data_aug_adam_val___recall_95_21

November 7, 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.

[ ]:
```
# Aumentar threshold de Early Stop.
# Aumentar las rotaciones y escalas.
# Jugar con las metricas AUC y recall.
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)
```

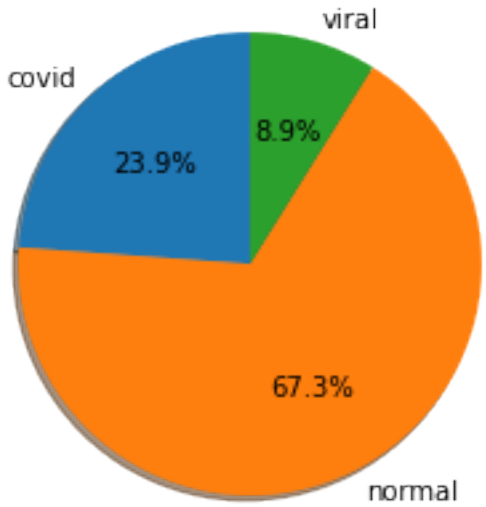
```
    saveAndSeparateFiles(ORIGINAL_COVID_DIR, TRAIN_COVID_DIR,
                         VALIDATION_COVID_DIR, TEST_COVID_DIR)
    saveAndSeparateFiles(ORIGINAL_VIRAL_DIR, TRAIN_VIRAL_DIR,
                         VALIDATION_VIRAL_DIR, TEST_VIRAL_DIR)
```

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)}
print(image_count)
fig1, ax1 = plt.subplots()
ax1.pie(image_count.values(),
        labels=image_count.keys(),
        shadow=True,
        autopct='%1.1f%%',
        startangle=90)
plt.show()
```

```
2021-11-07 02:28:43.494635: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcudart.so.10.1
```

```
{'covid': 2531, 'normal': 7134, 'viral': 941}
```



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

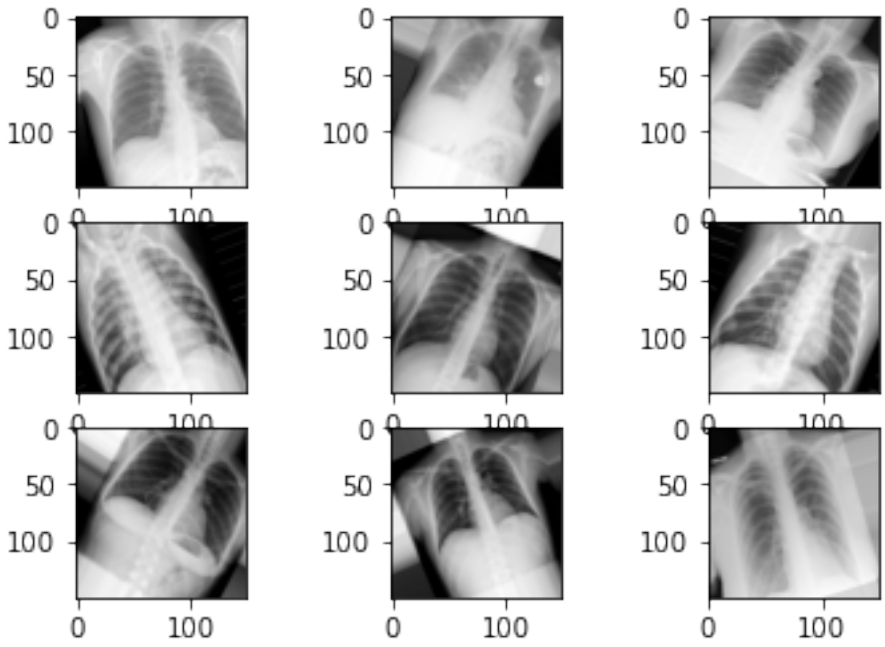
Our neural network will output neurons as 3 classes that will calculate the probability of being one using the softmax function.

[ ]:
```
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=30,
    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

# We want to make sure we start from the start when training our model␣
↪everytime we run it.
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()
```

```
2021-11-07 02:28:48.581211: I tensorflow/compiler/jit/xla_cpu_device.cc:41] Not
creating XLA devices, tf_xla_enable_xla_devices not set
2021-11-07 02:28:48.596081: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcuda.so.1
2021-11-07 02:28:48.922245: 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.
2021-11-07 02:28:48.922395: 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
2021-11-07 02:28:48.922463: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcudart.so.10.1
2021-11-07 02:28:48.944775: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcublas.so.10
2021-11-07 02:28:48.944879: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcublasLt.so.10
2021-11-07 02:28:48.962878: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcufft.so.10
2021-11-07 02:28:48.967771: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcurand.so.10
2021-11-07 02:28:48.998705: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcusolver.so.10
2021-11-07 02:28:49.009666: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcusparse.so.10
2021-11-07 02:28:49.064124: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcudnn.so.7
2021-11-07 02:28:49.065099: 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.
2021-11-07 02:28:49.065899: 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.
2021-11-07 02:28:49.066039: I
tensorflow/core/common_runtime/gpu/gpu_device.cc:1862] Adding visible gpu
devices: 0
2021-11-07 02:28:49.067407: 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.
2021-11-07 02:28:49.070833: 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.
2021-11-07 02:28:49.070861: 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
2021-11-07 02:28:49.070889: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcudart.so.10.1
2021-11-07 02:28:49.070916: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcublas.so.10
2021-11-07 02:28:49.070930: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcublasLt.so.10
2021-11-07 02:28:49.070941: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcufft.so.10
2021-11-07 02:28:49.070953: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcurand.so.10
2021-11-07 02:28:49.070964: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcusolver.so.10
2021-11-07 02:28:49.070977: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcusparse.so.10
2021-11-07 02:28:49.070989: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
```

```
opened dynamic library libcudnn.so.7
2021-11-07 02:28:49.071743: 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.
2021-11-07 02:28:49.072422: 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.
2021-11-07 02:28:49.072439: I
tensorflow/core/common_runtime/gpu/gpu_device.cc:1862] Adding visible gpu
devices: 0
2021-11-07 02:28:49.072646: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcudart.so.10.1
2021-11-07 02:28:50.844536: I
tensorflow/core/common_runtime/gpu/gpu_device.cc:1261] Device interconnect
StreamExecutor with strength 1 edge matrix:
2021-11-07 02:28:50.844562: I
tensorflow/core/common_runtime/gpu/gpu_device.cc:1267]      0
2021-11-07 02:28:50.844606: I
tensorflow/core/common_runtime/gpu/gpu_device.cc:1280] 0:   N
2021-11-07 02:28:50.845914: 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.
2021-11-07 02:28:50.845932: 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.
2021-11-07 02:28:50.846668: 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.
2021-11-07 02:28:50.847359: 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.
2021-11-07 02:28:50.847473: 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)
2021-11-07 02:28:50.848444: 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)

# try with metric categorical_crossentropy
model.compile(loss='categorical_crossentropy', optimizer=opt,␣
 ↪metrics=['accuracy', tf.keras.metrics.Recall()])
```

[ ]:
```
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=50)
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=400,
    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 "
2021-11-07 02:28:52.018106: I
tensorflow/compiler/mlir/mlir_graph_optimization_pass.cc:116] None of the MLIR
optimization passes are enabled (registered 2)
2021-11-07 02:28:52.019061: I
tensorflow/core/platform/profile_utils/cpu_utils.cc:112] CPU Frequency:
2208005000 Hz

Epoch 1/400

2021-11-07 02:28:52.839243: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcublas.so.10
2021-11-07 02:28:53.189598: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
```

```
opened dynamic library libcudnn.so.7
2021-11-07 02:28:55.493860: W tensorflow/stream_executor/gpu/asm_compiler.cc:63]
Running ptxas --version returned 256
2021-11-07 02:28:55.580483: 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: 1.0370 -
accuracy: 0.6136 - recall: 0.5867 - val_loss: 1.4091 - val_accuracy: 0.1535 -
val_recall: 0.0937

