data_aug_adam_val__recall_95_55

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.

```python
# 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)
```

```python
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

```python
[ ]: 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 12:13:43.980008: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcudart.so.10.1

{'covid': 2531, 'normal': 7134, 'viral': 941}
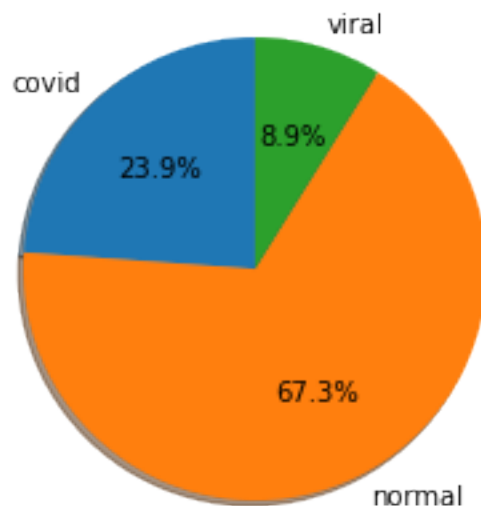
1.3 Create our Covnet Model

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.

```python
from keras.preprocessing.image import ImageDataGenerator

train_datagen = ImageDataGenerator(
    rescale=1./255,
    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=15,
    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,
```

```python
        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}
```

```python
[ ]: # 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
```

```python
[ ]: 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'))
```

```python
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(256, activation='relu'))
model.add(Dense(64, activation='relu'))
model.add(Dense(3, activation='softmax'))
model.summary()
```

```
2021-11-07 12:13:45.683310: I tensorflow/compiler/jit/xla_cpu_device.cc:41] Not
creating XLA devices, tf_xla_enable_xla_devices not set
2021-11-07 12:13:45.692143: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcuda.so.1
2021-11-07 12:13:45.958152: 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 12:13:45.958196: 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 12:13:45.958223: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcudart.so.10.1
2021-11-07 12:13:45.959635: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcublas.so.10
2021-11-07 12:13:45.959688: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcublasLt.so.10
2021-11-07 12:13:45.960842: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcufft.so.10
2021-11-07 12:13:45.961101: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcurand.so.10
```

2021-11-07 12:13:45.962559: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcusolver.so.10
2021-11-07 12:13:45.963359: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcusparse.so.10
2021-11-07 12:13:45.966224: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcudnn.so.7
2021-11-07 12:13:45.967129: 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 12:13:45.968017: 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 12:13:45.968035: I
tensorflow/core/common_runtime/gpu/gpu_device.cc:1862] Adding visible gpu
devices: 0
2021-11-07 12:13:45.970074: 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 12:13:45.971527: 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 12:13:45.971555: 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 12:13:45.971583: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcudart.so.10.1
2021-11-07 12:13:45.971611: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcublas.so.10
2021-11-07 12:13:45.971622: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcublasLt.so.10
2021-11-07 12:13:45.971632: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully

