```

```
Found 10606 images belonging to 3 classes.
{'covid': 0, 'normal': 1, 'viral_pneumonia': 2}
Found 2273 images belonging to 3 classes.
{'covid': 0, 'normal': 1, 'viral_pneumonia': 2}
Found 2274 images belonging to 3 classes.
{'covid': 0, 'normal': 1, 'viral_pneumonia': 2}
```

[ ]:

```
for X_batch, y_batch in train_generator:
        # create a grid of 3x3 images
        for i in range(0, 9):
                plt.subplot(330 + 1 + i)
                plt.imshow(X_batch[i].reshape(150, 150), cmap=plt.
 ↪get_cmap('gray'))
        # show the plot
        plt.show()
        break
```



```
[ ]: from keras.layers import Conv2D, BatchNormalization, MaxPooling2D, Dropout,␣
      ↪Flatten, Dense
     from keras.models import Sequential
     from keras import backend

     backend.clear_session()

     model = Sequential()
     model.add(Conv2D(64, (3, 3), activation='relu', input_shape=(150, 150, 1)))
     model.add(BatchNormalization())
     model.add(MaxPooling2D((2, 2)))
     model.add(Conv2D(64, (3, 3), activation='relu'))
     model.add(BatchNormalization())
     model.add(MaxPooling2D((2, 2)))
     model.add(Conv2D(128, (3, 3), activation='relu'))
     model.add(BatchNormalization())
     model.add(MaxPooling2D((2, 2)))
     model.add(Conv2D(128, (3, 3), activation='relu'))
     model.add(BatchNormalization())
     model.add(MaxPooling2D((2, 2)))
     model.add(Flatten())
     model.add(Dropout(0.5))
     model.add(Dense(512, activation='relu'))
     model.add(Dense(64, activation='relu'))
     model.add(Dense(3, activation='softmax'))
model.summary()
```

```
2021-10-10 18:47:12.881778: I tensorflow/compiler/jit/xla_cpu_device.cc:41] Not
creating XLA devices, tf_xla_enable_xla_devices not set
2021-10-10 18:47:12.891781: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcuda.so.1
2021-10-10 18:47:13.336200: E
tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:927] could not open file to
read NUMA node: /sys/bus/pci/devices/0000:01:00.0/numa_node
Your kernel may have been built without NUMA support.
2021-10-10 18:47:13.336504: I
tensorflow/core/common_runtime/gpu/gpu_device.cc:1720] Found device 0 with
properties:
pciBusID: 0000:01:00.0 name: NVIDIA GeForce RTX 2080 with Max-Q Design
computeCapability: 7.5
coreClock: 1.215GHz coreCount: 46 deviceMemorySize: 8.00GiB
deviceMemoryBandwidth: 357.69GiB/s
2021-10-10 18:47:13.336537: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcudart.so.10.1
2021-10-10 18:47:13.384368: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcublas.so.10
2021-10-10 18:47:13.384462: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcublasLt.so.10
2021-10-10 18:47:13.425423: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcufft.so.10
2021-10-10 18:47:13.434537: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcurand.so.10
2021-10-10 18:47:13.487728: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcusolver.so.10
2021-10-10 18:47:13.507442: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcusparse.so.10
2021-10-10 18:47:13.590740: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcudnn.so.7
2021-10-10 18:47:13.591807: E
tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:927] could not open file to
read NUMA node: /sys/bus/pci/devices/0000:01:00.0/numa_node
Your kernel may have been built without NUMA support.
2021-10-10 18:47:13.593207: E
```

```
tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:927] could not open file to
read NUMA node: /sys/bus/pci/devices/0000:01:00.0/numa_node
Your kernel may have been built without NUMA support.
2021-10-10 18:47:13.593615: I
tensorflow/core/common_runtime/gpu/gpu_device.cc:1862] Adding visible gpu
devices: 0
2021-10-10 18:47:13.596282: I tensorflow/core/platform/cpu_feature_guard.cc:142]
This TensorFlow binary is optimized with oneAPI Deep Neural Network Library
(oneDNN) to use the following CPU instructions in performance-critical
operations:  SSE4.1 SSE4.2 AVX AVX2 FMA
To enable them in other operations, rebuild TensorFlow with the appropriate
compiler flags.
2021-10-10 18:47:13.598129: E
tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:927] could not open file to
read NUMA node: /sys/bus/pci/devices/0000:01:00.0/numa_node
Your kernel may have been built without NUMA support.
2021-10-10 18:47:13.598592: I
tensorflow/core/common_runtime/gpu/gpu_device.cc:1720] Found device 0 with
properties:
pciBusID: 0000:01:00.0 name: NVIDIA GeForce RTX 2080 with Max-Q Design
computeCapability: 7.5
coreClock: 1.215GHz coreCount: 46 deviceMemorySize: 8.00GiB
deviceMemoryBandwidth: 357.69GiB/s
2021-10-10 18:47:13.598636: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcudart.so.10.1
2021-10-10 18:47:13.598700: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcublas.so.10
2021-10-10 18:47:13.598720: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcublasLt.so.10
2021-10-10 18:47:13.598732: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcufft.so.10
2021-10-10 18:47:13.598756: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcurand.so.10
2021-10-10 18:47:13.598776: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcusolver.so.10
2021-10-10 18:47:13.598788: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcusparse.so.10
2021-10-10 18:47:13.598800: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcudnn.so.7
2021-10-10 18:47:13.599627: E
```

```
tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:927] could not open file to
read NUMA node: /sys/bus/pci/devices/0000:01:00.0/numa_node
Your kernel may have been built without NUMA support.
2021-10-10 18:47:13.600782: E
tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:927] could not open file to
read NUMA node: /sys/bus/pci/devices/0000:01:00.0/numa_node
Your kernel may have been built without NUMA support.
2021-10-10 18:47:13.601256: I
tensorflow/core/common_runtime/gpu/gpu_device.cc:1862] Adding visible gpu
devices: 0
2021-10-10 18:47:13.602433: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcudart.so.10.1
2021-10-10 18:47:15.673924: I
tensorflow/core/common_runtime/gpu/gpu_device.cc:1261] Device interconnect
StreamExecutor with strength 1 edge matrix:
2021-10-10 18:47:15.673951: I
tensorflow/core/common_runtime/gpu/gpu_device.cc:1267]      0
2021-10-10 18:47:15.673957: I
tensorflow/core/common_runtime/gpu/gpu_device.cc:1280] 0:   N
2021-10-10 18:47:15.709348: E
tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:927] could not open file to
read NUMA node: /sys/bus/pci/devices/0000:01:00.0/numa_node
Your kernel may have been built without NUMA support.
2021-10-10 18:47:15.709892: I
tensorflow/core/common_runtime/gpu/gpu_device.cc:1489] Could not identify NUMA
node of platform GPU id 0, defaulting to 0.  Your kernel may not have been built
with NUMA support.
2021-10-10 18:47:15.710927: E
tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:927] could not open file to
read NUMA node: /sys/bus/pci/devices/0000:01:00.0/numa_node
Your kernel may have been built without NUMA support.
2021-10-10 18:47:15.712131: E
tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:927] could not open file to
read NUMA node: /sys/bus/pci/devices/0000:01:00.0/numa_node
Your kernel may have been built without NUMA support.
2021-10-10 18:47:15.712672: I
tensorflow/core/common_runtime/gpu/gpu_device.cc:1406] Created TensorFlow device
(/job:localhost/replica:0/task:0/device:GPU:0 with 6575 MB memory) -> physical
GPU (device: 0, name: NVIDIA GeForce RTX 2080 with Max-Q Design, pci bus id:
0000:01:00.0, compute capability: 7.5)
2021-10-10 18:47:15.715106: I tensorflow/compiler/jit/xla_gpu_device.cc:99] Not
creating XLA devices, tf_xla_enable_xla_devices not set
```