Epoch 00001: val_accuracy improved from -inf to 0.15354, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 2/400
331/331 [==============================] - 40s 120ms/step - loss: 0.6811 -
accuracy: 0.7065 - recall: 0.6864 - val_loss: 0.4735 - val_accuracy: 0.8069 -
val_recall: 0.7893

Epoch 00002: val_accuracy improved from 0.15354 to 0.80686, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 3/400
331/331 [==============================] - 40s 119ms/step - loss: 0.5920 -
accuracy: 0.7467 - recall: 0.7297 - val_loss: 0.4339 - val_accuracy: 0.8060 -
val_recall: 0.7959

Epoch 00003: val_accuracy did not improve from 0.80686
Epoch 4/400
331/331 [==============================] - 40s 119ms/step - loss: 0.5540 -
accuracy: 0.7560 - recall: 0.7448 - val_loss: 0.3941 - val_accuracy: 0.8218 -
val_recall: 0.8170

Epoch 00004: val_accuracy improved from 0.80686 to 0.82182, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 5/400
331/331 [==============================] - 40s 120ms/step - loss: 0.4982 -
accuracy: 0.7825 - recall: 0.7720 - val_loss: 0.3695 - val_accuracy: 0.8311 -
val_recall: 0.8289

Epoch 00005: val_accuracy improved from 0.82182 to 0.83106, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 6/400
331/331 [==============================] - 40s 120ms/step - loss: 0.4784 -
accuracy: 0.7912 - recall: 0.7828 - val_loss: 0.3578 - val_accuracy: 0.8368 -
val_recall: 0.8333
```

```
Epoch 00006: val_accuracy improved from 0.83106 to 0.83678, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 7/400
331/331 [==============================] - 40s 120ms/step - loss: 0.4461 -
accuracy: 0.8137 - recall: 0.8059 - val_loss: 0.3205 - val_accuracy: 0.8592 -
val_recall: 0.8575

Epoch 00007: val_accuracy improved from 0.83678 to 0.85922, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 8/400
331/331 [==============================] - 40s 120ms/step - loss: 0.4439 -
accuracy: 0.8147 - recall: 0.8070 - val_loss: 0.3214 - val_accuracy: 0.8627 -
val_recall: 0.8592

Epoch 00008: val_accuracy improved from 0.85922 to 0.86274, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 9/400
331/331 [==============================] - 40s 120ms/step - loss: 0.4336 -
accuracy: 0.8171 - recall: 0.8096 - val_loss: 0.3242 - val_accuracy: 0.8579 -
val_recall: 0.8570

Epoch 00009: val_accuracy did not improve from 0.86274
Epoch 10/400
331/331 [==============================] - 40s 120ms/step - loss: 0.4062 -
accuracy: 0.8312 - recall: 0.8220 - val_loss: 0.2969 - val_accuracy: 0.8746 -
val_recall: 0.8729

Epoch 00010: val_accuracy improved from 0.86274 to 0.87462, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 11/400
331/331 [==============================] - 40s 120ms/step - loss: 0.4033 -
accuracy: 0.8311 - recall: 0.8258 - val_loss: 0.2920 - val_accuracy: 0.8698 -
val_recall: 0.8685

Epoch 00011: val_accuracy did not improve from 0.87462
Epoch 12/400
331/331 [==============================] - 40s 120ms/step - loss: 0.3788 -
accuracy: 0.8379 - recall: 0.8313 - val_loss: 0.2835 - val_accuracy: 0.8795 -
val_recall: 0.8777

Epoch 00012: val_accuracy improved from 0.87462 to 0.87945, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 13/400
331/331 [==============================] - 40s 120ms/step - loss: 0.3831 -
accuracy: 0.8450 - recall: 0.8397 - val_loss: 0.2800 - val_accuracy: 0.8781 -
val_recall: 0.8759

Epoch 00013: val_accuracy did not improve from 0.87945
```

```
Epoch 14/400
331/331 [==============================] - 40s 120ms/step - loss: 0.3684 -
accuracy: 0.8419 - recall: 0.8359 - val_loss: 0.2625 - val_accuracy: 0.8839 -
val_recall: 0.8825

Epoch 00014: val_accuracy improved from 0.87945 to 0.88385, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 15/400
331/331 [==============================] - 40s 120ms/step - loss: 0.3374 -
accuracy: 0.8621 - recall: 0.8582 - val_loss: 0.2464 - val_accuracy: 0.8988 -
val_recall: 0.8971

Epoch 00015: val_accuracy improved from 0.88385 to 0.89881, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 16/400
331/331 [==============================] - 40s 120ms/step - loss: 0.3384 -
accuracy: 0.8576 - recall: 0.8539 - val_loss: 0.2637 - val_accuracy: 0.8847 -
val_recall: 0.8839

Epoch 00016: val_accuracy did not improve from 0.89881
Epoch 17/400
331/331 [==============================] - 40s 119ms/step - loss: 0.3354 -
accuracy: 0.8586 - recall: 0.8546 - val_loss: 0.2458 - val_accuracy: 0.8949 -
val_recall: 0.8940

Epoch 00017: val_accuracy did not improve from 0.89881
Epoch 18/400
331/331 [==============================] - 40s 120ms/step - loss: 0.3350 -
accuracy: 0.8648 - recall: 0.8620 - val_loss: 0.2373 - val_accuracy: 0.8971 -
val_recall: 0.8962

Epoch 00018: val_accuracy did not improve from 0.89881
Epoch 19/400
331/331 [==============================] - 40s 120ms/step - loss: 0.3249 -
accuracy: 0.8627 - recall: 0.8589 - val_loss: 0.2431 - val_accuracy: 0.8993 -
val_recall: 0.8979

Epoch 00019: val_accuracy improved from 0.89881 to 0.89925, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 20/400
331/331 [==============================] - 40s 120ms/step - loss: 0.3128 -
accuracy: 0.8755 - recall: 0.8716 - val_loss: 0.2232 - val_accuracy: 0.9054 -
val_recall: 0.9041

Epoch 00020: val_accuracy improved from 0.89925 to 0.90541, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 21/400
331/331 [==============================] - 40s 120ms/step - loss: 0.3121 -
```

```
accuracy: 0.8748 - recall: 0.8726 - val_loss: 0.2239 - val_accuracy: 0.9032 -
val_recall: 0.9019

Epoch 00021: val_accuracy did not improve from 0.90541
Epoch 22/400
331/331 [==============================] - 40s 119ms/step - loss: 0.3153 -
accuracy: 0.8728 - recall: 0.8702 - val_loss: 0.2281 - val_accuracy: 0.9015 -
val_recall: 0.9001

Epoch 00022: val_accuracy did not improve from 0.90541
Epoch 23/400
331/331 [==============================] - 40s 120ms/step - loss: 0.3068 -
accuracy: 0.8737 - recall: 0.8702 - val_loss: 0.2140 - val_accuracy: 0.9098 -
val_recall: 0.9076

Epoch 00023: val_accuracy improved from 0.90541 to 0.90981, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 24/400
331/331 [==============================] - 39s 117ms/step - loss: 0.2963 -
accuracy: 0.8827 - recall: 0.8788 - val_loss: 0.2106 - val_accuracy: 0.9138 -
val_recall: 0.9116

Epoch 00024: val_accuracy improved from 0.90981 to 0.91377, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 25/400
331/331 [==============================] - 39s 117ms/step - loss: 0.2940 -
accuracy: 0.8803 - recall: 0.8764 - val_loss: 0.2092 - val_accuracy: 0.9125 -
val_recall: 0.9107