opened dynamic library libcufft.so.10
2021-11-07 12:13:45.971642: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcurand.so.10
2021-11-07 12:13:45.971652: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcusolver.so.10
2021-11-07 12:13:45.971663: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcusparse.so.10
2021-11-07 12:13:45.971673: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcudnn.so.7
2021-11-07 12:13:45.972292: 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 12:13:45.972898: 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 12:13:45.972914: I
tensorflow/core/common_runtime/gpu/gpu_device.cc:1862] Adding visible gpu
devices: 0
2021-11-07 12:13:45.972947: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcudart.so.10.1
2021-11-07 12:13:46.741253: I
tensorflow/core/common_runtime/gpu/gpu_device.cc:1261] Device interconnect
StreamExecutor with strength 1 edge matrix:
2021-11-07 12:13:46.741274: I
tensorflow/core/common_runtime/gpu/gpu_device.cc:1267]   0
2021-11-07 12:13:46.741279: I
tensorflow/core/common_runtime/gpu/gpu_device.cc:1280] 0:   N
2021-11-07 12:13:46.776737: 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 12:13:46.776814: 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 12:13:46.777473: 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 12:13:46.778024: 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 12:13:46.778058: 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 12:13:46.778416: 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, 256)	131328
dense_2 (Dense)	(None, 64)	16448

```
dense_3 (Dense)                 (None, 3)                     195
=================================================================
Total params: 3,620,291
Trainable params: 3,619,523
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=100000,
    decay_rate=0.96,
    staircase=True)
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()])
```

```python
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=80)
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 12:13:47.761535: I
tensorflow/compiler/mlir/mlir_graph_optimization_pass.cc:116] None of the MLIR
optimization passes are enabled (registered 2)
2021-11-07 12:13:47.761851: I
tensorflow/core/platform/profile_utils/cpu_utils.cc:112] CPU Frequency:
2208005000 Hz

Epoch 1/400

2021-11-07 12:13:48.532130: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcublas.so.10
2021-11-07 12:13:48.762459: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcudnn.so.7
2021-11-07 12:13:49.777654: W tensorflow/stream_executor/gpu/asm_compiler.cc:63]
Running ptxas --version returned 256
2021-11-07 12:13:49.870722: 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 [==============================] - 83s 204ms/step - loss: 0.9386 -
accuracy: 0.6278 - recall: 0.5892 - val_loss: 1.2312 - val_accuracy: 0.2728 -
val_recall: 0.1733

Epoch 00001: val_accuracy improved from -inf to 0.27277, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 2/400
331/331 [==============================] - 42s 126ms/step - loss: 0.6055 -
accuracy: 0.7318 - recall: 0.7089 - val_loss: 0.4855 - val_accuracy: 0.8060 -
val_recall: 0.7765

Epoch 00002: val_accuracy improved from 0.27277 to 0.80598, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 3/400
331/331 [==============================] - 42s 127ms/step - loss: 0.5608 -
accuracy: 0.7564 - recall: 0.7361 - val_loss: 0.4022 - val_accuracy: 0.8165 -
val_recall: 0.8091

Epoch 00003: val_accuracy improved from 0.80598 to 0.81654, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 4/400
331/331 [==============================] - 42s 127ms/step - loss: 0.5045 -
accuracy: 0.7803 - recall: 0.7672 - val_loss: 0.3583 - val_accuracy: 0.8478 -
val_recall: 0.8407
```

```
Epoch 00004: val_accuracy improved from 0.81654 to 0.84778, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 5/400
331/331 [==============================] - 42s 127ms/step - loss: 0.4643 -
accuracy: 0.7996 - recall: 0.7888 - val_loss: 0.3552 - val_accuracy: 0.8465 -
val_recall: 0.8412

Epoch 00005: val_accuracy did not improve from 0.84778
Epoch 6/400
331/331 [==============================] - 42s 127ms/step - loss: 0.4483 -
accuracy: 0.8051 - recall: 0.7958 - val_loss: 0.3576 - val_accuracy: 0.8504 -
val_recall: 0.8469

Epoch 00006: val_accuracy improved from 0.84778 to 0.85042, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 7/400
331/331 [==============================] - 42s 127ms/step - loss: 0.4232 -
accuracy: 0.8215 - recall: 0.8128 - val_loss: 0.3334 - val_accuracy: 0.8614 -
val_recall: 0.8575

Epoch 00007: val_accuracy improved from 0.85042 to 0.86142, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 8/400
331/331 [==============================] - 42s 127ms/step - loss: 0.3908 -
accuracy: 0.8331 - recall: 0.8275 - val_loss: 0.3172 - val_accuracy: 0.8689 -
val_recall: 0.8627

Epoch 00008: val_accuracy improved from 0.86142 to 0.86890, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 9/400
331/331 [==============================] - 42s 128ms/step - loss: 0.3677 -
accuracy: 0.8496 - recall: 0.8415 - val_loss: 0.2749 - val_accuracy: 0.8913 -
val_recall: 0.8887

Epoch 00009: val_accuracy improved from 0.86890 to 0.89133, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 10/400
331/331 [==============================] - 42s 128ms/step - loss: 0.3616 -
accuracy: 0.8513 - recall: 0.8461 - val_loss: 0.2897 - val_accuracy: 0.8808 -
val_recall: 0.8777

Epoch 00010: val_accuracy did not improve from 0.89133
Epoch 11/400
331/331 [==============================] - 44s 132ms/step - loss: 0.3328 -
accuracy: 0.8672 - recall: 0.8638 - val_loss: 0.2891 - val_accuracy: 0.8799 -
val_recall: 0.8781

Epoch 00011: val_accuracy did not improve from 0.89133
```

```
Epoch 12/400
331/331 [==============================] - 45s 135ms/step - loss: 0.3374 -
accuracy: 0.8585 - recall: 0.8557 - val_loss: 0.2748 - val_accuracy: 0.8922 -
val_recall: 0.8905

Epoch 00012: val_accuracy improved from 0.89133 to 0.89221, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 13/400
331/331 [==============================] - 48s 144ms/step - loss: 0.3305 -
accuracy: 0.8616 - recall: 0.8589 - val_loss: 0.2613 - val_accuracy: 0.8949 -
val_recall: 0.8913

Epoch 00013: val_accuracy improved from 0.89221 to 0.89485, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 14/400
331/331 [==============================] - 43s 129ms/step - loss: 0.3176 -
accuracy: 0.8685 - recall: 0.8637 - val_loss: 0.2485 - val_accuracy: 0.9010 -
val_recall: 0.8979

Epoch 00014: val_accuracy improved from 0.89485 to 0.90101, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 15/400
331/331 [==============================] - 44s 133ms/step - loss: 0.3242 -
accuracy: 0.8693 - recall: 0.8666 - val_loss: 0.2477 - val_accuracy: 0.8979 -
val_recall: 0.8971

Epoch 00015: val_accuracy did not improve from 0.90101
Epoch 16/400
331/331 [==============================] - 45s 136ms/step - loss: 0.3183 -
accuracy: 0.8710 - recall: 0.8677 - val_loss: 0.2387 - val_accuracy: 0.9006 -
val_recall: 0.8993

Epoch 00016: val_accuracy did not improve from 0.90101
Epoch 17/400
331/331 [==============================] - 45s 135ms/step - loss: 0.2883 -
accuracy: 0.8823 - recall: 0.8794 - val_loss: 0.2178 - val_accuracy: 0.9116 -
val_recall: 0.9116

Epoch 00017: val_accuracy improved from 0.90101 to 0.91157, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 18/400
331/331 [==============================] - 43s 131ms/step - loss: 0.2818 -
accuracy: 0.8816 - recall: 0.8788 - val_loss: 0.2205 - val_accuracy: 0.9089 -
val_recall: 0.9045

Epoch 00018: val_accuracy did not improve from 0.91157
Epoch 19/400
331/331 [==============================] - 44s 131ms/step - loss: 0.2833 -
```

```
accuracy: 0.8866 - recall: 0.8834 - val_loss: 0.2195 - val_accuracy: 0.9120 -
val_recall: 0.9120


Epoch 00019: val_accuracy improved from 0.91157 to 0.91201, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 20/400
331/331 [==============================] - 45s 136ms/step - loss: 0.2771 -
accuracy: 0.8833 - recall: 0.8811 - val_loss: 0.2033 - val_accuracy: 0.9182 -
val_recall: 0.9160


Epoch 00020: val_accuracy improved from 0.91201 to 0.91817, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 21/400
331/331 [==============================] - 44s 133ms/step - loss: 0.2614 -
accuracy: 0.9003 - recall: 0.8980 - val_loss: 0.2220 - val_accuracy: 0.9129 -
val_recall: 0.9111


Epoch 00021: val_accuracy did not improve from 0.91817
Epoch 22/400
331/331 [==============================] - 43s 130ms/step - loss: 0.2491 -
accuracy: 0.9024 - recall: 0.8985 - val_loss: 0.1960 - val_accuracy: 0.9239 -
val_recall: 0.9226


Epoch 00022: val_accuracy improved from 0.91817 to 0.92389, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 23/400
331/331 [==============================] - 43s 130ms/step - loss: 0.2479 -
accuracy: 0.9037 - recall: 0.9021 - val_loss: 0.1997 - val_accuracy: 0.9226 -
val_recall: 0.9212


Epoch 00023: val_accuracy did not improve from 0.92389
Epoch 24/400
331/331 [==============================] - 43s 130ms/step - loss: 0.2365 -
accuracy: 0.9059 - recall: 0.9041 - val_loss: 0.1859 - val_accuracy: 0.9256 -
val_recall: 0.9248


Epoch 00024: val_accuracy improved from 0.92389 to 0.92565, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 25/400
331/331 [==============================] - 43s 130ms/step - loss: 0.2379 -
accuracy: 0.9067 - recall: 0.9045 - val_loss: 0.2356 - val_accuracy: 0.9023 -
val_recall: 0.9015


Epoch 00025: val_accuracy did not improve from 0.92565
Epoch 26/400
331/331 [==============================] - 44s 132ms/step - loss: 0.2241 -
accuracy: 0.9124 - recall: 0.9106 - val_loss: 0.1755 - val_accuracy: 0.9265 -
val_recall: 0.9256
```

```
Epoch 00026: val_accuracy improved from 0.92565 to 0.92653, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 27/400
331/331 [==============================] - 44s 133ms/step - loss: 0.2296 -
accuracy: 0.9106 - recall: 0.9093 - val_loss: 0.2014 - val_accuracy: 0.9230 -
val_recall: 0.9230

Epoch 00027: val_accuracy did not improve from 0.92653
Epoch 28/400
331/331 [==============================] - 43s 131ms/step - loss: 0.2320 -
accuracy: 0.9072 - recall: 0.9058 - val_loss: 0.1695 - val_accuracy: 0.9336 -
val_recall: 0.9327

Epoch 00028: val_accuracy improved from 0.92653 to 0.93357, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 29/400
331/331 [==============================] - 44s 133ms/step - loss: 0.2319 -
accuracy: 0.9114 - recall: 0.9087 - val_loss: 0.1538 - val_accuracy: 0.9384 -
val_recall: 0.9371

Epoch 00029: val_accuracy improved from 0.93357 to 0.93841, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 30/400
331/331 [==============================] - 43s 131ms/step - loss: 0.2147 -
accuracy: 0.9160 - recall: 0.9144 - val_loss: 0.1806 - val_accuracy: 0.9296 -
val_recall: 0.9283

Epoch 00030: val_accuracy did not improve from 0.93841
Epoch 31/400
331/331 [==============================] - 44s 132ms/step - loss: 0.2013 -
accuracy: 0.9237 - recall: 0.9225 - val_loss: 0.1507 - val_accuracy: 0.9415 -
val_recall: 0.9415

Epoch 00031: val_accuracy improved from 0.93841 to 0.94149, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 32/400
331/331 [==============================] - 43s 131ms/step - loss: 0.2040 -
accuracy: 0.9196 - recall: 0.9180 - val_loss: 0.1609 - val_accuracy: 0.9362 -
val_recall: 0.9349

Epoch 00032: val_accuracy did not improve from 0.94149
Epoch 33/400
331/331 [==============================] - 44s 133ms/step - loss: 0.2081 -
accuracy: 0.9198 - recall: 0.9184 - val_loss: 0.1417 - val_accuracy: 0.9463 -
val_recall: 0.9459

Epoch 00033: val_accuracy improved from 0.94149 to 0.94633, saving model to
```

```
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 34/400
331/331 [==============================] - 40s 120ms/step - loss: 0.1981 -
accuracy: 0.9237 - recall: 0.9221 - val_loss: 0.1546 - val_accuracy: 0.9397 -
val_recall: 0.9397

Epoch 00034: val_accuracy did not improve from 0.94633
Epoch 35/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1975 -
accuracy: 0.9250 - recall: 0.9241 - val_loss: 0.1516 - val_accuracy: 0.9397 -
val_recall: 0.9393

Epoch 00035: val_accuracy did not improve from 0.94633
Epoch 36/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1951 -
accuracy: 0.9297 - recall: 0.9286 - val_loss: 0.1404 - val_accuracy: 0.9454 -
val_recall: 0.9446

Epoch 00036: val_accuracy did not improve from 0.94633
Epoch 37/400
331/331 [==============================] - 39s 116ms/step - loss: 0.1940 -
accuracy: 0.9278 - recall: 0.9264 - val_loss: 0.1504 - val_accuracy: 0.9472 -
val_recall: 0.9463

Epoch 00037: val_accuracy improved from 0.94633 to 0.94721, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 38/400
331/331 [==============================] - 39s 118ms/step - loss: 0.1859 -
accuracy: 0.9286 - recall: 0.9272 - val_loss: 0.1592 - val_accuracy: 0.9344 -
val_recall: 0.9340

Epoch 00038: val_accuracy did not improve from 0.94721
Epoch 39/400
331/331 [==============================] - 38s 116ms/step - loss: 0.1969 -
accuracy: 0.9273 - recall: 0.9259 - val_loss: 0.1581 - val_accuracy: 0.9393 -
val_recall: 0.9393

Epoch 00039: val_accuracy did not improve from 0.94721
Epoch 40/400
331/331 [==============================] - 38s 116ms/step - loss: 0.1823 -
accuracy: 0.9299 - recall: 0.9287 - val_loss: 0.1793 - val_accuracy: 0.9331 -
val_recall: 0.9327

Epoch 00040: val_accuracy did not improve from 0.94721
Epoch 41/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1688 -
accuracy: 0.9394 - recall: 0.9386 - val_loss: 0.1468 - val_accuracy: 0.9428 -
val_recall: 0.9428
```

Epoch 00041: val_accuracy did not improve from 0.94721
Epoch 42/400
331/331 [==============================] - 39s 119ms/step - loss: 0.1759 -
accuracy: 0.9311 - recall: 0.9303 - val_loss: 0.1309 - val_accuracy: 0.9503 -
val_recall: 0.9503

Epoch 00042: val_accuracy improved from 0.94721 to 0.95029, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 43/400
331/331 [==============================] - 39s 116ms/step - loss: 0.1792 -
accuracy: 0.9345 - recall: 0.9335 - val_loss: 0.1298 - val_accuracy: 0.9534 -
val_recall: 0.9529

Epoch 00043: val_accuracy improved from 0.95029 to 0.95337, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 44/400
331/331 [==============================] - 38s 116ms/step - loss: 0.1689 -
accuracy: 0.9374 - recall: 0.9370 - val_loss: 0.1211 - val_accuracy: 0.9542 -
val_recall: 0.9538

Epoch 00044: val_accuracy improved from 0.95337 to 0.95425, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 45/400
331/331 [==============================] - 38s 116ms/step - loss: 0.1778 -
accuracy: 0.9331 - recall: 0.9309 - val_loss: 0.1374 - val_accuracy: 0.9485 -
val_recall: 0.9485

