

Covid_10_Fold_Binary (1)

August 13, 2020

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[1]: !wget https://www.dropbox.com/sh/ftf854x2q8d2o1r/AADmlvw-n6uIuTA63BjxPuVza?dl=0
```

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--2020-08-13 13:11:31--
https://www.dropbox.com/sh/ftf854x2q8d2o1r/AADmlvw-n6uIuTA63BjxPuVza?dl=0
Resolving www.dropbox.com (www.dropbox.com)... 162.125.65.1,
2620:100:6021:1::a27d:4101
Connecting to www.dropbox.com (www.dropbox.com)|162.125.65.1|:443... connected.
HTTP request sent, awaiting response... 301 Moved Permanently
Location: /sh/raw/ftf854x2q8d2o1r/AADmlvw-n6uIuTA63BjxPuVza [following]
--2020-08-13 13:11:32--
https://www.dropbox.com/sh/raw/ftf854x2q8d2o1r/AADmlvw-n6uIuTA63BjxPuVza
Reusing existing connection to www.dropbox.com:443.
HTTP request sent, awaiting response... 302 Found
Location: https://ucb8755ee45a1d7533502d6fac39.dl.dropboxusercontent.com/zip_download_get/Agw3jZmIZ8NfsXwmLY__KmXwHcB5DQIORSw4QntLhRQJJ3GVhZtYGI6ux709gmKs-P4CevD-35bb37YziQZ4FxYBjEXhKEwrHHNL82HkxdRiYw [following]
--2020-08-13 13:11:34-- https://ucb8755ee45a1d7533502d6fac39.dl.dropboxusercontent.com/zip_download_get/Agw3jZmIZ8NfsXwmLY__KmXwHcB5DQIORSw4QntLhRQJJ3GVhZtYGI6ux709gmKs-P4CevD-35bb37YziQZ4FxYBjEXhKEwrHHNL82HkxdRiYw
Resolving ucb8755ee45a1d7533502d6fac39.dl.dropboxusercontent.com
(ucb8755ee45a1d7533502d6fac39.dl.dropboxusercontent.com)... 162.125.65.15,
2620:100:6021:15::a27d:410f
Connecting to ucb8755ee45a1d7533502d6fac39.dl.dropboxusercontent.com
(ucb8755ee45a1d7533502d6fac39.dl.dropboxusercontent.com)|162.125.65.15|:443...
connected.
HTTP request sent, awaiting response... 200 OK
Length: 591895308 (564M) [application/zip]
Saving to: 'AADmlvw-n6uIuTA63BjxPuVza?dl=0'

AADmlvw-n6uIuTA63Bj 100%[=====] 564.47M 6.33MB/s in 77s

2020-08-13 13:12:52 (7.32 MB/s) - 'AADmlvw-n6uIuTA63BjxPuVza?dl=0' saved
[591895308/591895308]
```

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[2]: !unzip AADmlvw-n6uIuTA63BjxPuVza?dl=0
```

Archive: AADmlvw-n6uIuTA63BjxPuVza?dl=0

warning: stripped absolute path spec from /
mapname: conversion of failed
creating: COVID/
creating: NORMAL/
creating: COVID-AT/
creating: NORMAL-AT/
extracting: COVID/AR-2.jpg
extracting: COVID/AR-1.jpg
extracting: COVID/paving.jpg
extracting: COVID/fx1_lrg.jpg
extracting: COVID/d680397c.jpg
extracting: COVID/ee2d1bf6.jpg
extracting: COVID/35b446ce.jpg
extracting: COVID/bfefde5d.jpg
extracting: COVID/cb706009.jpg
extracting: COVID/3dedeb92.jpg
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extracting: COVID/nejmoa2001191_f5-L.jpeg
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```

1 archive had fatal errors.

```
[3]: !git clone https://github.com/mjkvaak/ImageDataAugmentor.git
```

```

Cloning into 'ImageDataAugmentor'...
remote: Enumerating objects: 141, done.
remote: Counting objects: 100% (141/141), done.
remote: Compressing objects: 100% (111/111), done.
remote: Total 306 (delta 72), reused 70 (delta 23), pack-reused 165
Receiving objects: 100% (306/306), 146.55 KiB | 852.00 KiB/s, done.
Resolving deltas: 100% (171/171), done.

```

```
[4]: pip install git+https://github.com/mjkvaak/ImageDataAugmentor
```

```

Collecting git+https://github.com/mjkvaak/ImageDataAugmentor
  Cloning https://github.com/mjkvaak/ImageDataAugmentor to /tmp/pip-req-
build-3f41_ijk
  Running command git clone -q https://github.com/mjkvaak/ImageDataAugmentor
/tmp/pip-req-build-3f41_ijk
Collecting opencv-python>=4.2
  Downloading https://files.pythonhosted.org/packages/bd/8a/7a01233c28f4f0
b49536498f2ae39aa9f70c6de85fe74dc17f53ec7d0b0e/opencv_python-4.4.0.40-cp36-cp36m
-manylinux2014_x86_64.whl (49.4MB)
    |                                     | 49.4MB 61kB/s
Requirement already satisfied: matplotlib in

```

```

/usr/local/lib/python3.6/dist-packages (from ImageDataAugmentor==0.0.0) (3.2.2)
Requirement already satisfied: Pillow in /usr/local/lib/python3.6/dist-packages
(from ImageDataAugmentor==0.0.0) (7.0.0)
Requirement already satisfied: scipy in /usr/local/lib/python3.6/dist-packages
(from ImageDataAugmentor==0.0.0) (1.4.1)
Requirement already satisfied: numpy>=1.13.3 in /usr/local/lib/python3.6/dist-
packages (from opencv-python>=4.2->ImageDataAugmentor==0.0.0) (1.18.5)
Requirement already satisfied: python-dateutil>=2.1 in
/usr/local/lib/python3.6/dist-packages (from
matplotlib->ImageDataAugmentor==0.0.0) (2.8.1)
Requirement already satisfied: cycler>=0.10 in /usr/local/lib/python3.6/dist-
packages (from matplotlib->ImageDataAugmentor==0.0.0) (0.10.0)
Requirement already satisfied: pyparsing!=2.0.4,!=2.1.2,!=2.1.6,>=2.0.1 in
/usr/local/lib/python3.6/dist-packages (from
matplotlib->ImageDataAugmentor==0.0.0) (2.4.7)
Requirement already satisfied: kiwisolver>=1.0.1 in
/usr/local/lib/python3.6/dist-packages (from
matplotlib->ImageDataAugmentor==0.0.0) (1.2.0)
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.6/dist-
packages (from python-dateutil>=2.1->matplotlib->ImageDataAugmentor==0.0.0)
(1.15.0)
Building wheels for collected packages: ImageDataAugmentor
  Building wheel for ImageDataAugmentor (setup.py) ... done
  Created wheel for ImageDataAugmentor:
filename=ImageDataAugmentor-0.0.0-cp36-none-any.whl size=28017
sha256=e6ba0a36fd48e07599713faf835497f780632ffb0968382726381764162cb864
  Stored in directory: /tmp/pip-ephem-wheel-cache-
ivexikgl/wheels/d9/10/55/6fca35a4072f87d694876d56ece64db3846cf45e1da1c381fe
Successfully built ImageDataAugmentor
ERROR: alumentations 0.1.12 has requirement imgaug<0.2.7,>=0.2.5, but
you'll have imgaug 0.2.9 which is incompatible.
Installing collected packages: opencv-python, ImageDataAugmentor
  Found existing installation: opencv-python 4.1.2.30
  Uninstalling opencv-python-4.1.2.30:
    Successfully uninstalled opencv-python-4.1.2.30
Successfully installed ImageDataAugmentor-0.0.0 opencv-python-4.4.0.40

```