```
Model: "sequential"
```

```
-----------------------------------------------------------------
Layer (type)                 Output Shape              Param #
=================================================================
conv2d (Conv2D)              (None, 148, 148, 64)      640
_________________________________________________________________
batch_normalization (BatchNo (None, 148, 148, 64)      256
_________________________________________________________________
max_pooling2d (MaxPooling2D) (None, 74, 74, 64)        0
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 72, 72, 64)        36928
_________________________________________________________________
batch_normalization_1 (Batch (None, 72, 72, 64)        256
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 36, 36, 64)        0
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 34, 34, 128)       73856
_________________________________________________________________
batch_normalization_2 (Batch (None, 34, 34, 128)       512
_________________________________________________________________
max_pooling2d_2 (MaxPooling2 (None, 17, 17, 128)       0
_________________________________________________________________
conv2d_3 (Conv2D)            (None, 15, 15, 128)       147584
_________________________________________________________________
batch_normalization_3 (Batch (None, 15, 15, 128)       512
_________________________________________________________________
max_pooling2d_3 (MaxPooling2 (None, 7, 7, 128)         0
_________________________________________________________________
flatten (Flatten)            (None, 6272)              0
_________________________________________________________________
dropout (Dropout)            (None, 6272)              0
_________________________________________________________________
dense (Dense)                (None, 512)               3211776
_________________________________________________________________
dense_1 (Dense)              (None, 64)                32832
_________________________________________________________________
dense_2 (Dense)              (None, 3)                 195
=================================================================
Total params: 3,505,347
Trainable params: 3,504,579
Non-trainable params: 768
_________________________________________________________________
```

[ ]:

```python
from keras import optimizers

# opt = RMSprop(lr=0.0001, decay=1e-6)
lr_schedule = optimizers.schedules.ExponentialDecay(
    initial_learning_rate=1e-5,
    decay_steps=2000,
    decay_rate=0.9)
opt = optimizers.Adam(learning_rate=lr_schedule)
```

```
model.compile(loss='categorical_crossentropy', optimizer=opt,␣
 ↪metrics=['accuracy'])
```

[ ]:

```
import numpy as np
from sklearn.utils import class_weight
from keras.callbacks import EarlyStopping
from keras.callbacks import ModelCheckpoint

classes = train_generator.classes
class_weights = class_weight.compute_class_weight(None,
                                                  np.unique(classes),
                                                  classes)
best_model_path = os.path.join(BASE_PATH, 'best_model.h5')
es = EarlyStopping(monitor='val_loss', mode='min', verbose=1, patience=10)
mc = ModelCheckpoint(best_model_path, monitor='val_accuracy', mode='max',␣
 ↪verbose=1, save_best_only=True)
history = model.fit(
    train_generator,
    steps_per_epoch=train_generator.n // 32,
    epochs=150,
    validation_data=validation_generator,
    class_weight=dict(zip(np.unique(classes), class_weights)),
    callbacks=[es, mc]
)
```

```
/home/hivini/anaconda3/envs/tf-gpu/lib/python3.9/site-
packages/sklearn/utils/validation.py:67: FutureWarning: Pass classes=[0 1 2],
y=[0 0 0 … 2 2 2] as keyword args. From version 0.25 passing these as
positional arguments will result in an error
  warnings.warn("Pass {} as keyword args. From version 0.25 "
2021-10-10 18:47:16.997222: I
tensorflow/compiler/mlir/mlir_graph_optimization_pass.cc:116] None of the MLIR
optimization passes are enabled (registered 2)
2021-10-10 18:47:17.000353: I
tensorflow/core/platform/profile_utils/cpu_utils.cc:112] CPU Frequency:
2208005000 Hz
```

```
Epoch 1/150
```

```
2021-10-10 18:47:17.734748: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcublas.so.10
2021-10-10 18:47:18.222118: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcudnn.so.7
2021-10-10 18:47:20.193316: W tensorflow/stream_executor/gpu/asm_compiler.cc:63]
```

```
Running ptxas --version returned 256
2021-10-10 18:47:20.290616: W
tensorflow/stream_executor/gpu/redzone_allocator.cc:314] Internal: ptxas exited
with non-zero error code 256, output:
Relying on driver to perform ptx compilation.
Modify $PATH to customize ptxas location.
This message will be only logged once.
```

```
331/331 [==============================] - 79s 186ms/step - loss: 1.0379 -
accuracy: 0.6214 - val_loss: 2.2961 - val_accuracy: 0.2415

Epoch 00001: val_accuracy improved from -inf to 0.24153, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 2/150
331/331 [==============================] - 33s 100ms/step - loss: 0.6581 -
accuracy: 0.7318 - val_loss: 0.4407 - val_accuracy: 0.8236

Epoch 00002: val_accuracy improved from 0.24153 to 0.82358, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 3/150
331/331 [==============================] - 33s 100ms/step - loss: 0.5599 -
accuracy: 0.7663 - val_loss: 0.4212 - val_accuracy: 0.8179

Epoch 00003: val_accuracy did not improve from 0.82358
Epoch 4/150
331/331 [==============================] - 33s 101ms/step - loss: 0.5002 -
accuracy: 0.7922 - val_loss: 0.3949 - val_accuracy: 0.8306

Epoch 00004: val_accuracy improved from 0.82358 to 0.83062, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 5/150
331/331 [==============================] - 33s 100ms/step - loss: 0.4587 -
accuracy: 0.8035 - val_loss: 0.3935 - val_accuracy: 0.8249

Epoch 00005: val_accuracy did not improve from 0.83062
Epoch 6/150
331/331 [==============================] - 33s 100ms/step - loss: 0.4461 -
accuracy: 0.8121 - val_loss: 0.3483 - val_accuracy: 0.8526