Epoch 00045: val_accuracy did not improve from 0.95425
Epoch 46/400
331/331 [==============================] - 39s 118ms/step - loss: 0.1601 -
accuracy: 0.9400 - recall: 0.9389 - val_loss: 0.1334 - val_accuracy: 0.9529 -
val_recall: 0.9525

Epoch 00046: val_accuracy did not improve from 0.95425
Epoch 47/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1723 -
accuracy: 0.9354 - recall: 0.9350 - val_loss: 0.1367 - val_accuracy: 0.9512 -
val_recall: 0.9503

Epoch 00047: val_accuracy did not improve from 0.95425
Epoch 48/400
331/331 [==============================] - 39s 116ms/step - loss: 0.1563 -
accuracy: 0.9400 - recall: 0.9391 - val_loss: 0.1841 - val_accuracy: 0.9314 -
val_recall: 0.9309

Epoch 00048: val_accuracy did not improve from 0.95425
Epoch 49/400

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331/331 [==============================] - 38s 116ms/step - loss: 0.1640 -
accuracy: 0.9397 - recall: 0.9393 - val_loss: 0.1668 - val_accuracy: 0.9340 -
val_recall: 0.9331


Epoch 00049: val_accuracy did not improve from 0.95425
Epoch 50/400
331/331 [==============================] - 39s 116ms/step - loss: 0.1598 -
accuracy: 0.9386 - recall: 0.9375 - val_loss: 0.1453 - val_accuracy: 0.9454 -
val_recall: 0.9446


Epoch 00050: val_accuracy did not improve from 0.95425
Epoch 51/400
331/331 [==============================] - 39s 116ms/step - loss: 0.1583 -
accuracy: 0.9397 - recall: 0.9391 - val_loss: 0.1294 - val_accuracy: 0.9520 -
val_recall: 0.9516


Epoch 00051: val_accuracy did not improve from 0.95425
Epoch 52/400
331/331 [==============================] - 39s 116ms/step - loss: 0.1598 -
accuracy: 0.9410 - recall: 0.9397 - val_loss: 0.1303 - val_accuracy: 0.9498 -
val_recall: 0.9494


Epoch 00052: val_accuracy did not improve from 0.95425
Epoch 53/400
331/331 [==============================] - 39s 116ms/step - loss: 0.1411 -
accuracy: 0.9495 - recall: 0.9487 - val_loss: 0.1433 - val_accuracy: 0.9463 -
val_recall: 0.9463


Epoch 00053: val_accuracy did not improve from 0.95425
Epoch 54/400
331/331 [==============================] - 38s 116ms/step - loss: 0.1510 -
accuracy: 0.9429 - recall: 0.9420 - val_loss: 0.1155 - val_accuracy: 0.9578 -
val_recall: 0.9578


Epoch 00054: val_accuracy improved from 0.95425 to 0.95777, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 55/400
331/331 [==============================] - 39s 116ms/step - loss: 0.1540 -
accuracy: 0.9393 - recall: 0.9377 - val_loss: 0.1282 - val_accuracy: 0.9534 -
val_recall: 0.9529


Epoch 00055: val_accuracy did not improve from 0.95777
Epoch 56/400
331/331 [==============================] - 38s 116ms/step - loss: 0.1509 -
accuracy: 0.9446 - recall: 0.9433 - val_loss: 0.1626 - val_accuracy: 0.9380 -
val_recall: 0.9366


Epoch 00056: val_accuracy did not improve from 0.95777
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Epoch 57/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1501 -
accuracy: 0.9487 - recall: 0.9484 - val_loss: 0.1316 - val_accuracy: 0.9525 -
val_recall: 0.9525

Epoch 00057: val_accuracy did not improve from 0.95777
Epoch 58/400
331/331 [==============================] - 38s 116ms/step - loss: 0.1437 -
accuracy: 0.9487 - recall: 0.9476 - val_loss: 0.1170 - val_accuracy: 0.9591 -
val_recall: 0.9586

Epoch 00058: val_accuracy improved from 0.95777 to 0.95908, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 59/400
331/331 [==============================] - 38s 116ms/step - loss: 0.1422 -
accuracy: 0.9461 - recall: 0.9457 - val_loss: 0.1112 - val_accuracy: 0.9591 -
val_recall: 0.9591

Epoch 00059: val_accuracy did not improve from 0.95908
Epoch 60/400
331/331 [==============================] - 38s 116ms/step - loss: 0.1390 -
accuracy: 0.9484 - recall: 0.9481 - val_loss: 0.1115 - val_accuracy: 0.9591 -
val_recall: 0.9586

Epoch 00060: val_accuracy did not improve from 0.95908
Epoch 61/400
331/331 [==============================] - 38s 116ms/step - loss: 0.1404 -
accuracy: 0.9521 - recall: 0.9509 - val_loss: 0.1023 - val_accuracy: 0.9604 -
val_recall: 0.9604

Epoch 00061: val_accuracy improved from 0.95908 to 0.96040, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 62/400
331/331 [==============================] - 38s 116ms/step - loss: 0.1290 -
accuracy: 0.9524 - recall: 0.9520 - val_loss: 0.1204 - val_accuracy: 0.9573 -
val_recall: 0.9573

Epoch 00062: val_accuracy did not improve from 0.96040
Epoch 63/400
331/331 [==============================] - 38s 116ms/step - loss: 0.1522 -
accuracy: 0.9438 - recall: 0.9429 - val_loss: 0.1124 - val_accuracy: 0.9617 -
val_recall: 0.9617

Epoch 00063: val_accuracy improved from 0.96040 to 0.96172, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 64/400
331/331 [==============================] - 38s 116ms/step - loss: 0.1307 -
accuracy: 0.9561 - recall: 0.9558 - val_loss: 0.1064 - val_accuracy: 0.9608 -
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val_recall: 0.9600

Epoch 00064: val_accuracy did not improve from 0.96172
Epoch 65/400
331/331 [==============================] - 39s 119ms/step - loss: 0.1251 - accuracy: 0.9523 - recall: 0.9520 - val_loss: 0.1069 - val_accuracy: 0.9617 - val_recall: 0.9613

Epoch 00065: val_accuracy did not improve from 0.96172
Epoch 66/400
331/331 [==============================] - 39s 116ms/step - loss: 0.1317 - accuracy: 0.9511 - recall: 0.9508 - val_loss: 0.1305 - val_accuracy: 0.9485 - val_recall: 0.9485

Epoch 00066: val_accuracy did not improve from 0.96172
Epoch 67/400
331/331 [==============================] - 38s 116ms/step - loss: 0.1292 - accuracy: 0.9535 - recall: 0.9517 - val_loss: 0.1157 - val_accuracy: 0.9560 - val_recall: 0.9551

Epoch 00067: val_accuracy did not improve from 0.96172
Epoch 68/400
331/331 [==============================] - 38s 116ms/step - loss: 0.1277 - accuracy: 0.9538 - recall: 0.9528 - val_loss: 0.1150 - val_accuracy: 0.9547 - val_recall: 0.9547

Epoch 00068: val_accuracy did not improve from 0.96172
Epoch 69/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1265 - accuracy: 0.9547 - recall: 0.9542 - val_loss: 0.1460 - val_accuracy: 0.9441 - val_recall: 0.9441

Epoch 00069: val_accuracy did not improve from 0.96172
Epoch 70/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1308 - accuracy: 0.9512 - recall: 0.9505 - val_loss: 0.1277 - val_accuracy: 0.9494 - val_recall: 0.9490

Epoch 00070: val_accuracy did not improve from 0.96172
Epoch 71/400
331/331 [==============================] - 38s 116ms/step - loss: 0.1204 - accuracy: 0.9555 - recall: 0.9548 - val_loss: 0.1433 - val_accuracy: 0.9432 - val_recall: 0.9432

Epoch 00071: val_accuracy did not improve from 0.96172
Epoch 72/400
331/331 [==============================] - 39s 116ms/step - loss: 0.1227 - accuracy: 0.9558 - recall: 0.9556 - val_loss: 0.1169 - val_accuracy: 0.9551 -

val_recall: 0.9547

Epoch 00072: val_accuracy did not improve from 0.96172
Epoch 73/400
331/331 [==============================] - 38s 116ms/step - loss: 0.1180 -
accuracy: 0.9568 - recall: 0.9564 - val_loss: 0.1110 - val_accuracy: 0.9591 -
val_recall: 0.9586

Epoch 00073: val_accuracy did not improve from 0.96172
Epoch 74/400
331/331 [==============================] - 38s 116ms/step - loss: 0.1273 -
accuracy: 0.9524 - recall: 0.9518 - val_loss: 0.1009 - val_accuracy: 0.9635 -
val_recall: 0.9630

Epoch 00074: val_accuracy improved from 0.96172 to 0.96348, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 75/400
331/331 [==============================] - 39s 116ms/step - loss: 0.1146 -
accuracy: 0.9572 - recall: 0.9567 - val_loss: 0.1109 - val_accuracy: 0.9578 -
val_recall: 0.9573

Epoch 00075: val_accuracy did not improve from 0.96348
Epoch 76/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1131 -
accuracy: 0.9556 - recall: 0.9551 - val_loss: 0.1218 - val_accuracy: 0.9560 -
val_recall: 0.9560