Epoch 00025: val_accuracy did not improve from 0.91377
Epoch 26/400
331/331 [==============================] - 39s 117ms/step - loss: 0.2942 -
accuracy: 0.8825 - recall: 0.8787 - val_loss: 0.2267 - val_accuracy: 0.9006 -
val_recall: 0.8993

Epoch 00026: val_accuracy did not improve from 0.91377
Epoch 27/400
331/331 [==============================] - 39s 117ms/step - loss: 0.2789 -
accuracy: 0.8875 - recall: 0.8856 - val_loss: 0.2001 - val_accuracy: 0.9151 -
val_recall: 0.9142

Epoch 00027: val_accuracy improved from 0.91377 to 0.91509, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 28/400
331/331 [==============================] - 39s 117ms/step - loss: 0.2743 -
accuracy: 0.8932 - recall: 0.8897 - val_loss: 0.1949 - val_accuracy: 0.9142 -
val_recall: 0.9129
```

```
Epoch 00028: val_accuracy did not improve from 0.91509
Epoch 29/400
331/331 [==============================] - 39s 117ms/step - loss: 0.2747 -
accuracy: 0.8866 - recall: 0.8843 - val_loss: 0.1994 - val_accuracy: 0.9125 -
val_recall: 0.9120

Epoch 00029: val_accuracy did not improve from 0.91509
Epoch 30/400
331/331 [==============================] - 39s 117ms/step - loss: 0.2736 -
accuracy: 0.8946 - recall: 0.8899 - val_loss: 0.1991 - val_accuracy: 0.9147 -
val_recall: 0.9138

Epoch 00030: val_accuracy did not improve from 0.91509
Epoch 31/400
331/331 [==============================] - 39s 117ms/step - loss: 0.2692 -
accuracy: 0.8948 - recall: 0.8917 - val_loss: 0.2022 - val_accuracy: 0.9129 -
val_recall: 0.9116

Epoch 00031: val_accuracy did not improve from 0.91509
Epoch 32/400
331/331 [==============================] - 39s 117ms/step - loss: 0.2631 -
accuracy: 0.8964 - recall: 0.8936 - val_loss: 0.1841 - val_accuracy: 0.9248 -
val_recall: 0.9243

Epoch 00032: val_accuracy improved from 0.91509 to 0.92477, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 33/400
331/331 [==============================] - 39s 117ms/step - loss: 0.2688 -
accuracy: 0.8919 - recall: 0.8896 - val_loss: 0.1939 - val_accuracy: 0.9160 -
val_recall: 0.9151

Epoch 00033: val_accuracy did not improve from 0.92477
Epoch 34/400
331/331 [==============================] - 39s 117ms/step - loss: 0.2650 -
accuracy: 0.8925 - recall: 0.8910 - val_loss: 0.1885 - val_accuracy: 0.9204 -
val_recall: 0.9199

Epoch 00034: val_accuracy did not improve from 0.92477
Epoch 35/400
331/331 [==============================] - 39s 117ms/step - loss: 0.2531 -
accuracy: 0.8949 - recall: 0.8935 - val_loss: 0.1789 - val_accuracy: 0.9265 -
val_recall: 0.9261

Epoch 00035: val_accuracy improved from 0.92477 to 0.92653, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 36/400
331/331 [==============================] - 39s 118ms/step - loss: 0.2433 -
accuracy: 0.9058 - recall: 0.9044 - val_loss: 0.1781 - val_accuracy: 0.9248 -
```

```
val_recall: 0.9243

Epoch 00036: val_accuracy did not improve from 0.92653
Epoch 37/400
331/331 [==============================] - 39s 117ms/step - loss: 0.2433 -
accuracy: 0.9003 - recall: 0.8984 - val_loss: 0.1858 - val_accuracy: 0.9217 -
val_recall: 0.9204

Epoch 00037: val_accuracy did not improve from 0.92653
Epoch 38/400
331/331 [==============================] - 39s 118ms/step - loss: 0.2605 -
accuracy: 0.8982 - recall: 0.8955 - val_loss: 0.1842 - val_accuracy: 0.9230 -
val_recall: 0.9226

Epoch 00038: val_accuracy did not improve from 0.92653
Epoch 39/400
331/331 [==============================] - 39s 117ms/step - loss: 0.2471 -
accuracy: 0.9025 - recall: 0.9006 - val_loss: 0.1739 - val_accuracy: 0.9274 -
val_recall: 0.9274

Epoch 00039: val_accuracy improved from 0.92653 to 0.92741, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 40/400
331/331 [==============================] - 39s 117ms/step - loss: 0.2477 -
accuracy: 0.8994 - recall: 0.8979 - val_loss: 0.1832 - val_accuracy: 0.9204 -
val_recall: 0.9199

Epoch 00040: val_accuracy did not improve from 0.92741
Epoch 41/400
331/331 [==============================] - 39s 117ms/step - loss: 0.2366 -
accuracy: 0.9030 - recall: 0.9011 - val_loss: 0.1731 - val_accuracy: 0.9287 -
val_recall: 0.9265

Epoch 00041: val_accuracy improved from 0.92741 to 0.92873, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 42/400
331/331 [==============================] - 39s 117ms/step - loss: 0.2332 -
accuracy: 0.9084 - recall: 0.9058 - val_loss: 0.1711 - val_accuracy: 0.9300 -
val_recall: 0.9292

Epoch 00042: val_accuracy improved from 0.92873 to 0.93005, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 43/400
331/331 [==============================] - 39s 117ms/step - loss: 0.2370 -
accuracy: 0.9070 - recall: 0.9051 - val_loss: 0.1692 - val_accuracy: 0.9300 -
val_recall: 0.9292

Epoch 00043: val_accuracy did not improve from 0.93005
```

```
Epoch 44/400
331/331 [==============================] - 39s 117ms/step - loss: 0.2379 -
accuracy: 0.9067 - recall: 0.9056 - val_loss: 0.1727 - val_accuracy: 0.9287 -
val_recall: 0.9274

Epoch 00044: val_accuracy did not improve from 0.93005
Epoch 45/400
331/331 [==============================] - 39s 117ms/step - loss: 0.2201 -
accuracy: 0.9156 - recall: 0.9141 - val_loss: 0.1785 - val_accuracy: 0.9270 -
val_recall: 0.9252

Epoch 00045: val_accuracy did not improve from 0.93005
Epoch 46/400
331/331 [==============================] - 39s 117ms/step - loss: 0.2136 -
accuracy: 0.9184 - recall: 0.9175 - val_loss: 0.1754 - val_accuracy: 0.9243 -
val_recall: 0.9234

Epoch 00046: val_accuracy did not improve from 0.93005
Epoch 47/400
331/331 [==============================] - 39s 117ms/step - loss: 0.2198 -
accuracy: 0.9113 - recall: 0.9099 - val_loss: 0.1705 - val_accuracy: 0.9305 -
val_recall: 0.9287

Epoch 00047: val_accuracy improved from 0.93005 to 0.93049, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 48/400
331/331 [==============================] - 39s 117ms/step - loss: 0.2184 -
accuracy: 0.9143 - recall: 0.9124 - val_loss: 0.1644 - val_accuracy: 0.9322 -
val_recall: 0.9300

Epoch 00048: val_accuracy improved from 0.93049 to 0.93225, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 49/400
331/331 [==============================] - 39s 117ms/step - loss: 0.2107 -
accuracy: 0.9160 - recall: 0.9142 - val_loss: 0.1696 - val_accuracy: 0.9296 -
val_recall: 0.9287

Epoch 00049: val_accuracy did not improve from 0.93225
Epoch 50/400
331/331 [==============================] - 39s 117ms/step - loss: 0.2201 -
accuracy: 0.9157 - recall: 0.9143 - val_loss: 0.1689 - val_accuracy: 0.9314 -
val_recall: 0.9309