Epoch 00006: val_accuracy improved from 0.83062 to 0.85262, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 7/150
331/331 [==============================] - 33s 100ms/step - loss: 0.4165 -
accuracy: 0.8248 - val_loss: 0.3109 - val_accuracy: 0.8649

Epoch 00007: val_accuracy improved from 0.85262 to 0.86494, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 8/150
```

```
331/331 [==============================] - 33s 100ms/step - loss: 0.3884 -
accuracy: 0.8358 - val_loss: 0.3000 - val_accuracy: 0.8698

Epoch 00008: val_accuracy improved from 0.86494 to 0.86978, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 9/150
331/331 [==============================] - 34s 101ms/step - loss: 0.3888 -
accuracy: 0.8371 - val_loss: 0.2910 - val_accuracy: 0.8715

Epoch 00009: val_accuracy improved from 0.86978 to 0.87154, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 10/150
331/331 [==============================] - 33s 101ms/step - loss: 0.3389 -
accuracy: 0.8605 - val_loss: 0.2661 - val_accuracy: 0.8843

Epoch 00010: val_accuracy improved from 0.87154 to 0.88429, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 11/150
331/331 [==============================] - 33s 101ms/step - loss: 0.3507 -
accuracy: 0.8537 - val_loss: 0.2513 - val_accuracy: 0.8918

Epoch 00011: val_accuracy improved from 0.88429 to 0.89177, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 12/150
331/331 [==============================] - 33s 101ms/step - loss: 0.3416 -
accuracy: 0.8605 - val_loss: 0.2367 - val_accuracy: 0.9063

Epoch 00012: val_accuracy improved from 0.89177 to 0.90629, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 13/150
331/331 [==============================] - 33s 101ms/step - loss: 0.3347 -
accuracy: 0.8572 - val_loss: 0.2352 - val_accuracy: 0.9001

Epoch 00013: val_accuracy did not improve from 0.90629
Epoch 14/150
331/331 [==============================] - 33s 101ms/step - loss: 0.3093 -
accuracy: 0.8768 - val_loss: 0.2175 - val_accuracy: 0.9147

Epoch 00014: val_accuracy improved from 0.90629 to 0.91465, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 15/150
331/331 [==============================] - 33s 100ms/step - loss: 0.3085 -
accuracy: 0.8725 - val_loss: 0.2058 - val_accuracy: 0.9190

Epoch 00015: val_accuracy improved from 0.91465 to 0.91905, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 16/150
331/331 [==============================] - 33s 100ms/step - loss: 0.2984 -
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accuracy: 0.8789 - val_loss: 0.2003 - val_accuracy: 0.9265

Epoch 00016: val_accuracy improved from 0.91905 to 0.92653, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 17/150
331/331 [==============================] - 34s 102ms/step - loss: 0.2922 -
accuracy: 0.8787 - val_loss: 0.1950 - val_accuracy: 0.9239

Epoch 00017: val_accuracy did not improve from 0.92653
Epoch 18/150
331/331 [==============================] - 34s 101ms/step - loss: 0.2848 -
accuracy: 0.8857 - val_loss: 0.1960 - val_accuracy: 0.9252

Epoch 00018: val_accuracy did not improve from 0.92653
Epoch 19/150
331/331 [==============================] - 34s 103ms/step - loss: 0.2720 -
accuracy: 0.8909 - val_loss: 0.2024 - val_accuracy: 0.9186

Epoch 00019: val_accuracy did not improve from 0.92653
Epoch 20/150
331/331 [==============================] - 32s 97ms/step - loss: 0.2753 -
accuracy: 0.8935 - val_loss: 0.1841 - val_accuracy: 0.9292

Epoch 00020: val_accuracy improved from 0.92653 to 0.92917, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 21/150
331/331 [==============================] - 32s 98ms/step - loss: 0.2523 -
accuracy: 0.9006 - val_loss: 0.1826 - val_accuracy: 0.9248

Epoch 00021: val_accuracy did not improve from 0.92917
Epoch 22/150
331/331 [==============================] - 34s 103ms/step - loss: 0.2642 -
accuracy: 0.8969 - val_loss: 0.1786 - val_accuracy: 0.9305

Epoch 00022: val_accuracy improved from 0.92917 to 0.93049, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 23/150
331/331 [==============================] - 33s 99ms/step - loss: 0.2428 -
accuracy: 0.9064 - val_loss: 0.1756 - val_accuracy: 0.9314

Epoch 00023: val_accuracy improved from 0.93049 to 0.93137, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 24/150
331/331 [==============================] - 33s 99ms/step - loss: 0.2398 -
accuracy: 0.9072 - val_loss: 0.1682 - val_accuracy: 0.9358

Epoch 00024: val_accuracy improved from 0.93137 to 0.93577, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
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Epoch 25/150
331/331 [==============================] - 36s 110ms/step - loss: 0.2311 -
accuracy: 0.9082 - val_loss: 0.1665 - val_accuracy: 0.9358

Epoch 00025: val_accuracy did not improve from 0.93577
Epoch 26/150
331/331 [==============================] - 36s 107ms/step - loss: 0.2412 -
accuracy: 0.9067 - val_loss: 0.1699 - val_accuracy: 0.9309

Epoch 00026: val_accuracy did not improve from 0.93577
Epoch 27/150
331/331 [==============================] - 34s 103ms/step - loss: 0.2193 -
accuracy: 0.9122 - val_loss: 0.1679 - val_accuracy: 0.9344

Epoch 00027: val_accuracy did not improve from 0.93577
Epoch 28/150
331/331 [==============================] - 34s 103ms/step - loss: 0.2217 -
accuracy: 0.9108 - val_loss: 0.1592 - val_accuracy: 0.9384

Epoch 00028: val_accuracy improved from 0.93577 to 0.93841, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 29/150
331/331 [==============================] - 35s 107ms/step - loss: 0.2206 -
accuracy: 0.9167 - val_loss: 0.1628 - val_accuracy: 0.9375

Epoch 00029: val_accuracy did not improve from 0.93841
Epoch 30/150
331/331 [==============================] - 35s 106ms/step - loss: 0.2190 -
accuracy: 0.9137 - val_loss: 0.1602 - val_accuracy: 0.9371

Epoch 00030: val_accuracy did not improve from 0.93841
Epoch 31/150
331/331 [==============================] - 35s 107ms/step - loss: 0.2123 -
accuracy: 0.9156 - val_loss: 0.1563 - val_accuracy: 0.9419

Epoch 00031: val_accuracy improved from 0.93841 to 0.94193, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 32/150
331/331 [==============================] - 34s 104ms/step - loss: 0.2154 -
accuracy: 0.9150 - val_loss: 0.1546 - val_accuracy: 0.9384