```
[5]: pip install twine
```

```

Collecting twine
  Downloading https://files.pythonhosted.org/packages/ad/db/b2c65078b783c6694bdf
a0911bbbe0e2be7fcb98ff23a99b8be544906b6/twine-3.2.0-py3-none-any.whl
Collecting readme-renderer>=21.0
  Downloading https://files.pythonhosted.org/packages/54/e4/ed43056d80a4fcc3667e
543a59cc6beaf0a3c0eade837e5591e82ad3c25a/readme_renderer-26.0-py2.py3-none-
any.whl
Requirement already satisfied: requests>=2.20 in /usr/local/lib/python3.6/dist-

```



```

packages (from twine) (2.23.0)
Requirement already satisfied: setuptools>=0.7.0 in
/usr/local/lib/python3.6/dist-packages (from twine) (49.2.0)
Collecting colorama>=0.4.3
  Downloading https://files.pythonhosted.org/packages/c9/dc/45cdef1b4d119eb96316
b3117e6d5708a08029992b2fee2c143c7a0a5cc5/colorama-0.4.3-py2.py3-none-any.whl
Requirement already satisfied: tqdm>=4.14 in /usr/local/lib/python3.6/dist-
packages (from twine) (4.41.1)
Collecting keyring>=15.1
  Downloading https://files.pythonhosted.org/packages/59/4d/469272124b46456c425a
505a8b5f2d42d2fe95d1181de2d888d684506cf7/keyring-21.3.0-py3-none-any.whl
Collecting requests-toolbelt!=0.9.0,>=0.8.0
  Downloading https://files.pythonhosted.org/packages/60/ef/7681134338fc09
7acef8d9b2f8abe0458e4d87559c689a8c306d0957ece5/requests_toolbelt-0.9.1-py2.py3-n
one-any.whl (54kB)
    |                                     | 61kB 6.6MB/s
Requirement already satisfied: importlib-metadata; python_version < "3.8"
in /usr/local/lib/python3.6/dist-packages (from twine) (1.7.0)
Collecting rfc3986>=1.4.0
  Downloading https://files.pythonhosted.org/packages/78/be/7b8b99fd74ff5684225f
50dd0e865393d2265656ef3b4ba9eaaaffe622b8/rfc3986-1.4.0-py2.py3-none-any.whl
Collecting pkginfo>=1.4.2
  Downloading https://files.pythonhosted.org/packages/e6/d5/451b913307b478c49eb2
9084916639dc53a88489b993530fed0a66bab8b9/pkginfo-1.5.0.1-py2.py3-none-any.whl
Requirement already satisfied: six in /usr/local/lib/python3.6/dist-packages
(from readme-renderer>=21.0->twine) (1.15.0)
Requirement already satisfied: bleach>=2.1.0 in /usr/local/lib/python3.6/dist-
packages (from readme-renderer>=21.0->twine) (3.1.5)
Requirement already satisfied: docutils>=0.13.1 in
/usr/local/lib/python3.6/dist-packages (from readme-renderer>=21.0->twine)
(0.15.2)
Collecting Pygments>=2.5.1
  Downloading https://files.pythonhosted.org/packages/2d/68/106af3ae51daf8
07e9cdcba6a90e518954eb8b70341cee52995540a53ead/Pygments-2.6.1-py3-none-any.whl
(914kB)
    |                                     | 921kB 16.3MB/s
Requirement already satisfied: urllib3!=1.25.0,!1.25.1,<1.26,>=1.21.1 in
/usr/local/lib/python3.6/dist-packages (from requests>=2.20->twine) (1.24.3)
Requirement already satisfied: idna<3,>=2.5 in /usr/local/lib/python3.6/dist-
packages (from requests>=2.20->twine) (2.10)
Requirement already satisfied: certifi>=2017.4.17 in
/usr/local/lib/python3.6/dist-packages (from requests>=2.20->twine) (2020.6.20)
Requirement already satisfied: chardet<4,>=3.0.2 in
/usr/local/lib/python3.6/dist-packages (from requests>=2.20->twine) (3.0.4)
Collecting SecretStorage>=3; sys_platform == "linux"
  Downloading https://files.pythonhosted.org/packages/c3/50/8a02cad020e949e6d710
5f5f4530d41e3febcaa5b73f8f2148aacb3aeba5/SecretStorage-3.1.2-py3-none-any.whl
Collecting jeepney>=0.4.2; sys_platform == "linux"

```

```

Downloading https://files.pythonhosted.org/packages/79/31/2e8d42727595faf224c6
dbb748c32b192e212f25495fe841fb7ce8e168b8/jeepney-0.4.3-py3-none-any.whl
Requirement already satisfied: zipp>=0.5 in /usr/local/lib/python3.6/dist-
packages (from importlib-metadata; python_version < "3.8"->twine) (3.1.0)
Requirement already satisfied: webencodings in /usr/local/lib/python3.6/dist-
packages (from bleach>=2.1.0->readme-renderer>=21.0->twine) (0.5.1)
Requirement already satisfied: packaging in /usr/local/lib/python3.6/dist-
packages (from bleach>=2.1.0->readme-renderer>=21.0->twine) (20.4)
Collecting cryptography
  Downloading https://files.pythonhosted.org/packages/ba/91/84a29d6a27fd6d
fc21f475704c4d2053d58ed7a4033c2b0ce1b4ca4d03d9/cryptography-3.0-cp35-abi3-manyli
nux2010_x86_64.whl (2.7MB)
    |                               | 2.7MB 43.7MB/s
Requirement already satisfied: pyparsing>=2.0.2 in
/usr/local/lib/python3.6/dist-packages (from packaging->bleach>=2.1.0->readme-
renderer>=21.0->twine) (2.4.7)
Requirement already satisfied: cffi!=1.11.3,>=1.8 in
/usr/local/lib/python3.6/dist-packages (from cryptography->SecretStorage>=3;
sys_platform == "linux"->keyring>=15.1->twine) (1.14.1)
Requirement already satisfied: pycparser in /usr/local/lib/python3.6/dist-
packages (from cffi!=1.11.3,>=1.8->cryptography->SecretStorage>=3; sys_platform
== "linux"->keyring>=15.1->twine) (2.20)
ERROR: datascience 0.10.6 has requirement folium==0.2.1, but you'll have
folium 0.8.3 which is incompatible.
Installing collected packages: Pygments, readme-renderer, colorama, jeepney,
cryptography, SecretStorage, keyring, requests-toolbelt, rfc3986, pkginfo, twine
Found existing installation: Pygments 2.1.3
Uninstalling Pygments-2.1.3:
  Successfully uninstalled Pygments-2.1.3
Successfully installed Pygments-2.6.1 SecretStorage-3.1.2 colorama-0.4.3
cryptography-3.0 jeepney-0.4.3 keyring-21.3.0 pkginfo-1.5.0.1 readme-
renderer-26.0 requests-toolbelt-0.9.1 rfc3986-1.4.0 twine-3.2.0

```

[6]: `pip install efficientnet`