Epoch 00050: val_accuracy did not improve from 0.93225
Epoch 51/400
331/331 [==============================] - 39s 117ms/step - loss: 0.2139 -
accuracy: 0.9164 - recall: 0.9153 - val_loss: 0.1687 - val_accuracy: 0.9283 -
val_recall: 0.9278
```

```
Epoch 00051: val_accuracy did not improve from 0.93225
Epoch 52/400
331/331 [==============================] - 39s 117ms/step - loss: 0.2037 -
accuracy: 0.9206 - recall: 0.9193 - val_loss: 0.1721 - val_accuracy: 0.9300 -
val_recall: 0.9296

Epoch 00052: val_accuracy did not improve from 0.93225
Epoch 53/400
331/331 [==============================] - 39s 118ms/step - loss: 0.2147 -
accuracy: 0.9217 - recall: 0.9202 - val_loss: 0.1575 - val_accuracy: 0.9393 -
val_recall: 0.9375

Epoch 00053: val_accuracy improved from 0.93225 to 0.93929, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 54/400
331/331 [==============================] - 39s 117ms/step - loss: 0.2094 -
accuracy: 0.9191 - recall: 0.9172 - val_loss: 0.1704 - val_accuracy: 0.9322 -
val_recall: 0.9318

Epoch 00054: val_accuracy did not improve from 0.93929
Epoch 55/400
331/331 [==============================] - 39s 117ms/step - loss: 0.2077 -
accuracy: 0.9179 - recall: 0.9165 - val_loss: 0.1570 - val_accuracy: 0.9384 -
val_recall: 0.9380

Epoch 00055: val_accuracy did not improve from 0.93929
Epoch 56/400
331/331 [==============================] - 39s 117ms/step - loss: 0.2207 -
accuracy: 0.9151 - recall: 0.9134 - val_loss: 0.1549 - val_accuracy: 0.9375 -
val_recall: 0.9371

Epoch 00056: val_accuracy did not improve from 0.93929
Epoch 57/400
331/331 [==============================] - 39s 117ms/step - loss: 0.2070 -
accuracy: 0.9218 - recall: 0.9197 - val_loss: 0.1575 - val_accuracy: 0.9331 -
val_recall: 0.9322

Epoch 00057: val_accuracy did not improve from 0.93929
Epoch 58/400
331/331 [==============================] - 39s 117ms/step - loss: 0.2081 -
accuracy: 0.9200 - recall: 0.9178 - val_loss: 0.1537 - val_accuracy: 0.9380 -
val_recall: 0.9371

Epoch 00058: val_accuracy did not improve from 0.93929
Epoch 59/400
331/331 [==============================] - 39s 118ms/step - loss: 0.2029 -
accuracy: 0.9200 - recall: 0.9186 - val_loss: 0.1600 - val_accuracy: 0.9366 -
```

```
val_recall: 0.9349

Epoch 00059: val_accuracy did not improve from 0.93929
Epoch 60/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1979 -
accuracy: 0.9244 - recall: 0.9229 - val_loss: 0.1626 - val_accuracy: 0.9336 -
val_recall: 0.9327

Epoch 00060: val_accuracy did not improve from 0.93929
Epoch 61/400
331/331 [==============================] - 39s 117ms/step - loss: 0.2063 -
accuracy: 0.9201 - recall: 0.9193 - val_loss: 0.1562 - val_accuracy: 0.9380 -
val_recall: 0.9375

Epoch 00061: val_accuracy did not improve from 0.93929
Epoch 62/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1917 -
accuracy: 0.9293 - recall: 0.9278 - val_loss: 0.1572 - val_accuracy: 0.9380 -
val_recall: 0.9375

Epoch 00062: val_accuracy did not improve from 0.93929
Epoch 63/400
331/331 [==============================] - 39s 117ms/step - loss: 0.2058 -
accuracy: 0.9200 - recall: 0.9185 - val_loss: 0.1613 - val_accuracy: 0.9344 -
val_recall: 0.9340

Epoch 00063: val_accuracy did not improve from 0.93929
Epoch 64/400
331/331 [==============================] - 39s 118ms/step - loss: 0.2041 -
accuracy: 0.9207 - recall: 0.9192 - val_loss: 0.1510 - val_accuracy: 0.9406 -
val_recall: 0.9406

Epoch 00064: val_accuracy improved from 0.93929 to 0.94061, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 65/400
331/331 [==============================] - 39s 117ms/step - loss: 0.2008 -
accuracy: 0.9222 - recall: 0.9213 - val_loss: 0.1506 - val_accuracy: 0.9397 -
val_recall: 0.9397

Epoch 00065: val_accuracy did not improve from 0.94061
Epoch 66/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1937 -
accuracy: 0.9262 - recall: 0.9242 - val_loss: 0.1484 - val_accuracy: 0.9406 -
val_recall: 0.9406

Epoch 00066: val_accuracy did not improve from 0.94061
Epoch 67/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1897 -
```

```
accuracy: 0.9273 - recall: 0.9258 - val_loss: 0.1521 - val_accuracy: 0.9393 -
val_recall: 0.9388

Epoch 00067: val_accuracy did not improve from 0.94061
Epoch 68/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1814 -
accuracy: 0.9299 - recall: 0.9287 - val_loss: 0.1470 - val_accuracy: 0.9402 -
val_recall: 0.9397

Epoch 00068: val_accuracy did not improve from 0.94061
Epoch 69/400
331/331 [==============================] - 39s 117ms/step - loss: 0.2030 -
accuracy: 0.9239 - recall: 0.9226 - val_loss: 0.1406 - val_accuracy: 0.9428 -
val_recall: 0.9415

Epoch 00069: val_accuracy improved from 0.94061 to 0.94281, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 70/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1913 -
accuracy: 0.9296 - recall: 0.9283 - val_loss: 0.1567 - val_accuracy: 0.9362 -
val_recall: 0.9358

Epoch 00070: val_accuracy did not improve from 0.94281
Epoch 71/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1825 -
accuracy: 0.9315 - recall: 0.9303 - val_loss: 0.1488 - val_accuracy: 0.9393 -
val_recall: 0.9393

Epoch 00071: val_accuracy did not improve from 0.94281
Epoch 72/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1951 -
accuracy: 0.9256 - recall: 0.9240 - val_loss: 0.1414 - val_accuracy: 0.9428 -
val_recall: 0.9428

Epoch 00072: val_accuracy did not improve from 0.94281
Epoch 73/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1915 -
accuracy: 0.9274 - recall: 0.9260 - val_loss: 0.1420 - val_accuracy: 0.9441 -
val_recall: 0.9441

Epoch 00073: val_accuracy improved from 0.94281 to 0.94413, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 74/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1912 -
accuracy: 0.9263 - recall: 0.9254 - val_loss: 0.1461 - val_accuracy: 0.9406 -
val_recall: 0.9406

Epoch 00074: val_accuracy did not improve from 0.94413
```

```
Epoch 75/400
331/331 [==============================] - 39s 119ms/step - loss: 0.1921 -
accuracy: 0.9251 - recall: 0.9243 - val_loss: 0.1392 - val_accuracy: 0.9446 -
val_recall: 0.9446

Epoch 00075: val_accuracy improved from 0.94413 to 0.94457, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 76/400
331/331 [==============================] - 41s 123ms/step - loss: 0.1793 -
accuracy: 0.9318 - recall: 0.9306 - val_loss: 0.1536 - val_accuracy: 0.9358 -
val_recall: 0.9358

Epoch 00076: val_accuracy did not improve from 0.94457
Epoch 77/400
331/331 [==============================] - 39s 119ms/step - loss: 0.1827 -
accuracy: 0.9305 - recall: 0.9299 - val_loss: 0.1429 - val_accuracy: 0.9419 -
val_recall: 0.9419

Epoch 00077: val_accuracy did not improve from 0.94457
Epoch 78/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1939 -
accuracy: 0.9244 - recall: 0.9234 - val_loss: 0.1440 - val_accuracy: 0.9406 -
val_recall: 0.9397