Epoch 00032: val_accuracy did not improve from 0.94193
Epoch 33/150
331/331 [==============================] - 34s 102ms/step - loss: 0.2079 -
accuracy: 0.9177 - val_loss: 0.1536 - val_accuracy: 0.9432

Epoch 00033: val_accuracy improved from 0.94193 to 0.94325, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
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Epoch 34/150
331/331 [==============================] - 35s 104ms/step - loss: 0.2005 -
accuracy: 0.9222 - val_loss: 0.1469 - val_accuracy: 0.9424

Epoch 00034: val_accuracy did not improve from 0.94325
Epoch 35/150
331/331 [==============================] - 35s 104ms/step - loss: 0.2063 -
accuracy: 0.9198 - val_loss: 0.1630 - val_accuracy: 0.9388

Epoch 00035: val_accuracy did not improve from 0.94325
Epoch 36/150
331/331 [==============================] - 34s 104ms/step - loss: 0.2009 -
accuracy: 0.9217 - val_loss: 0.1411 - val_accuracy: 0.9450

Epoch 00036: val_accuracy improved from 0.94325 to 0.94501, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 37/150
331/331 [==============================] - 33s 99ms/step - loss: 0.1833 -
accuracy: 0.9304 - val_loss: 0.1496 - val_accuracy: 0.9441

Epoch 00037: val_accuracy did not improve from 0.94501
Epoch 38/150
331/331 [==============================] - 35s 104ms/step - loss: 0.1866 -
accuracy: 0.9314 - val_loss: 0.1480 - val_accuracy: 0.9406

Epoch 00038: val_accuracy did not improve from 0.94501
Epoch 39/150
331/331 [==============================] - 35s 107ms/step - loss: 0.1996 -
accuracy: 0.9232 - val_loss: 0.1488 - val_accuracy: 0.9406

Epoch 00039: val_accuracy did not improve from 0.94501
Epoch 40/150
331/331 [==============================] - 38s 113ms/step - loss: 0.1913 -
accuracy: 0.9254 - val_loss: 0.1385 - val_accuracy: 0.9463

Epoch 00040: val_accuracy improved from 0.94501 to 0.94633, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 41/150
331/331 [==============================] - 36s 109ms/step - loss: 0.1961 -
accuracy: 0.9281 - val_loss: 0.1367 - val_accuracy: 0.9468

Epoch 00041: val_accuracy improved from 0.94633 to 0.94677, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 42/150
331/331 [==============================] - 36s 107ms/step - loss: 0.1815 -
accuracy: 0.9281 - val_loss: 0.1570 - val_accuracy: 0.9380

Epoch 00042: val_accuracy did not improve from 0.94677
Epoch 43/150
331/331 [==============================] - 36s 108ms/step - loss: 0.1729 -
accuracy: 0.9368 - val_loss: 0.1413 - val_accuracy: 0.9424

Epoch 00043: val_accuracy did not improve from 0.94677
Epoch 44/150
331/331 [==============================] - 34s 103ms/step - loss: 0.1856 -
accuracy: 0.9309 - val_loss: 0.1263 - val_accuracy: 0.9534

Epoch 00044: val_accuracy improved from 0.94677 to 0.95337, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 45/150
331/331 [==============================] - 34s 101ms/step - loss: 0.1770 -
accuracy: 0.9326 - val_loss: 0.1377 - val_accuracy: 0.9446

Epoch 00045: val_accuracy did not improve from 0.95337
Epoch 46/150
331/331 [==============================] - 34s 102ms/step - loss: 0.1764 -
accuracy: 0.9316 - val_loss: 0.1402 - val_accuracy: 0.9437

Epoch 00046: val_accuracy did not improve from 0.95337
Epoch 47/150
331/331 [==============================] - 40s 122ms/step - loss: 0.1673 -
accuracy: 0.9363 - val_loss: 0.1317 - val_accuracy: 0.9503

Epoch 00047: val_accuracy did not improve from 0.95337
Epoch 48/150
331/331 [==============================] - 35s 105ms/step - loss: 0.1790 -
accuracy: 0.9332 - val_loss: 0.1731 - val_accuracy: 0.9344

Epoch 00048: val_accuracy did not improve from 0.95337
Epoch 49/150
331/331 [==============================] - 33s 100ms/step - loss: 0.1714 -
accuracy: 0.9341 - val_loss: 0.1279 - val_accuracy: 0.9503

Epoch 00049: val_accuracy did not improve from 0.95337
Epoch 50/150
331/331 [==============================] - 33s 100ms/step - loss: 0.1713 -
accuracy: 0.9387 - val_loss: 0.1343 - val_accuracy: 0.9476

Epoch 00050: val_accuracy did not improve from 0.95337
Epoch 51/150
331/331 [==============================] - 33s 101ms/step - loss: 0.1696 -
accuracy: 0.9350 - val_loss: 0.1480 - val_accuracy: 0.9437

Epoch 00051: val_accuracy did not improve from 0.95337
Epoch 52/150
331/331 [==============================] - 35s 104ms/step - loss: 0.1719 -
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accuracy: 0.9337 - val_loss: 0.1330 - val_accuracy: 0.9472

Epoch 00052: val_accuracy did not improve from 0.95337
Epoch 53/150
331/331 [==============================] - 35s 106ms/step - loss: 0.1686 -
accuracy: 0.9350 - val_loss: 0.1314 - val_accuracy: 0.9481

Epoch 00053: val_accuracy did not improve from 0.95337
Epoch 54/150
331/331 [==============================] - 32s 97ms/step - loss: 0.1645 -
accuracy: 0.9395 - val_loss: 0.1253 - val_accuracy: 0.9512

Epoch 00054: val_accuracy did not improve from 0.95337
Epoch 55/150
331/331 [==============================] - 32s 97ms/step - loss: 0.1766 -
accuracy: 0.9315 - val_loss: 0.1413 - val_accuracy: 0.9410

Epoch 00055: val_accuracy did not improve from 0.95337
Epoch 56/150
331/331 [==============================] - 33s 100ms/step - loss: 0.1639 -
accuracy: 0.9405 - val_loss: 0.1280 - val_accuracy: 0.9520

Epoch 00056: val_accuracy did not improve from 0.95337
Epoch 57/150
331/331 [==============================] - 32s 97ms/step - loss: 0.1708 -
accuracy: 0.9367 - val_loss: 0.1230 - val_accuracy: 0.9542

Epoch 00057: val_accuracy improved from 0.95337 to 0.95425, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 58/150
331/331 [==============================] - 32s 97ms/step - loss: 0.1575 -
accuracy: 0.9419 - val_loss: 0.1349 - val_accuracy: 0.9476