Epoch 00076: val_accuracy did not improve from 0.96348
Epoch 77/400
331/331 [==============================] - 38s 116ms/step - loss: 0.1258 -
accuracy: 0.9533 - recall: 0.9524 - val_loss: 0.1062 - val_accuracy: 0.9657 -
val_recall: 0.9657

Epoch 00077: val_accuracy improved from 0.96348 to 0.96568, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 78/400
331/331 [==============================] - 38s 116ms/step - loss: 0.1218 -
accuracy: 0.9552 - recall: 0.9544 - val_loss: 0.0997 - val_accuracy: 0.9613 -
val_recall: 0.9608

Epoch 00078: val_accuracy did not improve from 0.96568
Epoch 79/400
331/331 [==============================] - 38s 116ms/step - loss: 0.1156 -
accuracy: 0.9599 - recall: 0.9594 - val_loss: 0.1003 - val_accuracy: 0.9635 -
val_recall: 0.9635

Epoch 00079: val_accuracy did not improve from 0.96568
Epoch 80/400

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331/331 [==============================] - 38s 116ms/step - loss: 0.1100 -
accuracy: 0.9614 - recall: 0.9613 - val_loss: 0.1047 - val_accuracy: 0.9617 -
val_recall: 0.9617

Epoch 00080: val_accuracy did not improve from 0.96568
Epoch 81/400
331/331 [==============================] - 39s 116ms/step - loss: 0.1118 -
accuracy: 0.9595 - recall: 0.9592 - val_loss: 0.1477 - val_accuracy: 0.9406 -
val_recall: 0.9406

Epoch 00081: val_accuracy did not improve from 0.96568
Epoch 82/400
331/331 [==============================] - 39s 116ms/step - loss: 0.1030 -
accuracy: 0.9636 - recall: 0.9635 - val_loss: 0.1107 - val_accuracy: 0.9578 -
val_recall: 0.9573

Epoch 00082: val_accuracy did not improve from 0.96568
Epoch 83/400
331/331 [==============================] - 38s 116ms/step - loss: 0.1056 -
accuracy: 0.9597 - recall: 0.9592 - val_loss: 0.1199 - val_accuracy: 0.9578 -
val_recall: 0.9578

Epoch 00083: val_accuracy did not improve from 0.96568
Epoch 84/400
331/331 [==============================] - 39s 116ms/step - loss: 0.1159 -
accuracy: 0.9570 - recall: 0.9564 - val_loss: 0.1388 - val_accuracy: 0.9525 -
val_recall: 0.9525

Epoch 00084: val_accuracy did not improve from 0.96568
Epoch 85/400
331/331 [==============================] - 39s 116ms/step - loss: 0.1168 -
accuracy: 0.9550 - recall: 0.9544 - val_loss: 0.0951 - val_accuracy: 0.9679 -
val_recall: 0.9679

Epoch 00085: val_accuracy improved from 0.96568 to 0.96788, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 86/400
331/331 [==============================] - 39s 116ms/step - loss: 0.0985 -
accuracy: 0.9645 - recall: 0.9640 - val_loss: 0.1122 - val_accuracy: 0.9595 -
val_recall: 0.9595

Epoch 00086: val_accuracy did not improve from 0.96788
Epoch 87/400
331/331 [==============================] - 39s 117ms/step - loss: 0.1122 -
accuracy: 0.9604 - recall: 0.9601 - val_loss: 0.1702 - val_accuracy: 0.9380 -
val_recall: 0.9380

Epoch 00087: val_accuracy did not improve from 0.96788
```

```
Epoch 88/400
331/331 [==============================] - 38s 116ms/step - loss: 0.1103 -
accuracy: 0.9590 - recall: 0.9580 - val_loss: 0.1075 - val_accuracy: 0.9630 -
val_recall: 0.9626

Epoch 00088: val_accuracy did not improve from 0.96788
Epoch 89/400
331/331 [==============================] - 39s 119ms/step - loss: 0.1129 -
accuracy: 0.9598 - recall: 0.9593 - val_loss: 0.0967 - val_accuracy: 0.9657 -
val_recall: 0.9652

Epoch 00089: val_accuracy did not improve from 0.96788
Epoch 90/400
331/331 [==============================] - 39s 116ms/step - loss: 0.1027 -
accuracy: 0.9626 - recall: 0.9622 - val_loss: 0.0876 - val_accuracy: 0.9714 -
val_recall: 0.9714

Epoch 00090: val_accuracy improved from 0.96788 to 0.97140, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 91/400
331/331 [==============================] - 39s 116ms/step - loss: 0.1027 -
accuracy: 0.9619 - recall: 0.9612 - val_loss: 0.1331 - val_accuracy: 0.9476 -
val_recall: 0.9476

Epoch 00091: val_accuracy did not improve from 0.97140
Epoch 92/400
331/331 [==============================] - 39s 116ms/step - loss: 0.0965 -
accuracy: 0.9658 - recall: 0.9654 - val_loss: 0.1568 - val_accuracy: 0.9446 -
val_recall: 0.9441

Epoch 00092: val_accuracy did not improve from 0.97140
Epoch 93/400
331/331 [==============================] - 39s 116ms/step - loss: 0.0977 -
accuracy: 0.9631 - recall: 0.9625 - val_loss: 0.0887 - val_accuracy: 0.9688 -
val_recall: 0.9688

Epoch 00093: val_accuracy did not improve from 0.97140
Epoch 94/400
331/331 [==============================] - 39s 116ms/step - loss: 0.1005 -
accuracy: 0.9617 - recall: 0.9616 - val_loss: 0.0922 - val_accuracy: 0.9666 -
val_recall: 0.9666

Epoch 00094: val_accuracy did not improve from 0.97140
Epoch 95/400
331/331 [==============================] - 39s 118ms/step - loss: 0.1030 -
accuracy: 0.9626 - recall: 0.9617 - val_loss: 0.1056 - val_accuracy: 0.9630 -
val_recall: 0.9630
```

```
Epoch 00095: val_accuracy did not improve from 0.97140
Epoch 96/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0976 -
accuracy: 0.9654 - recall: 0.9652 - val_loss: 0.1089 - val_accuracy: 0.9595 -
val_recall: 0.9586

Epoch 00096: val_accuracy did not improve from 0.97140
Epoch 97/400
331/331 [==============================] - 39s 118ms/step - loss: 0.0978 -
accuracy: 0.9648 - recall: 0.9648 - val_loss: 0.1121 - val_accuracy: 0.9622 -
val_recall: 0.9622

Epoch 00097: val_accuracy did not improve from 0.97140
Epoch 98/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0944 -
accuracy: 0.9664 - recall: 0.9662 - val_loss: 0.0812 - val_accuracy: 0.9710 -
val_recall: 0.9710

Epoch 00098: val_accuracy did not improve from 0.97140
Epoch 99/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0988 -
accuracy: 0.9619 - recall: 0.9615 - val_loss: 0.1075 - val_accuracy: 0.9595 -
val_recall: 0.9595

Epoch 00099: val_accuracy did not improve from 0.97140
Epoch 100/400
331/331 [==============================] - 39s 119ms/step - loss: 0.1000 -
accuracy: 0.9651 - recall: 0.9643 - val_loss: 0.0867 - val_accuracy: 0.9657 -
val_recall: 0.9652

Epoch 00100: val_accuracy did not improve from 0.97140
Epoch 101/400
331/331 [==============================] - 39s 118ms/step - loss: 0.1065 -
accuracy: 0.9592 - recall: 0.9586 - val_loss: 0.1555 - val_accuracy: 0.9424 -
val_recall: 0.9424

Epoch 00101: val_accuracy did not improve from 0.97140
Epoch 102/400
331/331 [==============================] - 49s 146ms/step - loss: 0.0950 -
accuracy: 0.9661 - recall: 0.9655 - val_loss: 0.0998 - val_accuracy: 0.9648 -
val_recall: 0.9648

Epoch 00102: val_accuracy did not improve from 0.97140
Epoch 103/400
331/331 [==============================] - 50s 151ms/step - loss: 0.0945 -
accuracy: 0.9655 - recall: 0.9655 - val_loss: 0.1081 - val_accuracy: 0.9613 -
val_recall: 0.9608
```

```
Epoch 00103: val_accuracy did not improve from 0.97140
Epoch 104/400
331/331 [==============================] - 52s 157ms/step - loss: 0.0906 -
accuracy: 0.9674 - recall: 0.9668 - val_loss: 0.1392 - val_accuracy: 0.9503 -
val_recall: 0.9503

Epoch 00104: val_accuracy did not improve from 0.97140
Epoch 105/400
331/331 [==============================] - 50s 152ms/step - loss: 0.0915 -
accuracy: 0.9689 - recall: 0.9684 - val_loss: 0.1428 - val_accuracy: 0.9547 -
val_recall: 0.9547

Epoch 00105: val_accuracy did not improve from 0.97140
Epoch 106/400
331/331 [==============================] - 50s 152ms/step - loss: 0.0882 -
accuracy: 0.9659 - recall: 0.9658 - val_loss: 0.0930 - val_accuracy: 0.9688 -
val_recall: 0.9683

Epoch 00106: val_accuracy did not improve from 0.97140
Epoch 107/400
331/331 [==============================] - 50s 150ms/step - loss: 0.1002 -
accuracy: 0.9641 - recall: 0.9637 - val_loss: 0.1049 - val_accuracy: 0.9630 -
val_recall: 0.9626