Epoch 00078: val_accuracy did not improve from 0.94457
Epoch 79/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1780 -
accuracy: 0.9306 - recall: 0.9294 - val_loss: 0.1370 - val_accuracy: 0.9454 -
val_recall: 0.9454

Epoch 00079: val_accuracy improved from 0.94457 to 0.94545, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 80/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1858 -
accuracy: 0.9320 - recall: 0.9304 - val_loss: 0.1495 - val_accuracy: 0.9388 -
val_recall: 0.9388

Epoch 00080: val_accuracy did not improve from 0.94545
Epoch 81/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1768 -
accuracy: 0.9335 - recall: 0.9323 - val_loss: 0.1421 - val_accuracy: 0.9419 -
val_recall: 0.9419

Epoch 00081: val_accuracy did not improve from 0.94545
Epoch 82/400
331/331 [==============================] - 40s 120ms/step - loss: 0.1802 -
accuracy: 0.9305 - recall: 0.9293 - val_loss: 0.1485 - val_accuracy: 0.9410 -
val_recall: 0.9410
```

```
Epoch 00082: val_accuracy did not improve from 0.94545
Epoch 83/400
331/331 [==============================] - 39s 118ms/step - loss: 0.1862 -
accuracy: 0.9304 - recall: 0.9292 - val_loss: 0.1340 - val_accuracy: 0.9476 -
val_recall: 0.9476

Epoch 00083: val_accuracy improved from 0.94545 to 0.94765, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 84/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1671 -
accuracy: 0.9362 - recall: 0.9350 - val_loss: 0.1412 - val_accuracy: 0.9424 -
val_recall: 0.9424

Epoch 00084: val_accuracy did not improve from 0.94765
Epoch 85/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1844 -
accuracy: 0.9307 - recall: 0.9299 - val_loss: 0.1350 - val_accuracy: 0.9463 -
val_recall: 0.9454

Epoch 00085: val_accuracy did not improve from 0.94765
Epoch 86/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1734 -
accuracy: 0.9328 - recall: 0.9318 - val_loss: 0.1304 - val_accuracy: 0.9476 -
val_recall: 0.9476

Epoch 00086: val_accuracy did not improve from 0.94765
Epoch 87/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1845 -
accuracy: 0.9283 - recall: 0.9272 - val_loss: 0.1369 - val_accuracy: 0.9463 -
val_recall: 0.9463

Epoch 00087: val_accuracy did not improve from 0.94765
Epoch 88/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1723 -
accuracy: 0.9354 - recall: 0.9341 - val_loss: 0.1365 - val_accuracy: 0.9468 -
val_recall: 0.9463

Epoch 00088: val_accuracy did not improve from 0.94765
Epoch 89/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1722 -
accuracy: 0.9330 - recall: 0.9322 - val_loss: 0.1338 - val_accuracy: 0.9472 -
val_recall: 0.9472

Epoch 00089: val_accuracy did not improve from 0.94765
Epoch 90/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1764 -
accuracy: 0.9332 - recall: 0.9320 - val_loss: 0.1390 - val_accuracy: 0.9437 -
```

```
val_recall: 0.9432

Epoch 00090: val_accuracy did not improve from 0.94765
Epoch 91/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1725 -
accuracy: 0.9311 - recall: 0.9298 - val_loss: 0.1416 - val_accuracy: 0.9437 -
val_recall: 0.9437

Epoch 00091: val_accuracy did not improve from 0.94765
Epoch 92/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1845 -
accuracy: 0.9262 - recall: 0.9249 - val_loss: 0.1405 - val_accuracy: 0.9441 -
val_recall: 0.9441

Epoch 00092: val_accuracy did not improve from 0.94765
Epoch 93/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1819 -
accuracy: 0.9292 - recall: 0.9282 - val_loss: 0.1367 - val_accuracy: 0.9463 -
val_recall: 0.9459

Epoch 00093: val_accuracy did not improve from 0.94765
Epoch 94/400
331/331 [==============================] - 40s 122ms/step - loss: 0.1801 -
accuracy: 0.9320 - recall: 0.9315 - val_loss: 0.1370 - val_accuracy: 0.9450 -
val_recall: 0.9450

Epoch 00094: val_accuracy did not improve from 0.94765
Epoch 95/400
331/331 [==============================] - 40s 120ms/step - loss: 0.1753 -
accuracy: 0.9316 - recall: 0.9309 - val_loss: 0.1381 - val_accuracy: 0.9463 -
val_recall: 0.9454

Epoch 00095: val_accuracy did not improve from 0.94765
Epoch 96/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1673 -
accuracy: 0.9359 - recall: 0.9342 - val_loss: 0.1375 - val_accuracy: 0.9441 -
val_recall: 0.9441

Epoch 00096: val_accuracy did not improve from 0.94765
Epoch 97/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1771 -
accuracy: 0.9364 - recall: 0.9357 - val_loss: 0.1383 - val_accuracy: 0.9463 -
val_recall: 0.9454

Epoch 00097: val_accuracy did not improve from 0.94765
Epoch 98/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1715 -
accuracy: 0.9337 - recall: 0.9329 - val_loss: 0.1392 - val_accuracy: 0.9419 -
```

```
val_recall: 0.9415

Epoch 00098: val_accuracy did not improve from 0.94765
Epoch 99/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1718 -
accuracy: 0.9347 - recall: 0.9335 - val_loss: 0.1354 - val_accuracy: 0.9476 -
val_recall: 0.9476

Epoch 00099: val_accuracy did not improve from 0.94765
Epoch 100/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1634 -
accuracy: 0.9403 - recall: 0.9389 - val_loss: 0.1340 - val_accuracy: 0.9463 -
val_recall: 0.9463

Epoch 00100: val_accuracy did not improve from 0.94765
Epoch 101/400
331/331 [==============================] - 39s 118ms/step - loss: 0.1699 -
accuracy: 0.9367 - recall: 0.9352 - val_loss: 0.1407 - val_accuracy: 0.9441 -
val_recall: 0.9437

Epoch 00101: val_accuracy did not improve from 0.94765
Epoch 102/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1724 -
accuracy: 0.9375 - recall: 0.9358 - val_loss: 0.1333 - val_accuracy: 0.9450 -
val_recall: 0.9446

Epoch 00102: val_accuracy did not improve from 0.94765
Epoch 103/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1628 -
accuracy: 0.9370 - recall: 0.9361 - val_loss: 0.1344 - val_accuracy: 0.9472 -
val_recall: 0.9472

Epoch 00103: val_accuracy did not improve from 0.94765
Epoch 104/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1814 -
accuracy: 0.9315 - recall: 0.9307 - val_loss: 0.1346 - val_accuracy: 0.9450 -
val_recall: 0.9450

Epoch 00104: val_accuracy did not improve from 0.94765
Epoch 105/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1723 -
accuracy: 0.9367 - recall: 0.9358 - val_loss: 0.1300 - val_accuracy: 0.9463 -
val_recall: 0.9463

Epoch 00105: val_accuracy did not improve from 0.94765
Epoch 106/400
331/331 [==============================] - 39s 118ms/step - loss: 0.1671 -
accuracy: 0.9384 - recall: 0.9370 - val_loss: 0.1321 - val_accuracy: 0.9468 -
```

```
val_recall: 0.9468

Epoch 00106: val_accuracy did not improve from 0.94765
Epoch 107/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1679 -
accuracy: 0.9358 - recall: 0.9348 - val_loss: 0.1386 - val_accuracy: 0.9437 -
val_recall: 0.9432

Epoch 00107: val_accuracy did not improve from 0.94765
Epoch 108/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1775 -
accuracy: 0.9370 - recall: 0.9344 - val_loss: 0.1331 - val_accuracy: 0.9468 -
val_recall: 0.9468