Epoch 00058: val_accuracy did not improve from 0.95425
Epoch 59/150
331/331 [==============================] - 32s 97ms/step - loss: 0.1686 -
accuracy: 0.9365 - val_loss: 0.1223 - val_accuracy: 0.9547

Epoch 00059: val_accuracy improved from 0.95425 to 0.95469, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 60/150
331/331 [==============================] - 32s 97ms/step - loss: 0.1551 -
accuracy: 0.9404 - val_loss: 0.1195 - val_accuracy: 0.9551

Epoch 00060: val_accuracy improved from 0.95469 to 0.95513, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 61/150
331/331 [==============================] - 36s 108ms/step - loss: 0.1661 -
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accuracy: 0.9369 - val_loss: 0.1217 - val_accuracy: 0.9534

Epoch 00061: val_accuracy did not improve from 0.95513
Epoch 62/150
331/331 [==============================] - 37s 113ms/step - loss: 0.1656 -
accuracy: 0.9390 - val_loss: 0.1193 - val_accuracy: 0.9556

Epoch 00062: val_accuracy improved from 0.95513 to 0.95557, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 63/150
331/331 [==============================] - 32s 97ms/step - loss: 0.1553 -
accuracy: 0.9432 - val_loss: 0.1307 - val_accuracy: 0.9468

Epoch 00063: val_accuracy did not improve from 0.95557
Epoch 64/150
331/331 [==============================] - 32s 98ms/step - loss: 0.1575 -
accuracy: 0.9403 - val_loss: 0.1202 - val_accuracy: 0.9534

Epoch 00064: val_accuracy did not improve from 0.95557
Epoch 65/150
331/331 [==============================] - 33s 98ms/step - loss: 0.1578 -
accuracy: 0.9409 - val_loss: 0.1177 - val_accuracy: 0.9556

Epoch 00065: val_accuracy did not improve from 0.95557
Epoch 66/150
331/331 [==============================] - 32s 97ms/step - loss: 0.1601 -
accuracy: 0.9387 - val_loss: 0.1276 - val_accuracy: 0.9485

Epoch 00066: val_accuracy did not improve from 0.95557
Epoch 67/150
331/331 [==============================] - 34s 102ms/step - loss: 0.1482 -
accuracy: 0.9458 - val_loss: 0.1223 - val_accuracy: 0.9503

Epoch 00067: val_accuracy did not improve from 0.95557
Epoch 68/150
331/331 [==============================] - 32s 97ms/step - loss: 0.1555 -
accuracy: 0.9427 - val_loss: 0.1191 - val_accuracy: 0.9534

Epoch 00068: val_accuracy did not improve from 0.95557
Epoch 69/150
331/331 [==============================] - 32s 97ms/step - loss: 0.1644 -
accuracy: 0.9368 - val_loss: 0.1170 - val_accuracy: 0.9569

Epoch 00069: val_accuracy improved from 0.95557 to 0.95689, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 70/150
331/331 [==============================] - 34s 102ms/step - loss: 0.1564 -
accuracy: 0.9407 - val_loss: 0.1134 - val_accuracy: 0.9573
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Epoch 00070: val_accuracy improved from 0.95689 to 0.95733, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 71/150
331/331 [==============================] - 33s 101ms/step - loss: 0.1389 -
accuracy: 0.9456 - val_loss: 0.1205 - val_accuracy: 0.9556

Epoch 00071: val_accuracy did not improve from 0.95733
Epoch 72/150
331/331 [==============================] - 33s 101ms/step - loss: 0.1539 -
accuracy: 0.9447 - val_loss: 0.1164 - val_accuracy: 0.9529

Epoch 00072: val_accuracy did not improve from 0.95733
Epoch 73/150
331/331 [==============================] - 33s 101ms/step - loss: 0.1309 -
accuracy: 0.9499 - val_loss: 0.1155 - val_accuracy: 0.9529

Epoch 00073: val_accuracy did not improve from 0.95733
Epoch 74/150
331/331 [==============================] - 34s 102ms/step - loss: 0.1501 -
accuracy: 0.9448 - val_loss: 0.1141 - val_accuracy: 0.9564

Epoch 00074: val_accuracy did not improve from 0.95733
Epoch 75/150
331/331 [==============================] - 35s 106ms/step - loss: 0.1426 -
accuracy: 0.9490 - val_loss: 0.1130 - val_accuracy: 0.9556

Epoch 00075: val_accuracy did not improve from 0.95733
Epoch 76/150
331/331 [==============================] - 37s 113ms/step - loss: 0.1450 -
accuracy: 0.9429 - val_loss: 0.1219 - val_accuracy: 0.9529

Epoch 00076: val_accuracy did not improve from 0.95733
Epoch 77/150
331/331 [==============================] - 32s 98ms/step - loss: 0.1500 -
accuracy: 0.9442 - val_loss: 0.1183 - val_accuracy: 0.9560

Epoch 00077: val_accuracy did not improve from 0.95733
Epoch 78/150
331/331 [==============================] - 32s 98ms/step - loss: 0.1507 -
accuracy: 0.9499 - val_loss: 0.1196 - val_accuracy: 0.9498

Epoch 00078: val_accuracy did not improve from 0.95733
Epoch 79/150
331/331 [==============================] - 33s 99ms/step - loss: 0.1474 -
accuracy: 0.9455 - val_loss: 0.1119 - val_accuracy: 0.9586

Epoch 00079: val_accuracy improved from 0.95733 to 0.95864, saving model to
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/home/hivini/learn/research/new-covid/best_model.h5
Epoch 80/150
331/331 [==============================] - 33s 98ms/step - loss: 0.1515 -
accuracy: 0.9447 - val_loss: 0.1222 - val_accuracy: 0.9556

Epoch 00080: val_accuracy did not improve from 0.95864
Epoch 81/150
331/331 [==============================] - 33s 99ms/step - loss: 0.1508 -
accuracy: 0.9429 - val_loss: 0.1131 - val_accuracy: 0.9569

Epoch 00081: val_accuracy did not improve from 0.95864
Epoch 82/150
331/331 [==============================] - 33s 99ms/step - loss: 0.1451 -
accuracy: 0.9433 - val_loss: 0.1158 - val_accuracy: 0.9534

Epoch 00082: val_accuracy did not improve from 0.95864
Epoch 83/150
331/331 [==============================] - 33s 99ms/step - loss: 0.1402 -
accuracy: 0.9469 - val_loss: 0.1143 - val_accuracy: 0.9569

Epoch 00083: val_accuracy did not improve from 0.95864
Epoch 84/150
331/331 [==============================] - 32s 98ms/step - loss: 0.1425 -
accuracy: 0.9498 - val_loss: 0.1212 - val_accuracy: 0.9529