```

Collecting efficientnet
  Downloading https://files.pythonhosted.org/packages/28/91/67848a143b54c331605b
fba5fd31cf4e9db13d2e429d103fe807acc3bcf4/efficientnet-1.1.0-py3-none-any.whl
Collecting keras-applications<=1.0.8,>=1.0.7
  Downloading https://files.pythonhosted.org/packages/71/e3/19762fd9c62877
ae9102edf6342d71b28fbfd9dea3d2f96a882ce099b03f/Keras_Applications-1.0.8-py3-none
-any.whl (50kB)
    |                               | 51kB 4.8MB/s
Requirement already satisfied: scikit-image in
/usr/local/lib/python3.6/dist-packages (from efficientnet) (0.16.2)
Requirement already satisfied: numpy>=1.9.1 in /usr/local/lib/python3.6/dist-
packages (from keras-applications<=1.0.8,>=1.0.7->efficientnet) (1.18.5)

```

Requirement already satisfied: h5py in /usr/local/lib/python3.6/dist-packages (from keras-applications<=1.0.8,>=1.0.7->efficientnet) (2.10.0)

Requirement already satisfied: PyWavelets>=0.4.0 in /usr/local/lib/python3.6/dist-packages (from scikit-image->efficientnet) (1.1.1)

Requirement already satisfied: matplotlib!=3.0.0,>=2.0.0 in /usr/local/lib/python3.6/dist-packages (from scikit-image->efficientnet) (3.2.2)

Requirement already satisfied: scipy>=0.19.0 in /usr/local/lib/python3.6/dist-packages (from scikit-image->efficientnet) (1.4.1)

Requirement already satisfied: networkx>=2.0 in /usr/local/lib/python3.6/dist-packages (from scikit-image->efficientnet) (2.4)

Requirement already satisfied: pillow>=4.3.0 in /usr/local/lib/python3.6/dist-packages (from scikit-image->efficientnet) (7.0.0)

Requirement already satisfied: imageio>=2.3.0 in /usr/local/lib/python3.6/dist-packages (from scikit-image->efficientnet) (2.4.1)

Requirement already satisfied: six in /usr/local/lib/python3.6/dist-packages (from h5py->keras-applications<=1.0.8,>=1.0.7->efficientnet) (1.15.0)

Requirement already satisfied: kiwisolver>=1.0.1 in /usr/local/lib/python3.6/dist-packages (from matplotlib!=3.0.0,>=2.0.0->scikit-image->efficientnet) (1.2.0)

Requirement already satisfied: python-dateutil>=2.1 in /usr/local/lib/python3.6/dist-packages (from matplotlib!=3.0.0,>=2.0.0->scikit-image->efficientnet) (2.8.1)

Requirement already satisfied: pyparsing!=2.0.4,!=2.1.2,!=2.1.6,>=2.0.1 in /usr/local/lib/python3.6/dist-packages (from matplotlib!=3.0.0,>=2.0.0->scikit-image->efficientnet) (2.4.7)

Requirement already satisfied: cycler>=0.10 in /usr/local/lib/python3.6/dist-packages (from matplotlib!=3.0.0,>=2.0.0->scikit-image->efficientnet) (0.10.0)

Requirement already satisfied: decorator>=4.3.0 in /usr/local/lib/python3.6/dist-packages (from networkx>=2.0->scikit-image->efficientnet) (4.4.2)

Installing collected packages: keras-applications, efficientnet

Successfully installed efficientnet-1.1.0 keras-applications-1.0.8

```
[7]: from ImageDataAugmentor.image_data_augmentor import *
```

```
[8]: import glob
import pandas as pd
import os
import numpy as np
```

```
[9]: covid=os.listdir('COVID')
normal=os.listdir('NORMAL')
```

```
[10]: covidt=os.listdir('COVID-AT')
normalt=os.listdir('NORMAL-AT')
```

```
[11]: cov=list(zip(covid,['covid']*(len(covid))))
covid_df = pd.DataFrame(cov,columns=['file','label'])
covid_df.head()
```

```
[11]:
```

	file	label
0	1-s2.0-S1931312820301852-gr1_lrg-b.png	covid
1	16751_3_1.jpg	covid
2	covid-19-pneumonia-progression-and-regression-...	covid
3	68_2020_1364_Fig1_HTML-c.png	covid
4	covid-19-caso-94-1-14.png	covid

```
[12]: cov=list(zip(covidt,['covid']*(len(covidt))))
covid_df1 = pd.DataFrame(cov,columns=['file','label'])
covid_df1.head()
```

```
[12]:
```

	file	label
0	1.CXRCTThoraximagesofCOVID-19fromSingapore.pdf...	covid
1	covid-19-pneumonia-53.jpg	covid
2	41591_2020_819_Fig1_HTML.webp-day10.png	covid
3	kjr-21-e24-g001-l-a.jpg	covid
4	53EC07C9-5CC6-4BE4-9B6F-D7B0D72AAA7E.jpeg	covid

```
[13]: norm=list(zip(normal,['normal']*(len(normal))))
normal_df = pd.DataFrame(norm,columns=['file','label'])
normal_df.head()
```

```
[13]:
```

	file	label
0	NORMAL2-IM-1170-0001.jpeg	normal
1	IM-0650-0001.jpeg	normal
2	IM-0569-0001.jpeg	normal
3	IM-0549-0001.jpeg	normal
4	NORMAL2-IM-0944-0001.jpeg	normal

```
[14]: norm=list(zip(normalt,['normal']*(len(normalt))))
normal_df1 = pd.DataFrame(norm,columns=['file','label'])
normal_df1.head()
```

```
[14]:
```

	file	label
0	IM-0370-0001.jpeg	normal
1	IM-0348-0001.jpeg	normal
2	IM-0201-0001.jpeg	normal
3	IM-0399-0001.jpeg	normal
4	IM-0170-0001.jpeg	normal

```
[15]: dataframe=pd.concat([covid_df,normal_df])
dataframe.head()
```

```
[15]:
```

	file	label
0	1-s2.0-S1931312820301852-gr1_lrg-b.png	covid
1	16751_3_1.jpg	covid
2	covid-19-pneumonia-progression-and-regression-...	covid
3	68_2020_1364_Fig1_HTML-c.png	covid
4	covid-19-caso-94-1-14.png	covid

```
[16]: dataframe1=pd.concat([covid_df1,normal_df1])
dataframe1.head()
```

```
[16]:
```

	file	label
0	1.CXRCTThoraximagesofCOVID-19fromSingapore.pdf...	covid
1	covid-19-pneumonia-53.jpg	covid
2	41591_2020_819_Fig1_HTML.webp-day10.png	covid
3	kjr-21-e24-g001-l-a.jpg	covid
4	53EC07C9-5CC6-4BE4-9B6F-D7B0D72AAA7E.jpeg	covid