Epoch 00108: val_accuracy did not improve from 0.94765
Epoch 109/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1678 -
accuracy: 0.9356 - recall: 0.9344 - val_loss: 0.1308 - val_accuracy: 0.9454 -
val_recall: 0.9454

Epoch 00109: val_accuracy did not improve from 0.94765
Epoch 110/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1633 -
accuracy: 0.9360 - recall: 0.9349 - val_loss: 0.1287 - val_accuracy: 0.9459 -
val_recall: 0.9459

Epoch 00110: val_accuracy did not improve from 0.94765
Epoch 111/400
331/331 [==============================] - 39s 118ms/step - loss: 0.1781 -
accuracy: 0.9301 - recall: 0.9297 - val_loss: 0.1368 - val_accuracy: 0.9463 -
val_recall: 0.9463

Epoch 00111: val_accuracy did not improve from 0.94765
Epoch 112/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1649 -
accuracy: 0.9384 - recall: 0.9377 - val_loss: 0.1349 - val_accuracy: 0.9459 -
val_recall: 0.9454

Epoch 00112: val_accuracy did not improve from 0.94765
Epoch 113/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1619 -
accuracy: 0.9385 - recall: 0.9368 - val_loss: 0.1304 - val_accuracy: 0.9481 -
val_recall: 0.9476

Epoch 00113: val_accuracy improved from 0.94765 to 0.94809, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 114/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1599 -
```

```
accuracy: 0.9384 - recall: 0.9367 - val_loss: 0.1288 - val_accuracy: 0.9481 -
val_recall: 0.9476

Epoch 00114: val_accuracy did not improve from 0.94809
Epoch 115/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1716 -
accuracy: 0.9324 - recall: 0.9318 - val_loss: 0.1312 - val_accuracy: 0.9472 -
val_recall: 0.9468

Epoch 00115: val_accuracy did not improve from 0.94809
Epoch 116/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1719 -
accuracy: 0.9340 - recall: 0.9333 - val_loss: 0.1294 - val_accuracy: 0.9476 -
val_recall: 0.9476

Epoch 00116: val_accuracy did not improve from 0.94809
Epoch 117/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1616 -
accuracy: 0.9400 - recall: 0.9394 - val_loss: 0.1299 - val_accuracy: 0.9476 -
val_recall: 0.9476

Epoch 00117: val_accuracy did not improve from 0.94809
Epoch 118/400
331/331 [==============================] - 39s 118ms/step - loss: 0.1600 -
accuracy: 0.9376 - recall: 0.9370 - val_loss: 0.1269 - val_accuracy: 0.9498 -
val_recall: 0.9494

Epoch 00118: val_accuracy improved from 0.94809 to 0.94985, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 119/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1599 -
accuracy: 0.9409 - recall: 0.9405 - val_loss: 0.1290 - val_accuracy: 0.9468 -
val_recall: 0.9463

Epoch 00119: val_accuracy did not improve from 0.94985
Epoch 120/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1735 -
accuracy: 0.9307 - recall: 0.9301 - val_loss: 0.1271 - val_accuracy: 0.9498 -
val_recall: 0.9494

Epoch 00120: val_accuracy did not improve from 0.94985
Epoch 121/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1610 -
accuracy: 0.9398 - recall: 0.9384 - val_loss: 0.1335 - val_accuracy: 0.9468 -
val_recall: 0.9468

Epoch 00121: val_accuracy did not improve from 0.94985
Epoch 122/400
```

```
331/331 [==============================] - 39s 117ms/step - loss: 0.1637 -
accuracy: 0.9395 - recall: 0.9374 - val_loss: 0.1339 - val_accuracy: 0.9463 -
val_recall: 0.9459

Epoch 00122: val_accuracy did not improve from 0.94985
Epoch 123/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1599 -
accuracy: 0.9407 - recall: 0.9400 - val_loss: 0.1282 - val_accuracy: 0.9494 -
val_recall: 0.9485

Epoch 00123: val_accuracy did not improve from 0.94985
Epoch 124/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1584 -
accuracy: 0.9431 - recall: 0.9424 - val_loss: 0.1287 - val_accuracy: 0.9503 -
val_recall: 0.9494

Epoch 00124: val_accuracy improved from 0.94985 to 0.95029, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 125/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1591 -
accuracy: 0.9455 - recall: 0.9439 - val_loss: 0.1302 - val_accuracy: 0.9468 -
val_recall: 0.9463

Epoch 00125: val_accuracy did not improve from 0.95029
Epoch 126/400
331/331 [==============================] - 39s 118ms/step - loss: 0.1650 -
accuracy: 0.9387 - recall: 0.9366 - val_loss: 0.1307 - val_accuracy: 0.9490 -
val_recall: 0.9485

Epoch 00126: val_accuracy did not improve from 0.95029
Epoch 127/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1550 -
accuracy: 0.9393 - recall: 0.9384 - val_loss: 0.1360 - val_accuracy: 0.9459 -
val_recall: 0.9459

Epoch 00127: val_accuracy did not improve from 0.95029
Epoch 128/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1548 -
accuracy: 0.9419 - recall: 0.9410 - val_loss: 0.1264 - val_accuracy: 0.9485 -
val_recall: 0.9476

Epoch 00128: val_accuracy did not improve from 0.95029
Epoch 129/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1736 -
accuracy: 0.9349 - recall: 0.9335 - val_loss: 0.1276 - val_accuracy: 0.9476 -
val_recall: 0.9472

Epoch 00129: val_accuracy did not improve from 0.95029
```

```
Epoch 130/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1552 -
accuracy: 0.9403 - recall: 0.9396 - val_loss: 0.1312 - val_accuracy: 0.9459 -
val_recall: 0.9459

Epoch 00130: val_accuracy did not improve from 0.95029
Epoch 131/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1590 -
accuracy: 0.9414 - recall: 0.9407 - val_loss: 0.1287 - val_accuracy: 0.9476 -
val_recall: 0.9472

Epoch 00131: val_accuracy did not improve from 0.95029
Epoch 132/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1649 -
accuracy: 0.9349 - recall: 0.9341 - val_loss: 0.1329 - val_accuracy: 0.9476 -
val_recall: 0.9472

Epoch 00132: val_accuracy did not improve from 0.95029
Epoch 133/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1626 -
accuracy: 0.9392 - recall: 0.9384 - val_loss: 0.1254 - val_accuracy: 0.9494 -
val_recall: 0.9494

Epoch 00133: val_accuracy did not improve from 0.95029
Epoch 134/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1557 -
accuracy: 0.9381 - recall: 0.9364 - val_loss: 0.1271 - val_accuracy: 0.9485 -
val_recall: 0.9476

Epoch 00134: val_accuracy did not improve from 0.95029
Epoch 135/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1523 -
accuracy: 0.9452 - recall: 0.9442 - val_loss: 0.1278 - val_accuracy: 0.9494 -
val_recall: 0.9490

Epoch 00135: val_accuracy did not improve from 0.95029
Epoch 136/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1624 -
accuracy: 0.9409 - recall: 0.9403 - val_loss: 0.1290 - val_accuracy: 0.9490 -
val_recall: 0.9490

Epoch 00136: val_accuracy did not improve from 0.95029
Epoch 137/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1572 -
accuracy: 0.9424 - recall: 0.9409 - val_loss: 0.1309 - val_accuracy: 0.9472 -
val_recall: 0.9472

Epoch 00137: val_accuracy did not improve from 0.95029
```

```
Epoch 138/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1720 -
accuracy: 0.9324 - recall: 0.9321 - val_loss: 0.1277 - val_accuracy: 0.9490 -
val_recall: 0.9481

Epoch 00138: val_accuracy did not improve from 0.95029
Epoch 139/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1511 -
accuracy: 0.9463 - recall: 0.9454 - val_loss: 0.1296 - val_accuracy: 0.9476 -
val_recall: 0.9472