Epoch 00084: val_accuracy did not improve from 0.95864
Epoch 85/150
331/331 [==============================] - 33s 99ms/step - loss: 0.1567 -
accuracy: 0.9397 - val_loss: 0.1152 - val_accuracy: 0.9569

Epoch 00085: val_accuracy did not improve from 0.95864
Epoch 86/150
331/331 [==============================] - 36s 109ms/step - loss: 0.1392 -
accuracy: 0.9473 - val_loss: 0.1152 - val_accuracy: 0.9564

Epoch 00086: val_accuracy did not improve from 0.95864
Epoch 87/150
331/331 [==============================] - 34s 103ms/step - loss: 0.1412 -
accuracy: 0.9468 - val_loss: 0.1115 - val_accuracy: 0.9591

Epoch 00087: val_accuracy improved from 0.95864 to 0.95908, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 88/150
331/331 [==============================] - 34s 102ms/step - loss: 0.1403 -
accuracy: 0.9457 - val_loss: 0.1182 - val_accuracy: 0.9547

Epoch 00088: val_accuracy did not improve from 0.95908
Epoch 89/150
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331/331 [==============================] - 40s 121ms/step - loss: 0.1408 -
accuracy: 0.9465 - val_loss: 0.1092 - val_accuracy: 0.9595

Epoch 00089: val_accuracy improved from 0.95908 to 0.95952, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 90/150
331/331 [==============================] - 40s 120ms/step - loss: 0.1496 -
accuracy: 0.9442 - val_loss: 0.1119 - val_accuracy: 0.9560

Epoch 00090: val_accuracy did not improve from 0.95952
Epoch 91/150
331/331 [==============================] - 36s 109ms/step - loss: 0.1339 -
accuracy: 0.9518 - val_loss: 0.1075 - val_accuracy: 0.9595

Epoch 00091: val_accuracy did not improve from 0.95952
Epoch 92/150
331/331 [==============================] - 37s 111ms/step - loss: 0.1412 -
accuracy: 0.9500 - val_loss: 0.1149 - val_accuracy: 0.9569

Epoch 00092: val_accuracy did not improve from 0.95952
Epoch 93/150
331/331 [==============================] - 38s 116ms/step - loss: 0.1395 -
accuracy: 0.9472 - val_loss: 0.1102 - val_accuracy: 0.9578

Epoch 00093: val_accuracy did not improve from 0.95952
Epoch 94/150
331/331 [==============================] - 39s 117ms/step - loss: 0.1402 -
accuracy: 0.9483 - val_loss: 0.1083 - val_accuracy: 0.9600

Epoch 00094: val_accuracy improved from 0.95952 to 0.95996, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 95/150
331/331 [==============================] - 40s 120ms/step - loss: 0.1352 -
accuracy: 0.9490 - val_loss: 0.1085 - val_accuracy: 0.9582

Epoch 00095: val_accuracy did not improve from 0.95996
Epoch 96/150
331/331 [==============================] - 37s 113ms/step - loss: 0.1379 -
accuracy: 0.9484 - val_loss: 0.1101 - val_accuracy: 0.9595

Epoch 00096: val_accuracy did not improve from 0.95996
Epoch 97/150
331/331 [==============================] - 39s 116ms/step - loss: 0.1451 -
accuracy: 0.9462 - val_loss: 0.1174 - val_accuracy: 0.9551

Epoch 00097: val_accuracy did not improve from 0.95996
Epoch 98/150
331/331 [==============================] - 40s 120ms/step - loss: 0.1315 -
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accuracy: 0.9518 - val_loss: 0.1147 - val_accuracy: 0.9569

Epoch 00098: val_accuracy did not improve from 0.95996
Epoch 99/150
331/331 [==============================] - 41s 122ms/step - loss: 0.1459 -
accuracy: 0.9461 - val_loss: 0.1133 - val_accuracy: 0.9578

Epoch 00099: val_accuracy did not improve from 0.95996
Epoch 100/150
331/331 [==============================] - 43s 130ms/step - loss: 0.1314 -
accuracy: 0.9550 - val_loss: 0.1161 - val_accuracy: 0.9551

Epoch 00100: val_accuracy did not improve from 0.95996
Epoch 101/150
331/331 [==============================] - 41s 124ms/step - loss: 0.1417 -
accuracy: 0.9488 - val_loss: 0.1068 - val_accuracy: 0.9600

Epoch 00101: val_accuracy did not improve from 0.95996
Epoch 102/150
331/331 [==============================] - 44s 133ms/step - loss: 0.1371 -
accuracy: 0.9473 - val_loss: 0.1077 - val_accuracy: 0.9604

Epoch 00102: val_accuracy improved from 0.95996 to 0.96040, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 103/150
331/331 [==============================] - 41s 123ms/step - loss: 0.1460 -
accuracy: 0.9452 - val_loss: 0.1085 - val_accuracy: 0.9617

Epoch 00103: val_accuracy improved from 0.96040 to 0.96172, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 104/150
331/331 [==============================] - 44s 133ms/step - loss: 0.1357 -
accuracy: 0.9517 - val_loss: 0.1049 - val_accuracy: 0.9617

Epoch 00104: val_accuracy did not improve from 0.96172
Epoch 105/150
331/331 [==============================] - 41s 123ms/step - loss: 0.1283 -
accuracy: 0.9552 - val_loss: 0.1106 - val_accuracy: 0.9591

Epoch 00105: val_accuracy did not improve from 0.96172
Epoch 106/150
331/331 [==============================] - 42s 127ms/step - loss: 0.1355 -
accuracy: 0.9521 - val_loss: 0.1078 - val_accuracy: 0.9617

Epoch 00106: val_accuracy did not improve from 0.96172
Epoch 107/150
331/331 [==============================] - 42s 127ms/step - loss: 0.1392 -
accuracy: 0.9481 - val_loss: 0.1058 - val_accuracy: 0.9608
```

```
Epoch 00107: val_accuracy did not improve from 0.96172
Epoch 108/150
331/331 [==============================] - 40s 121ms/step - loss: 0.1395 -
accuracy: 0.9495 - val_loss: 0.1079 - val_accuracy: 0.9586

Epoch 00108: val_accuracy did not improve from 0.96172
Epoch 109/150
331/331 [==============================] - 36s 110ms/step - loss: 0.1325 -
accuracy: 0.9515 - val_loss: 0.1076 - val_accuracy: 0.9560

Epoch 00109: val_accuracy did not improve from 0.96172
Epoch 110/150
331/331 [==============================] - 37s 111ms/step - loss: 0.1414 -
accuracy: 0.9479 - val_loss: 0.1046 - val_accuracy: 0.9613