Epoch 00107: val_accuracy did not improve from 0.97140
Epoch 108/400
331/331 [==============================] - 50s 150ms/step - loss: 0.0839 -
accuracy: 0.9692 - recall: 0.9690 - val_loss: 0.0926 - val_accuracy: 0.9674 -
val_recall: 0.9674

Epoch 00108: val_accuracy did not improve from 0.97140
Epoch 109/400
331/331 [==============================] - 50s 150ms/step - loss: 0.0901 -
accuracy: 0.9668 - recall: 0.9659 - val_loss: 0.1355 - val_accuracy: 0.9560 -
val_recall: 0.9560

Epoch 00109: val_accuracy did not improve from 0.97140
Epoch 110/400
331/331 [==============================] - 51s 155ms/step - loss: 0.0895 -
accuracy: 0.9652 - recall: 0.9649 - val_loss: 0.0934 - val_accuracy: 0.9670 -
val_recall: 0.9666

Epoch 00110: val_accuracy did not improve from 0.97140
Epoch 111/400
331/331 [==============================] - 48s 144ms/step - loss: 0.0840 -
accuracy: 0.9701 - recall: 0.9699 - val_loss: 0.1532 - val_accuracy: 0.9437 -
val_recall: 0.9437
```

```
Epoch 00111: val_accuracy did not improve from 0.97140
Epoch 112/400
331/331 [==============================] - 43s 131ms/step - loss: 0.0882 -
accuracy: 0.9654 - recall: 0.9646 - val_loss: 0.1358 - val_accuracy: 0.9538 -
val_recall: 0.9538

Epoch 00112: val_accuracy did not improve from 0.97140
Epoch 113/400
331/331 [==============================] - 45s 136ms/step - loss: 0.0957 -
accuracy: 0.9659 - recall: 0.9658 - val_loss: 0.0819 - val_accuracy: 0.9701 -
val_recall: 0.9696

Epoch 00113: val_accuracy did not improve from 0.97140
Epoch 114/400
331/331 [==============================] - 44s 133ms/step - loss: 0.0770 -
accuracy: 0.9712 - recall: 0.9711 - val_loss: 0.1027 - val_accuracy: 0.9608 -
val_recall: 0.9608

Epoch 00114: val_accuracy did not improve from 0.97140
Epoch 115/400
331/331 [==============================] - 42s 125ms/step - loss: 0.0849 -
accuracy: 0.9673 - recall: 0.9671 - val_loss: 0.1181 - val_accuracy: 0.9591 -
val_recall: 0.9591

Epoch 00115: val_accuracy did not improve from 0.97140
Epoch 116/400
331/331 [==============================] - 40s 122ms/step - loss: 0.0925 -
accuracy: 0.9681 - recall: 0.9681 - val_loss: 0.1037 - val_accuracy: 0.9644 -
val_recall: 0.9639

Epoch 00116: val_accuracy did not improve from 0.97140
Epoch 117/400
331/331 [==============================] - 43s 131ms/step - loss: 0.0838 -
accuracy: 0.9699 - recall: 0.9697 - val_loss: 0.0777 - val_accuracy: 0.9736 -
val_recall: 0.9736

Epoch 00117: val_accuracy improved from 0.97140 to 0.97360, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 118/400
331/331 [==============================] - 41s 124ms/step - loss: 0.0838 -
accuracy: 0.9683 - recall: 0.9678 - val_loss: 0.0863 - val_accuracy: 0.9692 -
val_recall: 0.9692

Epoch 00118: val_accuracy did not improve from 0.97360
Epoch 119/400
331/331 [==============================] - 40s 122ms/step - loss: 0.0807 -
accuracy: 0.9687 - recall: 0.9686 - val_loss: 0.1514 - val_accuracy: 0.9485 -
val_recall: 0.9481
```

```
Epoch 00119: val_accuracy did not improve from 0.97360
Epoch 120/400
331/331 [==============================] - 42s 127ms/step - loss: 0.0897 -
accuracy: 0.9673 - recall: 0.9665 - val_loss: 0.0831 - val_accuracy: 0.9679 -
val_recall: 0.9679

Epoch 00120: val_accuracy did not improve from 0.97360
Epoch 121/400
331/331 [==============================] - 43s 130ms/step - loss: 0.0919 -
accuracy: 0.9683 - recall: 0.9673 - val_loss: 0.0842 - val_accuracy: 0.9674 -
val_recall: 0.9674

Epoch 00121: val_accuracy did not improve from 0.97360
Epoch 122/400
331/331 [==============================] - 43s 129ms/step - loss: 0.0828 -
accuracy: 0.9705 - recall: 0.9698 - val_loss: 0.0835 - val_accuracy: 0.9692 -
val_recall: 0.9692

Epoch 00122: val_accuracy did not improve from 0.97360
Epoch 123/400
331/331 [==============================] - 42s 128ms/step - loss: 0.0810 -
accuracy: 0.9731 - recall: 0.9727 - val_loss: 0.0804 - val_accuracy: 0.9696 -
val_recall: 0.9692

Epoch 00123: val_accuracy did not improve from 0.97360
Epoch 124/400
331/331 [==============================] - 41s 124ms/step - loss: 0.0800 -
accuracy: 0.9675 - recall: 0.9670 - val_loss: 0.0888 - val_accuracy: 0.9679 -
val_recall: 0.9670

Epoch 00124: val_accuracy did not improve from 0.97360
Epoch 125/400
331/331 [==============================] - 40s 120ms/step - loss: 0.0849 -
accuracy: 0.9693 - recall: 0.9689 - val_loss: 0.0938 - val_accuracy: 0.9674 -
val_recall: 0.9674

Epoch 00125: val_accuracy did not improve from 0.97360
Epoch 126/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0734 -
accuracy: 0.9709 - recall: 0.9704 - val_loss: 0.0888 - val_accuracy: 0.9683 -
val_recall: 0.9679

Epoch 00126: val_accuracy did not improve from 0.97360
Epoch 127/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0727 -
accuracy: 0.9742 - recall: 0.9741 - val_loss: 0.1117 - val_accuracy: 0.9604 -
val_recall: 0.9600
```

```
Epoch 00127: val_accuracy did not improve from 0.97360
Epoch 128/400
331/331 [==============================] - 39s 118ms/step - loss: 0.0817 -
accuracy: 0.9712 - recall: 0.9707 - val_loss: 0.1032 - val_accuracy: 0.9626 -
val_recall: 0.9622

Epoch 00128: val_accuracy did not improve from 0.97360
Epoch 129/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0785 -
accuracy: 0.9726 - recall: 0.9720 - val_loss: 0.0974 - val_accuracy: 0.9630 -
val_recall: 0.9630

Epoch 00129: val_accuracy did not improve from 0.97360
Epoch 130/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0716 -
accuracy: 0.9733 - recall: 0.9732 - val_loss: 0.0848 - val_accuracy: 0.9696 -
val_recall: 0.9688

Epoch 00130: val_accuracy did not improve from 0.97360
Epoch 131/400
331/331 [==============================] - 40s 122ms/step - loss: 0.0752 -
accuracy: 0.9734 - recall: 0.9734 - val_loss: 0.1222 - val_accuracy: 0.9582 -
val_recall: 0.9582

Epoch 00131: val_accuracy did not improve from 0.97360
Epoch 132/400
331/331 [==============================] - 40s 120ms/step - loss: 0.0710 -
accuracy: 0.9751 - recall: 0.9748 - val_loss: 0.1095 - val_accuracy: 0.9608 -
val_recall: 0.9608

Epoch 00132: val_accuracy did not improve from 0.97360
Epoch 133/400
331/331 [==============================] - 42s 126ms/step - loss: 0.0698 -
accuracy: 0.9731 - recall: 0.9729 - val_loss: 0.0882 - val_accuracy: 0.9670 -
val_recall: 0.9670

Epoch 00133: val_accuracy did not improve from 0.97360
Epoch 134/400
331/331 [==============================] - 41s 125ms/step - loss: 0.0811 -
accuracy: 0.9700 - recall: 0.9699 - val_loss: 0.0864 - val_accuracy: 0.9692 -
val_recall: 0.9692

Epoch 00134: val_accuracy did not improve from 0.97360
Epoch 135/400
331/331 [==============================] - 41s 125ms/step - loss: 0.0742 -
accuracy: 0.9730 - recall: 0.9729 - val_loss: 0.0932 - val_accuracy: 0.9683 -
val_recall: 0.9674
```

```
Epoch 00135: val_accuracy did not improve from 0.97360
Epoch 136/400
331/331 [==============================] - 40s 122ms/step - loss: 0.0846 -
accuracy: 0.9679 - recall: 0.9676 - val_loss: 0.0893 - val_accuracy: 0.9701 -
val_recall: 0.9701

Epoch 00136: val_accuracy did not improve from 0.97360
Epoch 137/400
331/331 [==============================] - 39s 118ms/step - loss: 0.0669 -
accuracy: 0.9754 - recall: 0.9748 - val_loss: 0.1113 - val_accuracy: 0.9573 -
val_recall: 0.9573

Epoch 00137: val_accuracy did not improve from 0.97360
Epoch 138/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0688 -
accuracy: 0.9739 - recall: 0.9734 - val_loss: 0.0864 - val_accuracy: 0.9692 -
val_recall: 0.9688