```
[17]: dataframe=pd.concat([covid_df,normal_df])
dataframe.head()
```

```
[17]:
```

	file	label
0	1-s2.0-S1931312820301852-gr1_lrg-b.png	covid
1	16751_3_1.jpg	covid
2	covid-19-pneumonia-progression-and-regression-...	covid
3	68_2020_1364_Fig1_HTML-c.png	covid
4	covid-19-caso-94-1-14.png	covid

```
[18]: df = pd.get_dummies(dataframe['label'])
df.head()
```

```
[18]:
```

	covid	normal
0	1	0
1	1	0
2	1	0
3	1	0
4	1	0

```
[19]: df1 = pd.get_dummies(dataframe1['label'])
df1.head()
```

```
[19]:
```

	covid	normal
0	1	0
1	1	0
2	1	0
3	1	0
4	1	0

```
[20]: df = pd.concat([dataframe, df], axis=1)
      df.head()
      df.shape
```

```
[20]: (808, 4)
```

```
[21]: df1 = pd.concat([dataframe1, df1], axis=1)
      df1.head()
      df1.shape
```

```
[21]: (196, 4)
```

```
[22]: import numpy as np
      import pandas as pd
      import matplotlib.pyplot as plt
      from albumentations import *
```

```
[23]: aug=Compose([
      RandomRotate90(),
      Flip(),
      Transpose(),
      OneOf([
          IAAAdditiveGaussianNoise(),
          GaussNoise(),

      ], p=0.2),
      OneOf([
          MotionBlur(p=.2),
          MedianBlur(blur_limit=3, p=.1),
          Blur(blur_limit=3, p=.1),
      ], p=0.3),
      ShiftScaleRotate(shift_limit=0.0625, scale_limit=0.2, rotate_limit=45,
      ↪p=.2),
      OneOf([
          OpticalDistortion(p=0.3),
          GridDistortion(p=.1),
          IAAPiecewiseAffine(p=0.3),
      ], p=0.3),
      OneOf([
          CLAHE(clip_limit=2),
          IAASharpen(),
          IAAEmboss(),
          RandomContrast(),
          RandomBrightness(),
      ], p=0.3),
      #HueSaturationValue(p=0.3),
      ], p=1)
```

```
[24]: from ImageDataAugmentor.image_data_augmentor import *
      data_gen= ImageDataAugmentor(
          rescale=1/255,
          augment=aug)

[25]: img_shape=224
      batch_size=16

[26]: from tensorflow.keras.models import Sequential,Model
      from tensorflow.keras.layers import Activation, Dropout, Flatten, Dense,
      ↳Conv2D, MaxPool2D,
      ↳BatchNormalization,Input,MaxPooling2D,GlobalMaxPooling2D,concatenate
      from tensorflow.keras.layers import GlobalAveragePooling2D
      from tensorflow.keras.applications.resnet50 import ResNet50
      from tensorflow.keras.callbacks import ModelCheckpoint,ReduceLROnPlateau
      from tensorflow.keras.optimizers import Adam
      import tensorflow.keras.backend as K
      import tensorflow as tf
      from sklearn.metrics import confusion_matrix

[27]: !mkdir data

[28]: !mkdir data1

[29]: cp -r COVID/* data

[30]: cp -r COVID-AT/* data1

[31]: cp -r NORMAL/* data

[32]: cp -r NORMAL-AT/* data1

[33]: random.seed(1234)
      from sklearn.model_selection import KFold
      from sklearn.model_selection import StratifiedKFold
      import gc
      import seaborn as sns
      from sklearn.metrics import roc_curve
      from sklearn.metrics import roc_auc_score
      from sklearn.metrics import auc
      from sklearn.metrics import precision_recall_curve

      from sklearn.metrics import classification_report,accuracy_score,f1_score
      classification_reports=[]
      i=1
      kf = StratifiedKFold(10,shuffle=True,random_state=50)
      history=[]
```

```

accuracy=[]
f1_scores=[]
fold=0

for train_index, test_index in kf.split(df,df['label']):
    train=df.iloc[train_index,:]
    val=df.iloc[test_index,:]
    print('-----fold {}-----'.format(fold))
    train_generator=data_gen.flow_from_dataframe(train,directory='data',
                                                x_col="file",
                                                y_col=['covid','normal'],
                                                class_mode='raw',
                                                shuffle=True,
                                                batch_size=batch_size)

    →target_size=(img_shape,img_shape),

    val_generator=data_gen.flow_from_dataframe(val,directory='data',
                                                x_col="file",
                                                y_col=['covid','normal'],
                                                class_mode='raw',
                                                shuffle=False,
                                                batch_size=batch_size)

    →target_size=(img_shape,img_shape),

    →y_col=['covid','normal'],

import efficientnet.tfkeras as efn
model =efn.EfficientNetB4(weights ='noisy-student', include_top=False,
→input_shape = (img_shape,img_shape,3))
x = model.output
x = GlobalAveragePooling2D()(x)
x = Dense(128, activation="relu")(x)
x = Dropout(0.3)(x)
x = Dense(64, activation="relu")(x)
x = Dropout(0.3)(x)
x = Dense(32, activation="relu")(x)
x = Dropout(0.3)(x)
predictions = Dense(2, activation="softmax")(x)
model = Model(inputs=model.input, outputs=predictions)

def custom_loss(y_true, y_pred):
    return tf.keras.losses.categorical_crossentropy(y_true, y_pred,
→label_smoothing=0.1)
model.compile(optimizer=Adam(0.0001), loss=custom_loss, metrics=['accuracy'])

results = model.fit(train_generator,epochs=11,

```



```

        steps_per_epoch=train_generator.n/batch_size,
        validation_data=val_generator,
        validation_steps=val_generator.n/batch_size,
        callbacks=[ReduceLROnPlateau(monitor='val_loss',
→factor=0.5,patience=3, min_lr=0.000001),
                    ModelCheckpoint('model_{}.hdf5'.
→format(fold), save_best_only=True, monitor='val_loss', mode='min')
                    ])
    model.load_weights('model_{}.hdf5'.format(fold))
    model.save('final_model_{}'.format(fold))
    val_generator.reset()
    y_pred=model.predict(val_generator,steps=val_generator.n/batch_size,verbose=1)
    y_pred=y_pred.round().astype(int)
    y_true=val.iloc[:,2:]
    classification_reports.append(classification_report(y_true,
→y_pred,target_names=['covid','normal'],digits=6))
    accuracy.append(accuracy_score(y_true,y_pred))
    f1=f1_score(y_true,y_pred,average='macro')
    print('f1 score is ', f1)
    f1_scores.append(f1)
    fold+=1
    cm=confusion_matrix(y_true.values.argmax(axis=1), y_pred.argmax(axis=1))
    plt.figure(figsize=(5.5,4))
    sns.heatmap(cm, annot=True)
    plt.title('Covid Classifier \nAccuracy:{0:.4f}'.format(accuracy_score(y_true,
→y_pred)))
    plt.ylabel('True label')
    plt.xlabel('Predicted label')
    plt.show()

    plt.plot(results.history['accuracy'])
    plt.plot(results.history['val_accuracy'])
    plt.title('model accuracy')
    plt.ylabel('accuracy')
    plt.xlabel('epoch')
    plt.legend(['train', 'test'], loc='upper left')
    plt.show()