Epoch 00110: val_accuracy did not improve from 0.96172
Epoch 111/150
331/331 [==============================] - 40s 119ms/step - loss: 0.1261 -
accuracy: 0.9538 - val_loss: 0.1058 - val_accuracy: 0.9604

Epoch 00111: val_accuracy did not improve from 0.96172
Epoch 112/150
331/331 [==============================] - 37s 111ms/step - loss: 0.1325 -
accuracy: 0.9502 - val_loss: 0.1087 - val_accuracy: 0.9600

Epoch 00112: val_accuracy did not improve from 0.96172
Epoch 113/150
331/331 [==============================] - 36s 110ms/step - loss: 0.1369 -
accuracy: 0.9494 - val_loss: 0.1082 - val_accuracy: 0.9617

Epoch 00113: val_accuracy did not improve from 0.96172
Epoch 114/150
331/331 [==============================] - 37s 112ms/step - loss: 0.1370 -
accuracy: 0.9499 - val_loss: 0.1044 - val_accuracy: 0.9622

Epoch 00114: val_accuracy improved from 0.96172 to 0.96216, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 115/150
331/331 [==============================] - 39s 117ms/step - loss: 0.1287 -
accuracy: 0.9527 - val_loss: 0.1057 - val_accuracy: 0.9617

Epoch 00115: val_accuracy did not improve from 0.96216
Epoch 116/150
331/331 [==============================] - 36s 109ms/step - loss: 0.1240 -
accuracy: 0.9562 - val_loss: 0.1070 - val_accuracy: 0.9600

Epoch 00116: val_accuracy did not improve from 0.96216
Epoch 117/150
331/331 [==============================] - 36s 109ms/step - loss: 0.1352 -
accuracy: 0.9480 - val_loss: 0.1106 - val_accuracy: 0.9547

Epoch 00117: val_accuracy did not improve from 0.96216
Epoch 118/150
331/331 [==============================] - 39s 119ms/step - loss: 0.1260 -
accuracy: 0.9544 - val_loss: 0.1086 - val_accuracy: 0.9591

Epoch 00118: val_accuracy did not improve from 0.96216
Epoch 119/150
331/331 [==============================] - 38s 115ms/step - loss: 0.1278 -
accuracy: 0.9541 - val_loss: 0.1049 - val_accuracy: 0.9622

Epoch 00119: val_accuracy did not improve from 0.96216
Epoch 120/150
331/331 [==============================] - 40s 120ms/step - loss: 0.1296 -
accuracy: 0.9505 - val_loss: 0.1034 - val_accuracy: 0.9613

Epoch 00120: val_accuracy did not improve from 0.96216
Epoch 121/150
331/331 [==============================] - 41s 123ms/step - loss: 0.1284 -
accuracy: 0.9525 - val_loss: 0.1028 - val_accuracy: 0.9617

Epoch 00121: val_accuracy did not improve from 0.96216
Epoch 122/150
331/331 [==============================] - 40s 121ms/step - loss: 0.1353 -
accuracy: 0.9495 - val_loss: 0.1053 - val_accuracy: 0.9604

Epoch 00122: val_accuracy did not improve from 0.96216
Epoch 123/150
331/331 [==============================] - 36s 110ms/step - loss: 0.1262 -
accuracy: 0.9539 - val_loss: 0.1014 - val_accuracy: 0.9622

Epoch 00123: val_accuracy did not improve from 0.96216
Epoch 124/150
331/331 [==============================] - 35s 105ms/step - loss: 0.1243 -
accuracy: 0.9556 - val_loss: 0.1042 - val_accuracy: 0.9608

Epoch 00124: val_accuracy did not improve from 0.96216
Epoch 125/150
331/331 [==============================] - 35s 106ms/step - loss: 0.1416 -
accuracy: 0.9507 - val_loss: 0.1035 - val_accuracy: 0.9617

Epoch 00125: val_accuracy did not improve from 0.96216
Epoch 126/150
331/331 [==============================] - 35s 105ms/step - loss: 0.1387 -
accuracy: 0.9480 - val_loss: 0.1040 - val_accuracy: 0.9608
```

```
Epoch 00126: val_accuracy did not improve from 0.96216
Epoch 127/150
331/331 [==============================] - 34s 104ms/step - loss: 0.1351 -
accuracy: 0.9505 - val_loss: 0.1038 - val_accuracy: 0.9608

Epoch 00127: val_accuracy did not improve from 0.96216
Epoch 128/150
331/331 [==============================] - 36s 110ms/step - loss: 0.1318 -
accuracy: 0.9492 - val_loss: 0.1033 - val_accuracy: 0.9613

Epoch 00128: val_accuracy did not improve from 0.96216
Epoch 129/150
331/331 [==============================] - 36s 109ms/step - loss: 0.1226 -
accuracy: 0.9545 - val_loss: 0.1013 - val_accuracy: 0.9622

Epoch 00129: val_accuracy did not improve from 0.96216
Epoch 130/150
331/331 [==============================] - 36s 109ms/step - loss: 0.1320 -
accuracy: 0.9506 - val_loss: 0.1029 - val_accuracy: 0.9608

Epoch 00130: val_accuracy did not improve from 0.96216
Epoch 131/150
331/331 [==============================] - 36s 108ms/step - loss: 0.1341 -
accuracy: 0.9499 - val_loss: 0.1031 - val_accuracy: 0.9613

Epoch 00131: val_accuracy did not improve from 0.96216
Epoch 132/150
331/331 [==============================] - 35s 106ms/step - loss: 0.1368 -
accuracy: 0.9482 - val_loss: 0.1037 - val_accuracy: 0.9595

Epoch 00132: val_accuracy did not improve from 0.96216
Epoch 133/150
331/331 [==============================] - 36s 109ms/step - loss: 0.1157 -
accuracy: 0.9594 - val_loss: 0.1022 - val_accuracy: 0.9622

Epoch 00133: val_accuracy did not improve from 0.96216
Epoch 134/150
331/331 [==============================] - 36s 110ms/step - loss: 0.1273 -
accuracy: 0.9552 - val_loss: 0.1036 - val_accuracy: 0.9613

Epoch 00134: val_accuracy did not improve from 0.96216
Epoch 135/150
331/331 [==============================] - 35s 105ms/step - loss: 0.1234 -
accuracy: 0.9571 - val_loss: 0.1049 - val_accuracy: 0.9586

Epoch 00135: val_accuracy did not improve from 0.96216
Epoch 136/150
```

```
331/331 [==============================] - 36s 110ms/step - loss: 0.1201 -
accuracy: 0.9564 - val_loss: 0.1052 - val_accuracy: 0.9604

Epoch 00136: val_accuracy did not improve from 0.96216
Epoch 137/150
331/331 [==============================] - 36s 110ms/step - loss: 0.1246 -
accuracy: 0.9552 - val_loss: 0.1028 - val_accuracy: 0.9639