Epoch 00138: val_accuracy did not improve from 0.97360
Epoch 139/400
331/331 [==============================] - 39s 118ms/step - loss: 0.0790 -
accuracy: 0.9710 - recall: 0.9705 - val_loss: 0.0935 - val_accuracy: 0.9670 -
val_recall: 0.9670

Epoch 00139: val_accuracy did not improve from 0.97360
Epoch 140/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0702 -
accuracy: 0.9749 - recall: 0.9748 - val_loss: 0.1076 - val_accuracy: 0.9657 -
val_recall: 0.9657

Epoch 00140: val_accuracy did not improve from 0.97360
Epoch 141/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0701 -
accuracy: 0.9754 - recall: 0.9752 - val_loss: 0.1100 - val_accuracy: 0.9604 -
val_recall: 0.9604

Epoch 00141: val_accuracy did not improve from 0.97360
Epoch 142/400
331/331 [==============================] - 39s 118ms/step - loss: 0.0673 -
accuracy: 0.9753 - recall: 0.9752 - val_loss: 0.1045 - val_accuracy: 0.9626 -
val_recall: 0.9622

Epoch 00142: val_accuracy did not improve from 0.97360
Epoch 143/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0690 -
accuracy: 0.9742 - recall: 0.9738 - val_loss: 0.0820 - val_accuracy: 0.9727 -
val_recall: 0.9723
```

```
Epoch 00143: val_accuracy did not improve from 0.97360
Epoch 144/400
331/331 [==============================] - 39s 118ms/step - loss: 0.0745 -
accuracy: 0.9731 - recall: 0.9729 - val_loss: 0.1220 - val_accuracy: 0.9635 -
val_recall: 0.9635

Epoch 00144: val_accuracy did not improve from 0.97360
Epoch 145/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0700 -
accuracy: 0.9739 - recall: 0.9736 - val_loss: 0.0761 - val_accuracy: 0.9754 -
val_recall: 0.9754

Epoch 00145: val_accuracy improved from 0.97360 to 0.97536, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 146/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0656 -
accuracy: 0.9757 - recall: 0.9756 - val_loss: 0.1086 - val_accuracy: 0.9595 -
val_recall: 0.9591

Epoch 00146: val_accuracy did not improve from 0.97536
Epoch 147/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0616 -
accuracy: 0.9790 - recall: 0.9787 - val_loss: 0.0764 - val_accuracy: 0.9727 -
val_recall: 0.9723

Epoch 00147: val_accuracy did not improve from 0.97536
Epoch 148/400
331/331 [==============================] - 38s 116ms/step - loss: 0.0642 -
accuracy: 0.9770 - recall: 0.9769 - val_loss: 0.0953 - val_accuracy: 0.9648 -
val_recall: 0.9648

Epoch 00148: val_accuracy did not improve from 0.97536
Epoch 149/400
331/331 [==============================] - 39s 117ms/step - loss: 0.0653 -
accuracy: 0.9774 - recall: 0.9770 - val_loss: 0.1316 - val_accuracy: 0.9564 -
val_recall: 0.9564

Epoch 00149: val_accuracy did not improve from 0.97536
Epoch 150/400
331/331 [==============================] - 39s 116ms/step - loss: 0.0718 -
accuracy: 0.9712 - recall: 0.9710 - val_loss: 0.1036 - val_accuracy: 0.9600 -
val_recall: 0.9600