Epoch 00139: val_accuracy did not improve from 0.95029
Epoch 140/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1542 -
accuracy: 0.9421 - recall: 0.9412 - val_loss: 0.1282 - val_accuracy: 0.9485 -
val_recall: 0.9481

Epoch 00140: val_accuracy did not improve from 0.95029
Epoch 141/400
331/331 [==============================] - 39s 118ms/step - loss: 0.1576 -
accuracy: 0.9397 - recall: 0.9384 - val_loss: 0.1299 - val_accuracy: 0.9472 -
val_recall: 0.9468

Epoch 00141: val_accuracy did not improve from 0.95029
Epoch 142/400
331/331 [==============================] - 40s 121ms/step - loss: 0.1552 -
accuracy: 0.9414 - recall: 0.9403 - val_loss: 0.1270 - val_accuracy: 0.9490 -
val_recall: 0.9490

Epoch 00142: val_accuracy did not improve from 0.95029
Epoch 143/400
331/331 [==============================] - 40s 120ms/step - loss: 0.1617 -
accuracy: 0.9418 - recall: 0.9413 - val_loss: 0.1282 - val_accuracy: 0.9494 -
val_recall: 0.9494

Epoch 00143: val_accuracy did not improve from 0.95029
Epoch 144/400
331/331 [==============================] - 40s 120ms/step - loss: 0.1697 -
accuracy: 0.9375 - recall: 0.9366 - val_loss: 0.1298 - val_accuracy: 0.9498 -
val_recall: 0.9494

Epoch 00144: val_accuracy did not improve from 0.95029
Epoch 145/400
331/331 [==============================] - 40s 120ms/step - loss: 0.1470 -
accuracy: 0.9452 - recall: 0.9443 - val_loss: 0.1274 - val_accuracy: 0.9476 -
val_recall: 0.9472

Epoch 00145: val_accuracy did not improve from 0.95029
```

```
Epoch 146/400
331/331 [==============================] - 40s 120ms/step - loss: 0.1621 -
accuracy: 0.9359 - recall: 0.9353 - val_loss: 0.1281 - val_accuracy: 0.9494 -
val_recall: 0.9490

Epoch 00146: val_accuracy did not improve from 0.95029
Epoch 147/400
331/331 [==============================] - 40s 120ms/step - loss: 0.1578 -
accuracy: 0.9454 - recall: 0.9449 - val_loss: 0.1295 - val_accuracy: 0.9476 -
val_recall: 0.9468

Epoch 00147: val_accuracy did not improve from 0.95029
Epoch 148/400
331/331 [==============================] - 40s 120ms/step - loss: 0.1565 -
accuracy: 0.9421 - recall: 0.9413 - val_loss: 0.1268 - val_accuracy: 0.9498 -
val_recall: 0.9498

Epoch 00148: val_accuracy did not improve from 0.95029
Epoch 149/400
331/331 [==============================] - 40s 120ms/step - loss: 0.1642 -
accuracy: 0.9394 - recall: 0.9374 - val_loss: 0.1286 - val_accuracy: 0.9481 -
val_recall: 0.9481

Epoch 00149: val_accuracy did not improve from 0.95029
Epoch 150/400
331/331 [==============================] - 40s 120ms/step - loss: 0.1596 -
accuracy: 0.9420 - recall: 0.9411 - val_loss: 0.1274 - val_accuracy: 0.9494 -
val_recall: 0.9490

Epoch 00150: val_accuracy did not improve from 0.95029
Epoch 151/400
331/331 [==============================] - 40s 120ms/step - loss: 0.1474 -
accuracy: 0.9456 - recall: 0.9440 - val_loss: 0.1303 - val_accuracy: 0.9472 -
val_recall: 0.9472

Epoch 00151: val_accuracy did not improve from 0.95029
Epoch 152/400
331/331 [==============================] - 40s 120ms/step - loss: 0.1550 -
accuracy: 0.9415 - recall: 0.9405 - val_loss: 0.1314 - val_accuracy: 0.9494 -
val_recall: 0.9490

Epoch 00152: val_accuracy did not improve from 0.95029
Epoch 153/400
331/331 [==============================] - 40s 120ms/step - loss: 0.1695 -
accuracy: 0.9384 - recall: 0.9367 - val_loss: 0.1340 - val_accuracy: 0.9463 -
val_recall: 0.9463

Epoch 00153: val_accuracy did not improve from 0.95029
```

```
Epoch 154/400
331/331 [==============================] - 40s 120ms/step - loss: 0.1436 -
accuracy: 0.9467 - recall: 0.9459 - val_loss: 0.1295 - val_accuracy: 0.9476 -
val_recall: 0.9472

Epoch 00154: val_accuracy did not improve from 0.95029
Epoch 155/400
331/331 [==============================] - 40s 120ms/step - loss: 0.1534 -
accuracy: 0.9447 - recall: 0.9441 - val_loss: 0.1297 - val_accuracy: 0.9498 -
val_recall: 0.9490

Epoch 00155: val_accuracy did not improve from 0.95029
Epoch 156/400
331/331 [==============================] - 40s 120ms/step - loss: 0.1640 -
accuracy: 0.9375 - recall: 0.9368 - val_loss: 0.1316 - val_accuracy: 0.9463 -
val_recall: 0.9459

Epoch 00156: val_accuracy did not improve from 0.95029
Epoch 157/400
331/331 [==============================] - 40s 120ms/step - loss: 0.1429 -
accuracy: 0.9461 - recall: 0.9451 - val_loss: 0.1273 - val_accuracy: 0.9481 -
val_recall: 0.9481

Epoch 00157: val_accuracy did not improve from 0.95029
Epoch 158/400
331/331 [==============================] - 40s 120ms/step - loss: 0.1566 -
accuracy: 0.9414 - recall: 0.9408 - val_loss: 0.1271 - val_accuracy: 0.9476 -
val_recall: 0.9472

Epoch 00158: val_accuracy did not improve from 0.95029
Epoch 159/400
331/331 [==============================] - 40s 120ms/step - loss: 0.1569 -
accuracy: 0.9392 - recall: 0.9378 - val_loss: 0.1263 - val_accuracy: 0.9503 -
val_recall: 0.9498

Epoch 00159: val_accuracy did not improve from 0.95029
Epoch 160/400
331/331 [==============================] - 40s 120ms/step - loss: 0.1542 -
accuracy: 0.9414 - recall: 0.9403 - val_loss: 0.1274 - val_accuracy: 0.9472 -
val_recall: 0.9468

Epoch 00160: val_accuracy did not improve from 0.95029
Epoch 161/400
331/331 [==============================] - 40s 120ms/step - loss: 0.1414 -
accuracy: 0.9483 - recall: 0.9465 - val_loss: 0.1272 - val_accuracy: 0.9481 -
val_recall: 0.9476

Epoch 00161: val_accuracy did not improve from 0.95029
```

```
Epoch 162/400
331/331 [==============================] - 40s 120ms/step - loss: 0.1590 -
accuracy: 0.9388 - recall: 0.9373 - val_loss: 0.1278 - val_accuracy: 0.9485 -
val_recall: 0.9481

Epoch 00162: val_accuracy did not improve from 0.95029
Epoch 163/400
331/331 [==============================] - 40s 119ms/step - loss: 0.1470 -
accuracy: 0.9443 - recall: 0.9435 - val_loss: 0.1291 - val_accuracy: 0.9490 -
val_recall: 0.9490

Epoch 00163: val_accuracy did not improve from 0.95029
Epoch 164/400
331/331 [==============================] - 40s 120ms/step - loss: 0.1477 -
accuracy: 0.9470 - recall: 0.9459 - val_loss: 0.1274 - val_accuracy: 0.9498 -
val_recall: 0.9494

Epoch 00164: val_accuracy did not improve from 0.95029
Epoch 165/400
331/331 [==============================] - 40s 120ms/step - loss: 0.1590 -
accuracy: 0.9416 - recall: 0.9412 - val_loss: 0.1289 - val_accuracy: 0.9481 -
val_recall: 0.9481