    plt.plot(results.history['loss'])
    plt.plot(results.history['val_loss'])
    plt.title('model loss')
    plt.ylabel('loss')
    plt.xlabel('epoch')
    plt.legend(['train', 'test'], loc='upper left')
    plt.show()

    from itertools import cycle

```

```

plt.style.use('ggplot')
fpr = dict()
tpr = dict()
roc_auc = dict()
n_classes=2
for i in range(n_classes):
    fpr[i], tpr[i], _ = roc_curve(y_true.values[:, i], y_pred[:, i])
    roc_auc[i] = auc(fpr[i], tpr[i])
colors = cycle(['blue', 'red'])
for i, color in zip(range(n_classes), colors):
    plt.plot(fpr[i], tpr[i], color=color, lw=1.5, label='ROC curve of class {0}_
→(area = {1:0.2f})' ''.format(i+1, roc_auc[i]))
plt.plot([0, 1], [0, 1], 'k-', lw=1.5)
plt.xlim([-0.05, 1.0])
plt.ylim([0.0, 1.05])
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver operating characteristic for binary-class data')
plt.legend(loc="lower right")
plt.show()
del model
tf.keras.backend.clear_session()
gc.collect()

```

```

/usr/local/lib/python3.6/dist-packages/statsmodels/tools/_testing.py:19:
FutureWarning: pandas.util.testing is deprecated. Use the functions in the
public API at pandas.testing instead.
    import pandas.util.testing as tm

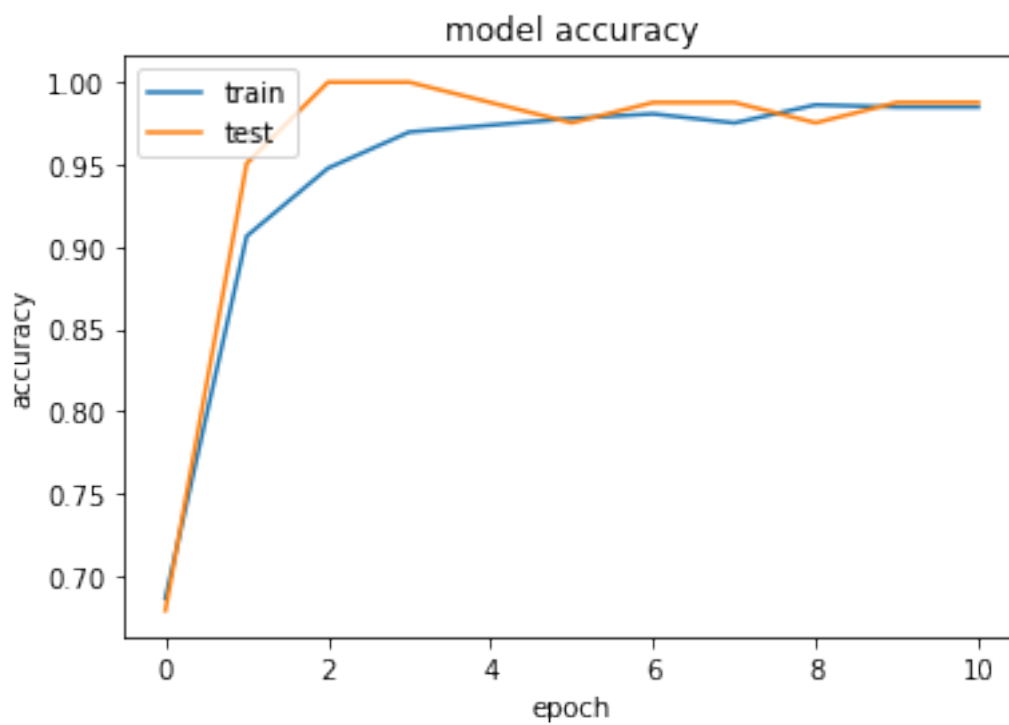
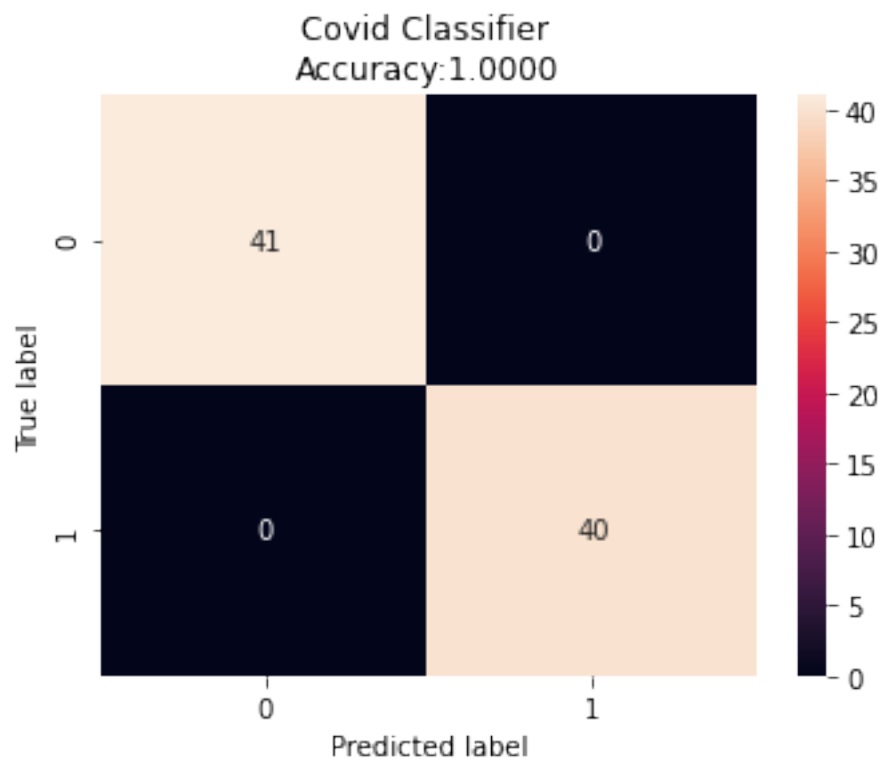
-----fold 0-----
Found 727 validated image filenames.
Found 81 validated image filenames.
Downloading data from https://github.com/qubvel/efficientnet/releases/download/v
0.0.1/efficientnet-b4_noisy-student_notop.h5
71680000/71678424 [=====] - 3s 0us/step
Epoch 1/11
46/45 [=====] - 47s 1s/step - loss: 0.6138 - accuracy:
0.6864 - val_loss: 0.5993 - val_accuracy: 0.6790
Epoch 2/11
46/45 [=====] - 44s 951ms/step - loss: 0.3972 -
accuracy: 0.9065 - val_loss: 0.3545 - val_accuracy: 0.9506
Epoch 3/11
46/45 [=====] - 46s 1s/step - loss: 0.3195 - accuracy:
0.9477 - val_loss: 0.2630 - val_accuracy: 1.0000
Epoch 4/11
46/45 [=====] - 46s 1s/step - loss: 0.2892 - accuracy:
0.9697 - val_loss: 0.2358 - val_accuracy: 1.0000
Epoch 5/11