Epoch 00150: val_accuracy did not improve from 0.97536
Epoch 151/400
331/331 [==============================] - 39s 117ms/step - loss: 0.0648 -
accuracy: 0.9745 - recall: 0.9739 - val_loss: 0.1177 - val_accuracy: 0.9586 -
```

val_recall: 0.9573

Epoch 00151: val_accuracy did not improve from 0.97536
Epoch 152/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0619 -
accuracy: 0.9789 - recall: 0.9789 - val_loss: 0.0863 - val_accuracy: 0.9674 -
val_recall: 0.9674

Epoch 00152: val_accuracy did not improve from 0.97536
Epoch 153/400
331/331 [==============================] - 39s 118ms/step - loss: 0.0752 -
accuracy: 0.9717 - recall: 0.9715 - val_loss: 0.0743 - val_accuracy: 0.9745 -
val_recall: 0.9740

Epoch 00153: val_accuracy did not improve from 0.97536
Epoch 154/400
331/331 [==============================] - 40s 122ms/step - loss: 0.0651 -
accuracy: 0.9754 - recall: 0.9752 - val_loss: 0.0812 - val_accuracy: 0.9736 -
val_recall: 0.9736

Epoch 00154: val_accuracy did not improve from 0.97536
Epoch 155/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0634 -
accuracy: 0.9769 - recall: 0.9768 - val_loss: 0.2091 - val_accuracy: 0.9336 -
val_recall: 0.9336

Epoch 00155: val_accuracy did not improve from 0.97536
Epoch 156/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0707 -
accuracy: 0.9730 - recall: 0.9728 - val_loss: 0.0951 - val_accuracy: 0.9688 -
val_recall: 0.9688

Epoch 00156: val_accuracy did not improve from 0.97536
Epoch 157/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0590 -
accuracy: 0.9795 - recall: 0.9795 - val_loss: 0.0989 - val_accuracy: 0.9635 -
val_recall: 0.9635

Epoch 00157: val_accuracy did not improve from 0.97536
Epoch 158/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0582 -
accuracy: 0.9786 - recall: 0.9784 - val_loss: 0.0975 - val_accuracy: 0.9644 -
val_recall: 0.9644

Epoch 00158: val_accuracy did not improve from 0.97536
Epoch 159/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0636 -
accuracy: 0.9759 - recall: 0.9757 - val_loss: 0.0787 - val_accuracy: 0.9718 -

val_recall: 0.9718

Epoch 00159: val_accuracy did not improve from 0.97536
Epoch 160/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0682 -
accuracy: 0.9750 - recall: 0.9750 - val_loss: 0.0870 - val_accuracy: 0.9723 -
val_recall: 0.9723

Epoch 00160: val_accuracy did not improve from 0.97536
Epoch 161/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0670 -
accuracy: 0.9754 - recall: 0.9751 - val_loss: 0.0865 - val_accuracy: 0.9692 -
val_recall: 0.9692

Epoch 00161: val_accuracy did not improve from 0.97536
Epoch 162/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0645 -
accuracy: 0.9775 - recall: 0.9773 - val_loss: 0.0932 - val_accuracy: 0.9688 -
val_recall: 0.9688

Epoch 00162: val_accuracy did not improve from 0.97536
Epoch 163/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0600 -
accuracy: 0.9785 - recall: 0.9784 - val_loss: 0.1052 - val_accuracy: 0.9635 -
val_recall: 0.9635

Epoch 00163: val_accuracy did not improve from 0.97536
Epoch 164/400
331/331 [==============================] - 39s 118ms/step - loss: 0.0580 -
accuracy: 0.9791 - recall: 0.9784 - val_loss: 0.1098 - val_accuracy: 0.9635 -
val_recall: 0.9635

Epoch 00164: val_accuracy did not improve from 0.97536
Epoch 165/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0573 -
accuracy: 0.9792 - recall: 0.9788 - val_loss: 0.0911 - val_accuracy: 0.9683 -
val_recall: 0.9683

Epoch 00165: val_accuracy did not improve from 0.97536
Epoch 166/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0591 -
accuracy: 0.9769 - recall: 0.9766 - val_loss: 0.2163 - val_accuracy: 0.9309 -
val_recall: 0.9309

Epoch 00166: val_accuracy did not improve from 0.97536
Epoch 167/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0602 -
accuracy: 0.9776 - recall: 0.9773 - val_loss: 0.0784 - val_accuracy: 0.9736 -

val_recall: 0.9736

Epoch 00167: val_accuracy did not improve from 0.97536
Epoch 168/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0651 -
accuracy: 0.9765 - recall: 0.9762 - val_loss: 0.0862 - val_accuracy: 0.9758 -
val_recall: 0.9758

Epoch 00168: val_accuracy improved from 0.97536 to 0.97580, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 169/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0581 -
accuracy: 0.9813 - recall: 0.9808 - val_loss: 0.1265 - val_accuracy: 0.9547 -
val_recall: 0.9547

Epoch 00169: val_accuracy did not improve from 0.97580
Epoch 170/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0595 -
accuracy: 0.9789 - recall: 0.9788 - val_loss: 0.0886 - val_accuracy: 0.9727 -
val_recall: 0.9727

Epoch 00170: val_accuracy did not improve from 0.97580
Epoch 171/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0614 -
accuracy: 0.9748 - recall: 0.9745 - val_loss: 0.0927 - val_accuracy: 0.9652 -
val_recall: 0.9648

Epoch 00171: val_accuracy did not improve from 0.97580
Epoch 172/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0630 -
accuracy: 0.9750 - recall: 0.9746 - val_loss: 0.1112 - val_accuracy: 0.9626 -
val_recall: 0.9622

Epoch 00172: val_accuracy did not improve from 0.97580
Epoch 173/400
331/331 [==============================] - 39s 118ms/step - loss: 0.0605 -
accuracy: 0.9777 - recall: 0.9776 - val_loss: 0.0869 - val_accuracy: 0.9723 -
val_recall: 0.9718

Epoch 00173: val_accuracy did not improve from 0.97580
Epoch 174/400
331/331 [==============================] - 40s 120ms/step - loss: 0.0601 -
accuracy: 0.9787 - recall: 0.9781 - val_loss: 0.0843 - val_accuracy: 0.9714 -
val_recall: 0.9714

Epoch 00174: val_accuracy did not improve from 0.97580
Epoch 175/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0580 -

accuracy: 0.9810 - recall: 0.9810 - val_loss: 0.0890 - val_accuracy: 0.9732 - val_recall: 0.9727

Epoch 00175: val_accuracy did not improve from 0.97580
Epoch 176/400
331/331 [==============================] - 39s 117ms/step - loss: 0.0549 - accuracy: 0.9800 - recall: 0.9800 - val_loss: 0.0868 - val_accuracy: 0.9683 - val_recall: 0.9683

Epoch 00176: val_accuracy did not improve from 0.97580
Epoch 177/400
331/331 [==============================] - 39s 118ms/step - loss: 0.0609 - accuracy: 0.9780 - recall: 0.9777 - val_loss: 0.0983 - val_accuracy: 0.9688 - val_recall: 0.9688

Epoch 00177: val_accuracy did not improve from 0.97580
Epoch 178/400
331/331 [==============================] - 39s 116ms/step - loss: 0.0526 - accuracy: 0.9823 - recall: 0.9821 - val_loss: 0.0894 - val_accuracy: 0.9732 - val_recall: 0.9727

Epoch 00178: val_accuracy did not improve from 0.97580
Epoch 179/400
331/331 [==============================] - 39s 116ms/step - loss: 0.0631 - accuracy: 0.9771 - recall: 0.9764 - val_loss: 0.0977 - val_accuracy: 0.9696 - val_recall: 0.9696

Epoch 00179: val_accuracy did not improve from 0.97580
Epoch 180/400
331/331 [==============================] - 39s 117ms/step - loss: 0.0513 - accuracy: 0.9824 - recall: 0.9824 - val_loss: 0.0924 - val_accuracy: 0.9679 - val_recall: 0.9679

Epoch 00180: val_accuracy did not improve from 0.97580
Epoch 181/400
331/331 [==============================] - 39s 117ms/step - loss: 0.0640 - accuracy: 0.9770 - recall: 0.9769 - val_loss: 0.0926 - val_accuracy: 0.9692 - val_recall: 0.9692

Epoch 00181: val_accuracy did not improve from 0.97580
Epoch 182/400
331/331 [==============================] - 39s 116ms/step - loss: 0.0575 - accuracy: 0.9782 - recall: 0.9780 - val_loss: 0.1582 - val_accuracy: 0.9450 - val_recall: 0.9450

Epoch 00182: val_accuracy did not improve from 0.97580
Epoch 183/400
331/331 [==============================] - 39s 117ms/step - loss: 0.0571 -

accuracy: 0.9795 - recall: 0.9793 - val_loss: 0.1235 - val_accuracy: 0.9604 - val_recall: 0.9600

Epoch 00183: val_accuracy did not improve from 0.97580
Epoch 184/400
331/331 [==============================] - 39s 117ms/step - loss: 0.0513 - accuracy: 0.9812 - recall: 0.9808 - val_loss: 0.1177 - val_accuracy: 0.9617 - val_recall: 0.9613

Epoch 00184: val_accuracy did not improve from 0.97580
Epoch 185/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0508 - accuracy: 0.9811 - recall: 0.9811 - val_loss: 0.0836 - val_accuracy: 0.9723 - val_recall: 0.9718

Epoch 00185: val_accuracy did not improve from 0.97580
Epoch 186/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0583 - accuracy: 0.9783 - recall: 0.9778 - val_loss: 0.0938 - val_accuracy: 0.9674 - val_recall: 0.9674

Epoch 00186: val_accuracy did not improve from 0.97580
Epoch 187/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0491 - accuracy: 0.9809 - recall: 0.9808 - val_loss: 0.0784 - val_accuracy: 0.9758 - val_recall: 0.9754

Epoch 00187: val_accuracy did not improve from 0.97580
Epoch 188/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0596 - accuracy: 0.9788 - recall: 0.9785 - val_loss: 0.0878 - val_accuracy: 0.9705 - val_recall: 0.9701

Epoch 00188: val_accuracy did not improve from 0.97580
Epoch 189/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0572 - accuracy: 0.9789 - recall: 0.9788 - val_loss: 0.1206 - val_accuracy: 0.9586 - val_recall: 0.9586

Epoch 00189: val_accuracy did not improve from 0.97580
Epoch 190/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0504 - accuracy: 0.9813 - recall: 0.9812 - val_loss: 0.1486 - val_accuracy: 0.9542 - val_recall: 0.9542

Epoch 00190: val_accuracy did not improve from 0.97580
Epoch 191/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0572 -

accuracy: 0.9801 - recall: 0.9801 - val_loss: 0.1353 - val_accuracy: 0.9551 -
val_recall: 0.9547

Epoch 00191: val_accuracy did not improve from 0.97580
Epoch 192/400
331/331 [==============================] - 39s 118ms/step - loss: 0.0557 -
accuracy: 0.9776 - recall: 0.9775 - val_loss: 0.0889 - val_accuracy: 0.9683 -
val_recall: 0.9679

Epoch 00192: val_accuracy did not improve from 0.97580
Epoch 193/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0552 -
accuracy: 0.9792 - recall: 0.9791 - val_loss: 0.0833 - val_accuracy: 0.9736 -
val_recall: 0.9736

Epoch 00193: val_accuracy did not improve from 0.97580
Epoch 194/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0551 -
accuracy: 0.9797 - recall: 0.9796 - val_loss: 0.1278 - val_accuracy: 0.9613 -
val_recall: 0.9608

Epoch 00194: val_accuracy did not improve from 0.97580
Epoch 195/400
331/331 [==============================] - 40s 120ms/step - loss: 0.0576 -
accuracy: 0.9790 - recall: 0.9788 - val_loss: 0.1065 - val_accuracy: 0.9666 -
val_recall: 0.9666

Epoch 00195: val_accuracy did not improve from 0.97580
Epoch 196/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0454 -
accuracy: 0.9843 - recall: 0.9841 - val_loss: 0.1164 - val_accuracy: 0.9617 -
val_recall: 0.9617

Epoch 00196: val_accuracy did not improve from 0.97580
Epoch 197/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0573 -
accuracy: 0.9784 - recall: 0.9782 - val_loss: 0.0813 - val_accuracy: 0.9714 -
val_recall: 0.9714

Epoch 00197: val_accuracy did not improve from 0.97580
Epoch 198/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0539 -
accuracy: 0.9802 - recall: 0.9801 - val_loss: 0.1005 - val_accuracy: 0.9683 -
val_recall: 0.9679

Epoch 00198: val_accuracy did not improve from 0.97580
Epoch 199/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0523 -

accuracy: 0.9785 - recall: 0.9785 - val_loss: 0.1226 - val_accuracy: 0.9608 - val_recall: 0.9608

Epoch 00199: val_accuracy did not improve from 0.97580
Epoch 200/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0524 - accuracy: 0.9810 - recall: 0.9809 - val_loss: 0.2036 - val_accuracy: 0.9362 - val_recall: 0.9349

Epoch 00200: val_accuracy did not improve from 0.97580
Epoch 201/400
331/331 [==============================] - 40s 121ms/step - loss: 0.0527 - accuracy: 0.9803 - recall: 0.9801 - val_loss: 0.0826 - val_accuracy: 0.9745 - val_recall: 0.9745

Epoch 00201: val_accuracy did not improve from 0.97580
Epoch 202/400
331/331 [==============================] - 40s 119ms/step - loss: 0.0527 - accuracy: 0.9802 - recall: 0.9799 - val_loss: 0.0922 - val_accuracy: 0.9714 - val_recall: 0.9714

Epoch 00202: val_accuracy did not improve from 0.97580
Epoch 203/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0527 - accuracy: 0.9792 - recall: 0.9786 - val_loss: 0.1057 - val_accuracy: 0.9670 - val_recall: 0.9670

Epoch 00203: val_accuracy did not improve from 0.97580
Epoch 204/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0465 - accuracy: 0.9834 - recall: 0.9829 - val_loss: 0.0819 - val_accuracy: 0.9762 - val_recall: 0.9762

Epoch 00204: val_accuracy improved from 0.97580 to 0.97624, saving model to /home/hivini/learn/research/new-covid/best_model.h5
Epoch 205/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0474 - accuracy: 0.9824 - recall: 0.9823 - val_loss: 0.0995 - val_accuracy: 0.9683 - val_recall: 0.9683

Epoch 00205: val_accuracy did not improve from 0.97624
Epoch 206/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0493 - accuracy: 0.9823 - recall: 0.9817 - val_loss: 0.1292 - val_accuracy: 0.9560 - val_recall: 0.9560

Epoch 00206: val_accuracy did not improve from 0.97624
Epoch 207/400

331/331 [==============================] - 39s 118ms/step - loss: 0.0423 -
accuracy: 0.9847 - recall: 0.9846 - val_loss: 0.0951 - val_accuracy: 0.9679 -
val_recall: 0.9679

Epoch 00207: val_accuracy did not improve from 0.97624
Epoch 208/400
331/331 [==============================] - 39s 117ms/step - loss: 0.0517 -
accuracy: 0.9825 - recall: 0.9822 - val_loss: 0.0980 - val_accuracy: 0.9679 -
val_recall: 0.9679

Epoch 00208: val_accuracy did not improve from 0.97624
Epoch 209/400
331/331 [==============================] - 39s 116ms/step - loss: 0.0560 -
accuracy: 0.9787 - recall: 0.9781 - val_loss: 0.0867 - val_accuracy: 0.9710 -
val_recall: 0.9705

Epoch 00209: val_accuracy did not improve from 0.97624
Epoch 210/400
331/331 [==============================] - 39s 118ms/step - loss: 0.0537 -
accuracy: 0.9795 - recall: 0.9794 - val_loss: 0.1242 - val_accuracy: 0.9600 -
val_recall: 0.9600

Epoch 00210: val_accuracy did not improve from 0.97624
Epoch 211/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0442 -
accuracy: 0.9840 - recall: 0.9835 - val_loss: 0.1105 - val_accuracy: 0.9652 -
val_recall: 0.9652

Epoch 00211: val_accuracy did not improve from 0.97624
Epoch 212/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0478 -
accuracy: 0.9820 - recall: 0.9820 - val_loss: 0.1008 - val_accuracy: 0.9666 -
val_recall: 0.9666

Epoch 00212: val_accuracy did not improve from 0.97624
Epoch 213/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0497 -
accuracy: 0.9828 - recall: 0.9828 - val_loss: 0.1155 - val_accuracy: 0.9644 -
val_recall: 0.9635

Epoch 00213: val_accuracy did not improve from 0.97624
Epoch 214/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0523 -
accuracy: 0.9798 - recall: 0.9797 - val_loss: 0.0915 - val_accuracy: 0.9674 -
val_recall: 0.9674

Epoch 00214: val_accuracy did not improve from 0.97624
Epoch 215/400