Epoch 00165: val_accuracy did not improve from 0.95029
Epoch 166/400
331/331 [==============================] - 39s 118ms/step - loss: 0.1418 -
accuracy: 0.9470 - recall: 0.9460 - val_loss: 0.1280 - val_accuracy: 0.9503 -
val_recall: 0.9498

Epoch 00166: val_accuracy did not improve from 0.95029
Epoch 167/400
331/331 [==============================] - 39s 118ms/step - loss: 0.1553 -
accuracy: 0.9458 - recall: 0.9453 - val_loss: 0.1284 - val_accuracy: 0.9503 -
val_recall: 0.9498

Epoch 00167: val_accuracy did not improve from 0.95029
Epoch 168/400
331/331 [==============================] - 39s 118ms/step - loss: 0.1600 -
accuracy: 0.9396 - recall: 0.9391 - val_loss: 0.1293 - val_accuracy: 0.9490 -
val_recall: 0.9485

Epoch 00168: val_accuracy did not improve from 0.95029
Epoch 169/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1622 -
accuracy: 0.9375 - recall: 0.9369 - val_loss: 0.1275 - val_accuracy: 0.9490 -
val_recall: 0.9485

Epoch 00169: val_accuracy did not improve from 0.95029
```

```
Epoch 170/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1563 -
accuracy: 0.9404 - recall: 0.9388 - val_loss: 0.1313 - val_accuracy: 0.9481 -
val_recall: 0.9468

Epoch 00170: val_accuracy did not improve from 0.95029
Epoch 171/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1513 -
accuracy: 0.9439 - recall: 0.9428 - val_loss: 0.1285 - val_accuracy: 0.9490 -
val_recall: 0.9485

Epoch 00171: val_accuracy did not improve from 0.95029
Epoch 172/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1561 -
accuracy: 0.9415 - recall: 0.9404 - val_loss: 0.1291 - val_accuracy: 0.9476 -
val_recall: 0.9472

Epoch 00172: val_accuracy did not improve from 0.95029
Epoch 173/400
331/331 [==============================] - 39s 118ms/step - loss: 0.1559 -
accuracy: 0.9435 - recall: 0.9422 - val_loss: 0.1311 - val_accuracy: 0.9494 -
val_recall: 0.9481

Epoch 00173: val_accuracy did not improve from 0.95029
Epoch 174/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1554 -
accuracy: 0.9426 - recall: 0.9413 - val_loss: 0.1295 - val_accuracy: 0.9512 -
val_recall: 0.9507

Epoch 00174: val_accuracy improved from 0.95029 to 0.95117, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 175/400
331/331 [==============================] - 39s 118ms/step - loss: 0.1533 -
accuracy: 0.9451 - recall: 0.9444 - val_loss: 0.1309 - val_accuracy: 0.9490 -
val_recall: 0.9490

Epoch 00175: val_accuracy did not improve from 0.95117
Epoch 176/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1613 -
accuracy: 0.9401 - recall: 0.9388 - val_loss: 0.1275 - val_accuracy: 0.9516 -
val_recall: 0.9512

Epoch 00176: val_accuracy improved from 0.95117 to 0.95161, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 177/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1570 -
accuracy: 0.9430 - recall: 0.9416 - val_loss: 0.1320 - val_accuracy: 0.9494 -
val_recall: 0.9494
```

```
Epoch 00177: val_accuracy did not improve from 0.95161
Epoch 178/400
331/331 [==============================] - 39s 118ms/step - loss: 0.1578 -
accuracy: 0.9424 - recall: 0.9418 - val_loss: 0.1292 - val_accuracy: 0.9507 -
val_recall: 0.9507

Epoch 00178: val_accuracy did not improve from 0.95161
Epoch 179/400
331/331 [==============================] - 39s 118ms/step - loss: 0.1571 -
accuracy: 0.9407 - recall: 0.9396 - val_loss: 0.1287 - val_accuracy: 0.9494 -
val_recall: 0.9494

Epoch 00179: val_accuracy did not improve from 0.95161
Epoch 180/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1444 -
accuracy: 0.9456 - recall: 0.9448 - val_loss: 0.1321 - val_accuracy: 0.9472 -
val_recall: 0.9472

Epoch 00180: val_accuracy did not improve from 0.95161
Epoch 181/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1459 -
accuracy: 0.9460 - recall: 0.9441 - val_loss: 0.1300 - val_accuracy: 0.9485 -
val_recall: 0.9481

Epoch 00181: val_accuracy did not improve from 0.95161
Epoch 182/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1464 -
accuracy: 0.9445 - recall: 0.9440 - val_loss: 0.1289 - val_accuracy: 0.9503 -
val_recall: 0.9503

Epoch 00182: val_accuracy did not improve from 0.95161
Epoch 183/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1527 -
accuracy: 0.9455 - recall: 0.9442 - val_loss: 0.1280 - val_accuracy: 0.9507 -
val_recall: 0.9507

Epoch 00183: val_accuracy did not improve from 0.95161
Epoch 00183: early stopping
```

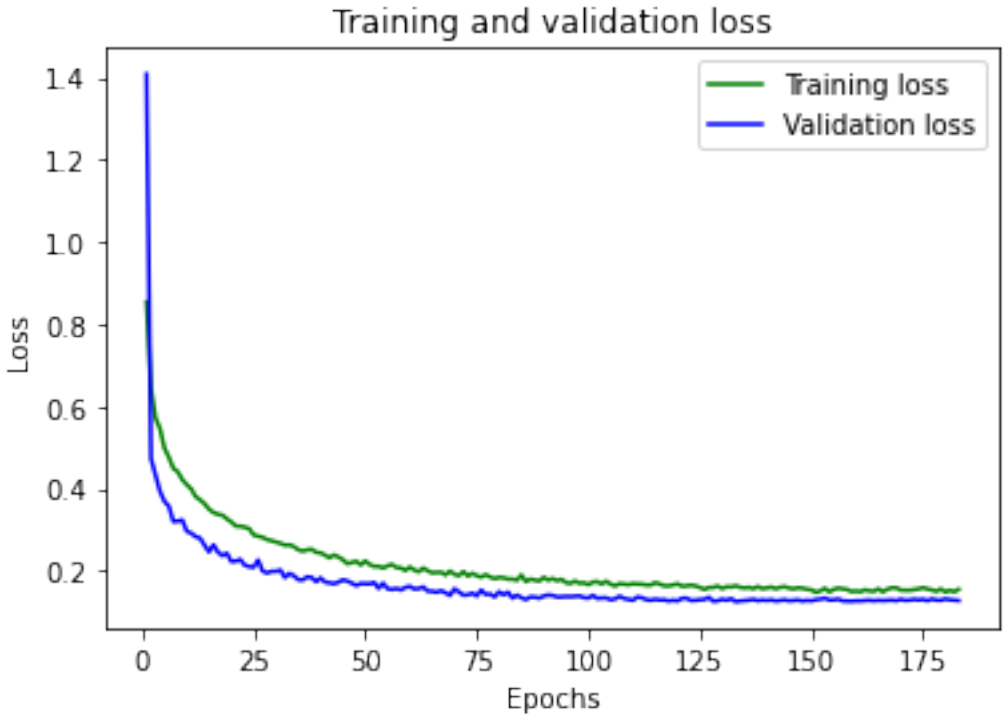
[ ]:
```
model.save(os.path.join(BASE_PATH, 'covid_classifier_result.h5'))
```

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

```
72/72 [==============================] - 10s 133ms/step - loss: 0.1194 -
accuracy: 0.9521 - recall: 0.9512
```

```
Loss on test set:  0.11938603967428207
Accuracy on test set:  0.9520668387413025
```

[ ]:
```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()
```