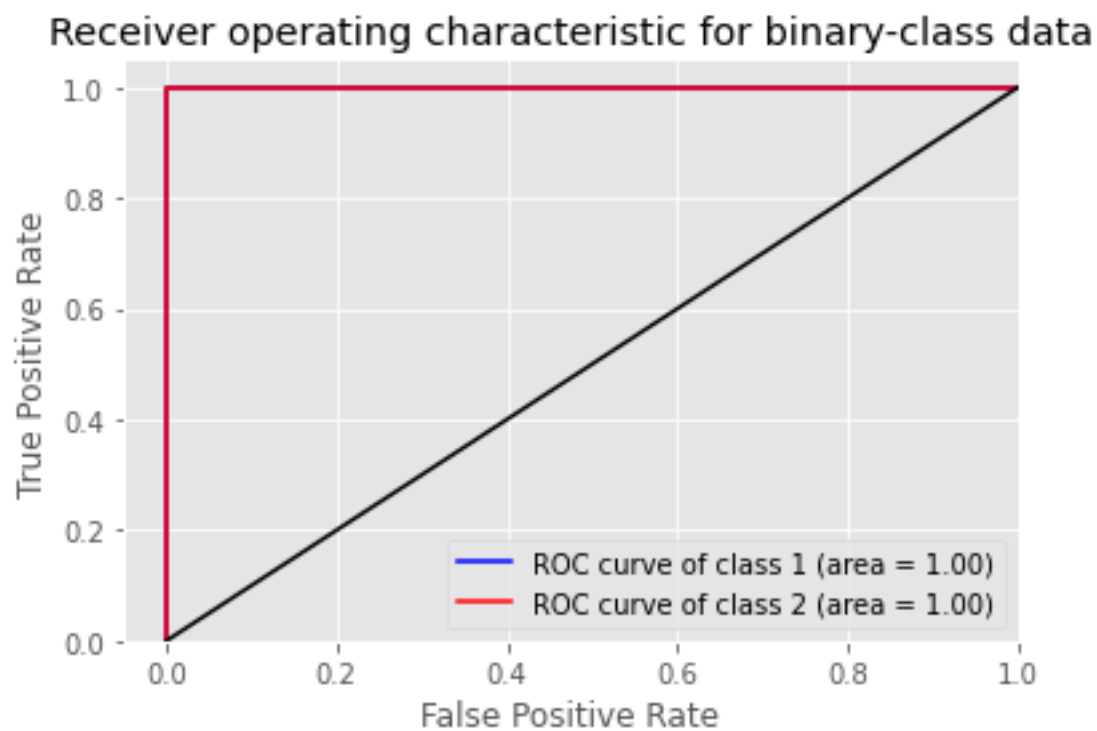
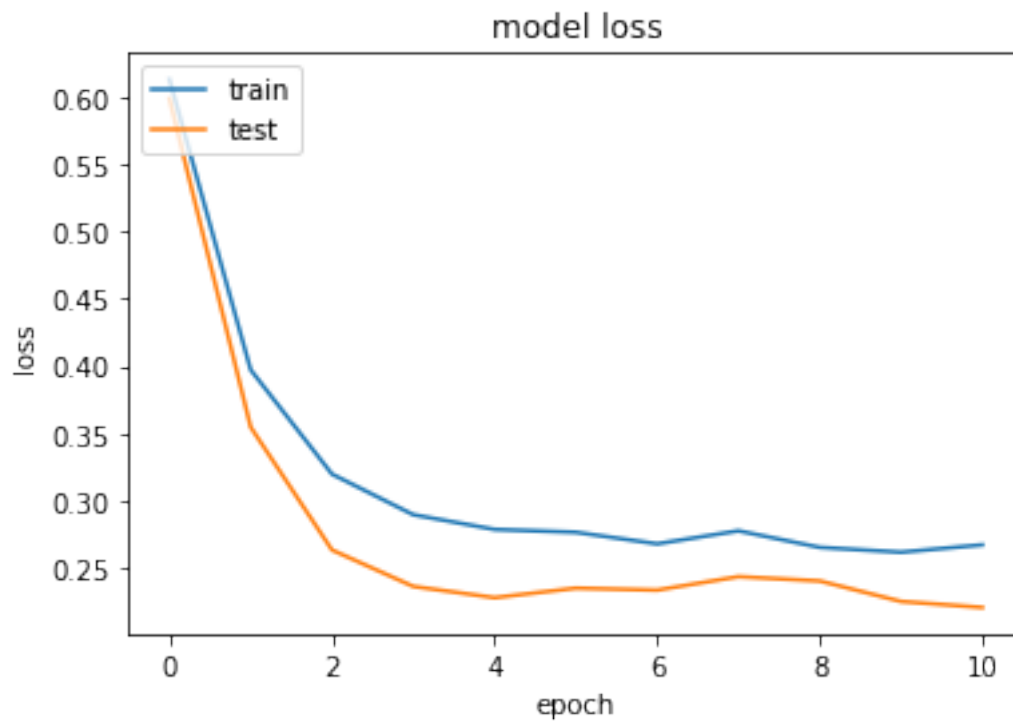
```