```
331/331 [==============================] - 39s 119ms/step - loss: 0.0429 -
accuracy: 0.9857 - recall: 0.9856 - val_loss: 0.1309 - val_accuracy: 0.9534 -
val_recall: 0.9534


Epoch 00215: val_accuracy did not improve from 0.97624
Epoch 216/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0468 -
accuracy: 0.9821 - recall: 0.9821 - val_loss: 0.0855 - val_accuracy: 0.9723 -
val_recall: 0.9723


Epoch 00216: val_accuracy did not improve from 0.97624
Epoch 217/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0402 -
accuracy: 0.9852 - recall: 0.9851 - val_loss: 0.0883 - val_accuracy: 0.9736 -
val_recall: 0.9732


Epoch 00217: val_accuracy did not improve from 0.97624
Epoch 218/400
331/331 [==============================] - 40s 120ms/step - loss: 0.0389 -
accuracy: 0.9837 - recall: 0.9837 - val_loss: 0.0743 - val_accuracy: 0.9780 -
val_recall: 0.9780


Epoch 00218: val_accuracy improved from 0.97624 to 0.97800, saving model to
/home/hivini/learn/research/new-covid/best_model.h5
Epoch 219/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0470 -
accuracy: 0.9842 - recall: 0.9841 - val_loss: 0.2913 - val_accuracy: 0.9151 -
val_recall: 0.9151


Epoch 00219: val_accuracy did not improve from 0.97800
Epoch 220/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0454 -
accuracy: 0.9828 - recall: 0.9826 - val_loss: 0.1661 - val_accuracy: 0.9534 -
val_recall: 0.9534


Epoch 00220: val_accuracy did not improve from 0.97800
Epoch 221/400
331/331 [==============================] - 41s 124ms/step - loss: 0.0419 -
accuracy: 0.9839 - recall: 0.9834 - val_loss: 0.0905 - val_accuracy: 0.9705 -
val_recall: 0.9705


Epoch 00221: val_accuracy did not improve from 0.97800
Epoch 222/400
331/331 [==============================] - 41s 125ms/step - loss: 0.0438 -
accuracy: 0.9847 - recall: 0.9846 - val_loss: 0.1589 - val_accuracy: 0.9564 -
val_recall: 0.9564


Epoch 00222: val_accuracy did not improve from 0.97800
```

```
Epoch 223/400
331/331 [==============================] - 40s 119ms/step - loss: 0.0461 -
accuracy: 0.9833 - recall: 0.9830 - val_loss: 0.1214 - val_accuracy: 0.9613 -
val_recall: 0.9613

Epoch 00223: val_accuracy did not improve from 0.97800
Epoch 224/400
331/331 [==============================] - 40s 121ms/step - loss: 0.0405 -
accuracy: 0.9861 - recall: 0.9859 - val_loss: 0.1080 - val_accuracy: 0.9692 -
val_recall: 0.9692

Epoch 00224: val_accuracy did not improve from 0.97800
Epoch 225/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0461 -
accuracy: 0.9830 - recall: 0.9830 - val_loss: 0.0883 - val_accuracy: 0.9692 -
val_recall: 0.9692

Epoch 00225: val_accuracy did not improve from 0.97800
Epoch 226/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0442 -
accuracy: 0.9848 - recall: 0.9845 - val_loss: 0.1141 - val_accuracy: 0.9670 -
val_recall: 0.9661

Epoch 00226: val_accuracy did not improve from 0.97800
Epoch 227/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0388 -
accuracy: 0.9865 - recall: 0.9865 - val_loss: 0.1422 - val_accuracy: 0.9556 -
val_recall: 0.9556

Epoch 00227: val_accuracy did not improve from 0.97800
Epoch 228/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0445 -
accuracy: 0.9822 - recall: 0.9822 - val_loss: 0.1181 - val_accuracy: 0.9639 -
val_recall: 0.9639

Epoch 00228: val_accuracy did not improve from 0.97800
Epoch 229/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0391 -
accuracy: 0.9872 - recall: 0.9871 - val_loss: 0.0951 - val_accuracy: 0.9714 -
val_recall: 0.9714

Epoch 00229: val_accuracy did not improve from 0.97800
Epoch 230/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0542 -
accuracy: 0.9796 - recall: 0.9794 - val_loss: 0.2615 - val_accuracy: 0.9274 -
val_recall: 0.9274

Epoch 00230: val_accuracy did not improve from 0.97800
```

```
Epoch 231/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0413 -
accuracy: 0.9856 - recall: 0.9854 - val_loss: 0.1077 - val_accuracy: 0.9644 -
val_recall: 0.9644

Epoch 00231: val_accuracy did not improve from 0.97800
Epoch 232/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0470 -
accuracy: 0.9850 - recall: 0.9849 - val_loss: 0.0999 - val_accuracy: 0.9688 -
val_recall: 0.9688

Epoch 00232: val_accuracy did not improve from 0.97800
Epoch 233/400
331/331 [==============================] - 39s 119ms/step - loss: 0.0465 -
accuracy: 0.9845 - recall: 0.9845 - val_loss: 0.1350 - val_accuracy: 0.9595 -
val_recall: 0.9595

Epoch 00233: val_accuracy did not improve from 0.97800
Epoch 00233: early stopping
```

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

```python
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 [==============================] - 13s 187ms/step - loss: 0.1432 -
accuracy: 0.9556 - recall: 0.9551
Loss on test set:  0.14316390454769135
Accuracy on test set:  0.9555848836898804
```

```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()
```


Training and validation loss
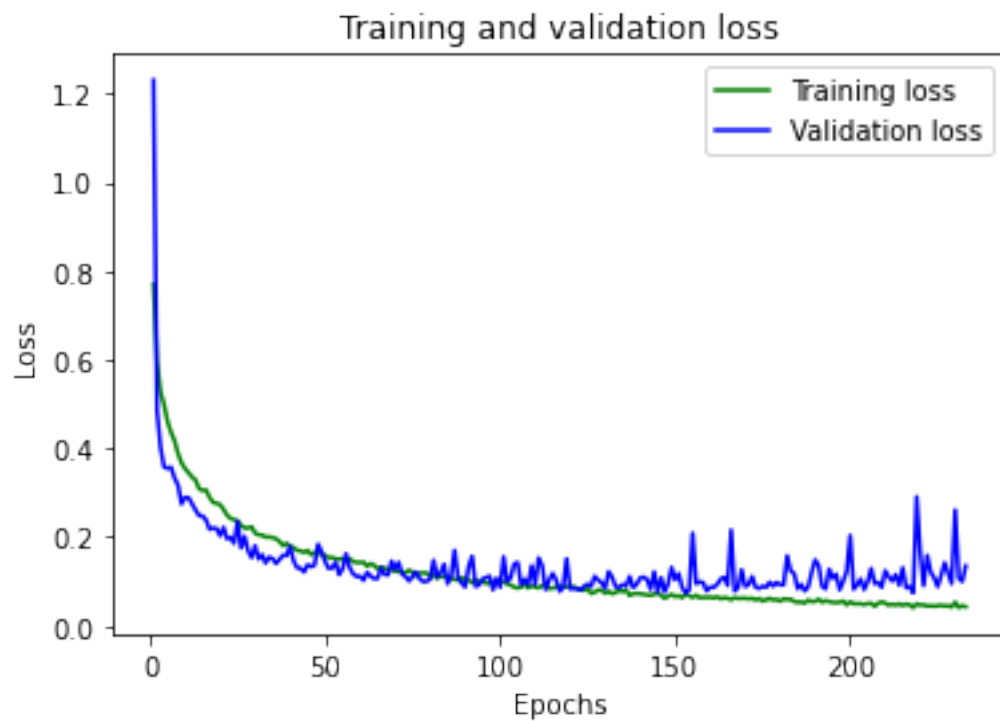
[ ]:
```
plt.clf()

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