Epoch 00137: val_accuracy improved from 0.96216 to 0.96392, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 138/150
331/331 [==============================] - 35s 106ms/step - loss: 0.1216 -
accuracy: 0.9523 - val_loss: 0.1029 - val_accuracy: 0.9622

Epoch 00138: val_accuracy did not improve from 0.96392
Epoch 139/150
331/331 [==============================] - 36s 110ms/step - loss: 0.1237 -
accuracy: 0.9551 - val_loss: 0.1023 - val_accuracy: 0.9608

Epoch 00139: val_accuracy did not improve from 0.96392
Epoch 00139: early stopping
```

[ ]:
```python
model.save(os.path.join(BASE_PATH, 'covid_classifier_result.h5'))
```

[ ]:
```python
test_loss, test_acc = model.evaluate(test_generator)
print("Loss on test set: ", test_loss)
print("Accuracy on test set: ", test_acc)
```

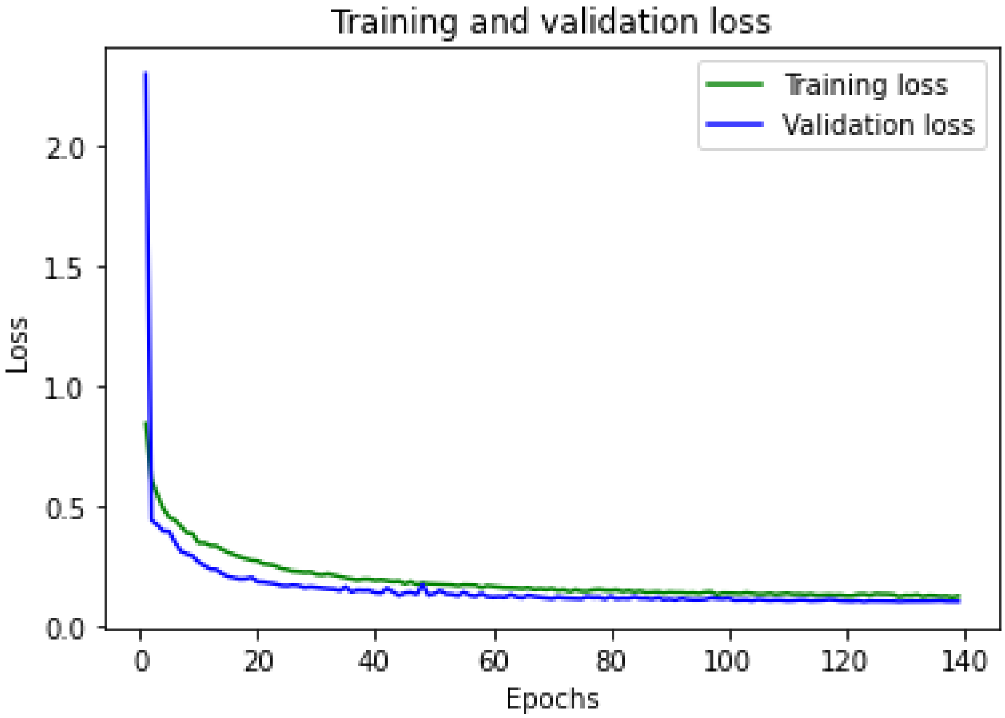
```
72/72 [==============================] - 12s 171ms/step - loss: 0.0858 -
accuracy: 0.9666
Loss on test set:  0.08580382913351059
Accuracy on test set:  0.9665787220001221
```

[ ]:
```python
import matplotlib.pyplot as plt

acc = history.history['accuracy']
val_acc = history.history['val_accuracy']
loss = history.history['loss']
val_loss = history.history['val_loss']

epochs = range(1, len(acc) + 1)
# bo is for blue dot.
plt.plot(epochs, loss, 'g', label='Training loss')
# b is for solid blue line
plt.plot(epochs, val_loss, 'b', label='Validation loss')
plt.title('Training and validation loss')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()

plt.show()
```

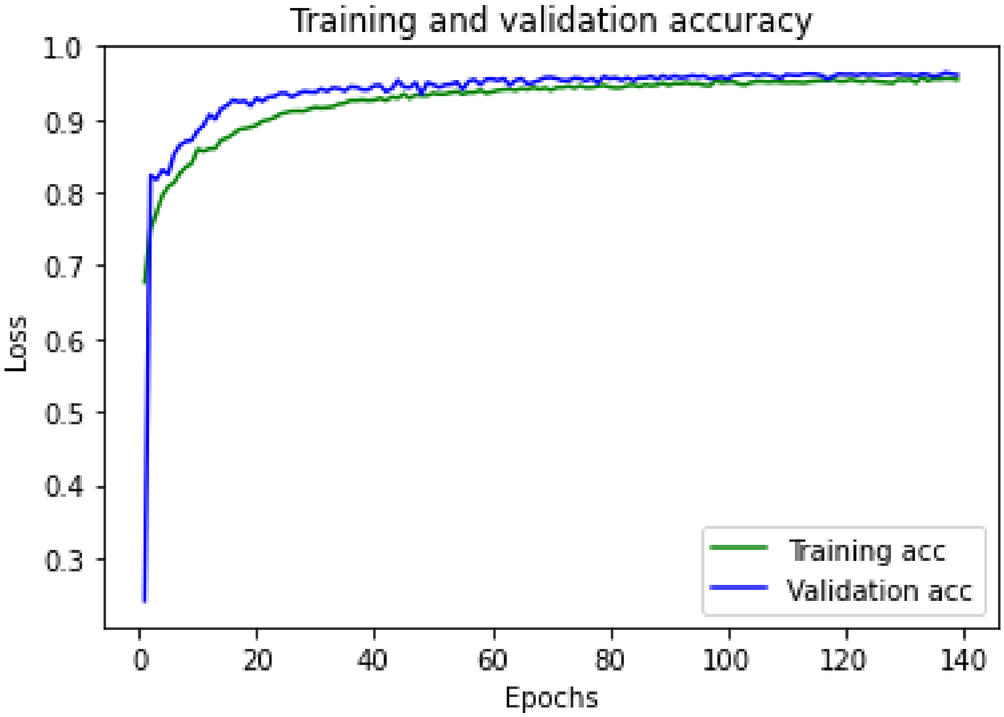


[ ]:

```
plt.clf()

plt.plot(epochs, acc, 'g', label='Training acc')
plt.plot(epochs, val_acc, 'b', label='Validation acc')
plt.title('Training and validation accuracy')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()

plt.show()
```


Training and validation accuracy
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
Loss
0
20
40
60
80
100
120
140
Epochs
Training acc
Validation acc