```

46/45 [=====] - 44s 953ms/step - loss: 0.2783 -
accuracy: 0.9739 - val_loss: 0.2274 - val_accuracy: 0.9877
Epoch 6/11
46/45 [=====] - 44s 959ms/step - loss: 0.2761 -
accuracy: 0.9780 - val_loss: 0.2345 - val_accuracy: 0.9753
Epoch 7/11
46/45 [=====] - 43s 934ms/step - loss: 0.2675 -
accuracy: 0.9807 - val_loss: 0.2331 - val_accuracy: 0.9877
Epoch 8/11
46/45 [=====] - 43s 930ms/step - loss: 0.2772 -
accuracy: 0.9752 - val_loss: 0.2431 - val_accuracy: 0.9877
Epoch 9/11
46/45 [=====] - 43s 945ms/step - loss: 0.2649 -
accuracy: 0.9862 - val_loss: 0.2399 - val_accuracy: 0.9753
Epoch 10/11
46/45 [=====] - 46s 997ms/step - loss: 0.2613 -
accuracy: 0.9849 - val_loss: 0.2246 - val_accuracy: 0.9877
Epoch 11/11
46/45 [=====] - 44s 966ms/step - loss: 0.2668 -
accuracy: 0.9849 - val_loss: 0.2201 - val_accuracy: 0.9877
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-
packages/tensorflow/python/training/tracking/tracking.py:111:
Model.state_updates (from tensorflow.python.keras.engine.training) is deprecated
and will be removed in a future version.
Instructions for updating:
This property should not be used in TensorFlow 2.0, as updates are applied
automatically.
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-
packages/tensorflow/python/training/tracking/tracking.py:111: Layer.updates
(from tensorflow.python.keras.engine.base_layer) is deprecated and will be
removed in a future version.
Instructions for updating:
This property should not be used in TensorFlow 2.0, as updates are applied
automatically.
INFO:tensorflow:Assets written to: final_model_0/assets
6/5 [=====] - 3s 431ms/step
f1 score is 1.0

```

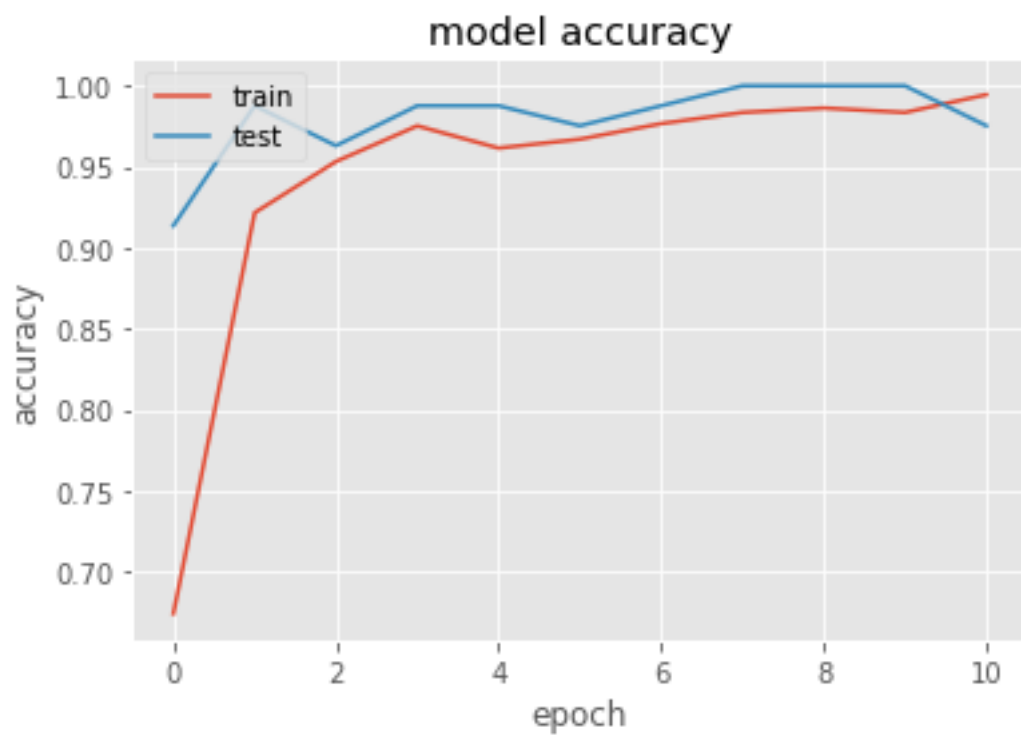
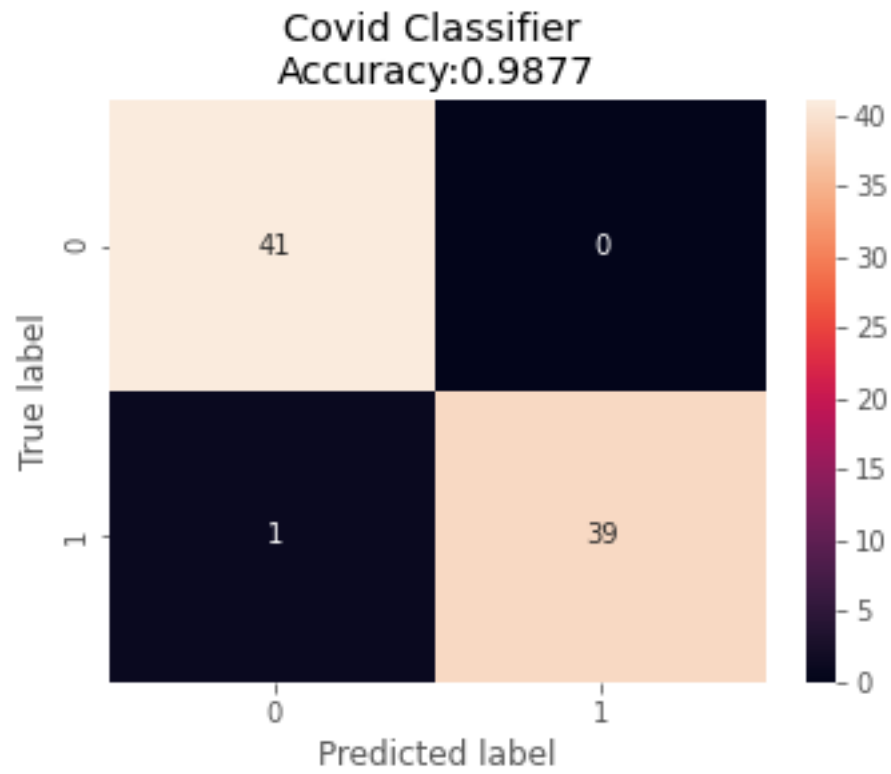


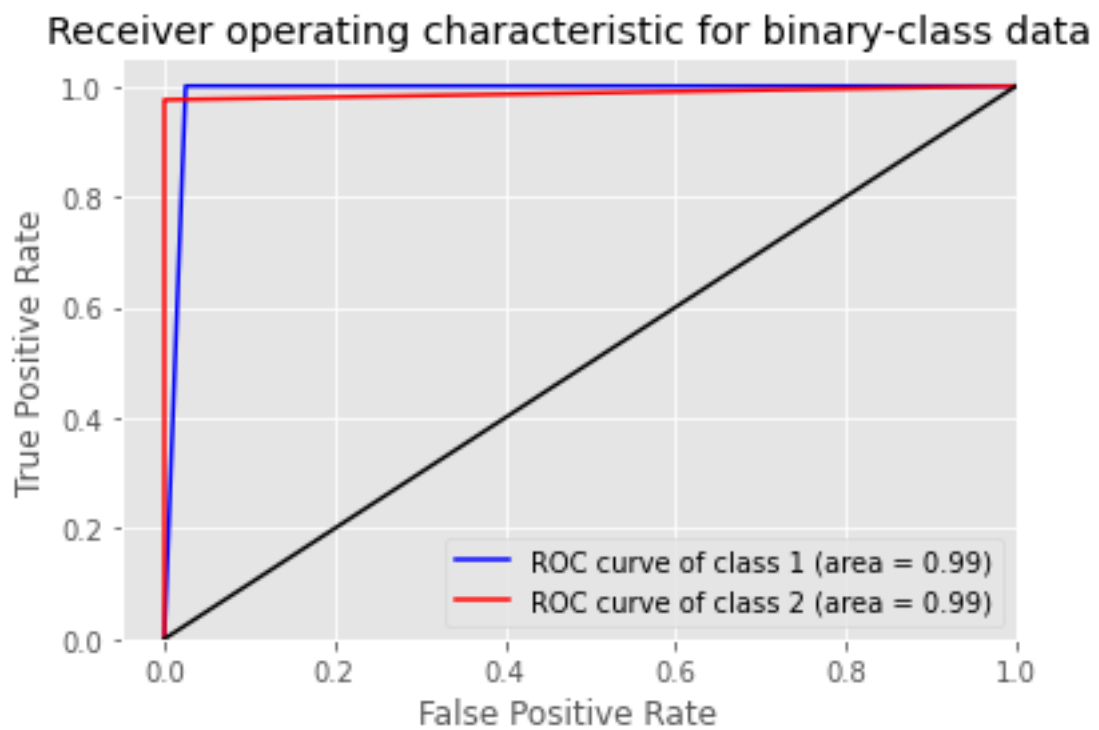
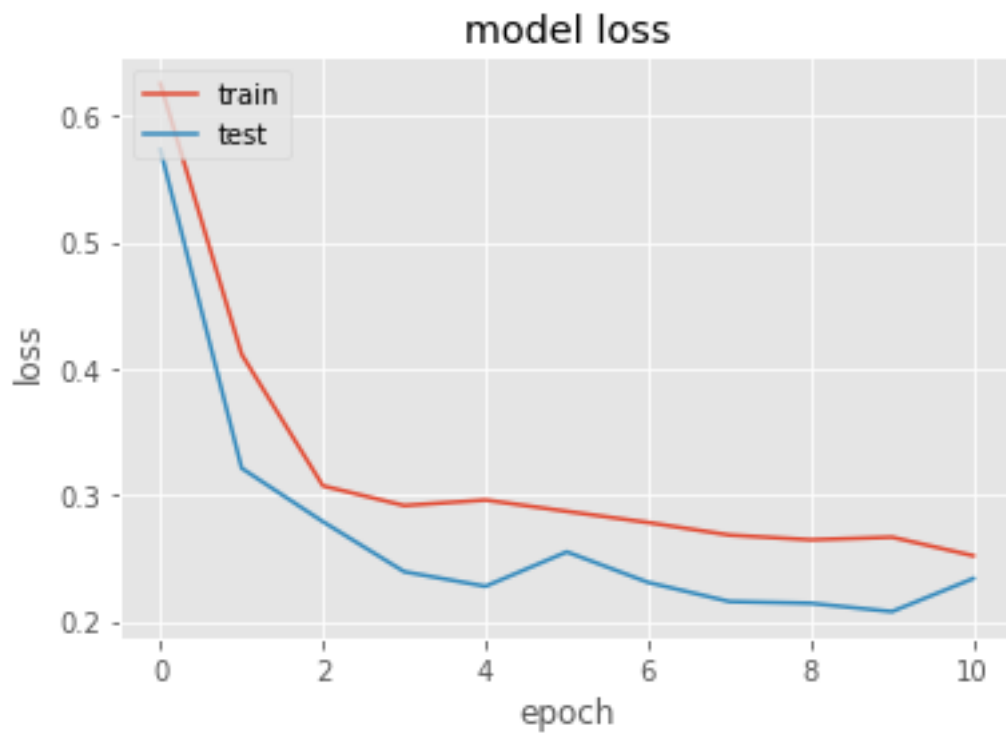


```

-----fold 1-----
Found 727 validated image filenames.
Found 81 validated image filenames.
Epoch 1/11
46/45 [=====] - 50s 1s/step - loss: 0.6256 - accuracy:
0.6740 - val_loss: 0.5734 - val_accuracy: 0.9136
Epoch 2/11
46/45 [=====] - 46s 996ms/step - loss: 0.4113 -
accuracy: 0.9216 - val_loss: 0.3211 - val_accuracy: 0.9877
Epoch 3/11
46/45 [=====] - 45s 976ms/step - loss: 0.3071 -
accuracy: 0.9532 - val_loss: 0.2788 - val_accuracy: 0.9630
Epoch 4/11
46/45 [=====] - 47s 1s/step - loss: 0.2915 - accuracy:
0.9752 - val_loss: 0.2392 - val_accuracy: 0.9877
Epoch 5/11
46/45 [=====] - 46s 996ms/step - loss: 0.2959 -
accuracy: 0.9615 - val_loss: 0.2276 - val_accuracy: 0.9877
Epoch 6/11
46/45 [=====] - 43s 945ms/step - loss: 0.2869 -
accuracy: 0.9670 - val_loss: 0.2549 - val_accuracy: 0.9753
Epoch 7/11
46/45 [=====] - 44s 950ms/step - loss: 0.2781 -
accuracy: 0.9766 - val_loss: 0.2307 - val_accuracy: 0.9877
Epoch 8/11
46/45 [=====] - 47s 1s/step - loss: 0.2682 - accuracy:
0.9835 - val_loss: 0.2155 - val_accuracy: 1.0000
Epoch 9/11
46/45 [=====] - 45s 984ms/step - loss: 0.2644 -
accuracy: 0.9862 - val_loss: 0.2142 - val_accuracy: 1.0000
Epoch 10/11
46/45 [=====] - 46s 992ms/step - loss: 0.2665 -
accuracy: 0.9835 - val_loss: 0.2076 - val_accuracy: 1.0000
Epoch 11/11
46/45 [=====] - 44s 950ms/step - loss: 0.2518 -
accuracy: 0.9945 - val_loss: 0.2338 - val_accuracy: 0.9753
INFO:tensorflow:Assets written to: final_model_1/assets
6/5 [=====] - 4s 610ms/step
f1 score is 0.9876467896904071

```

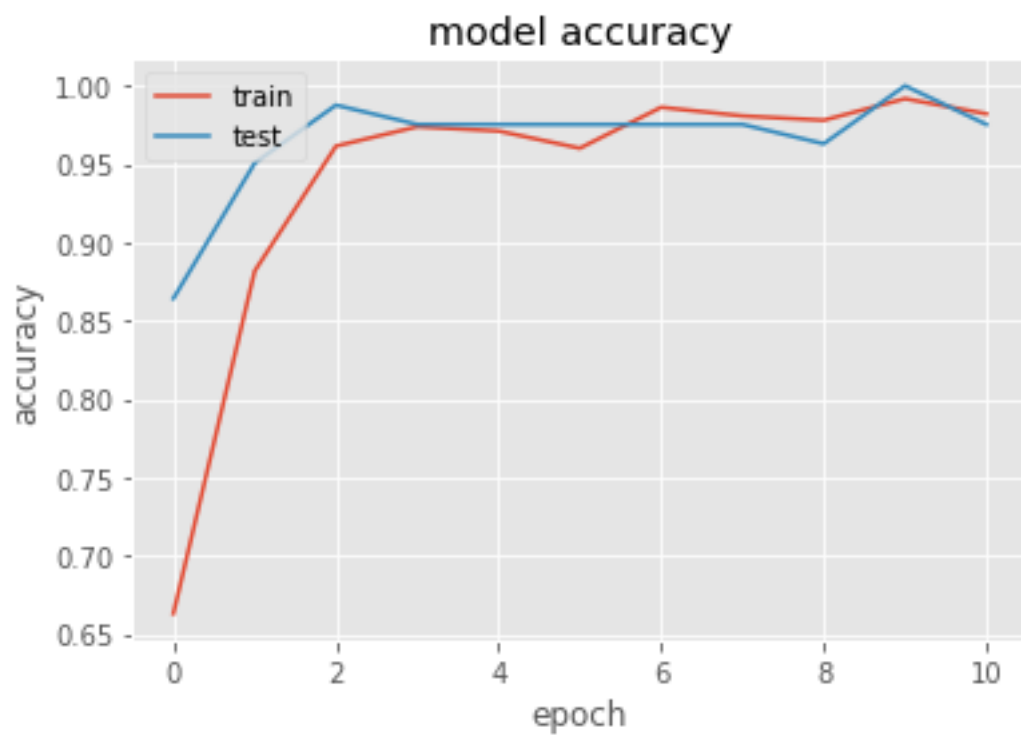
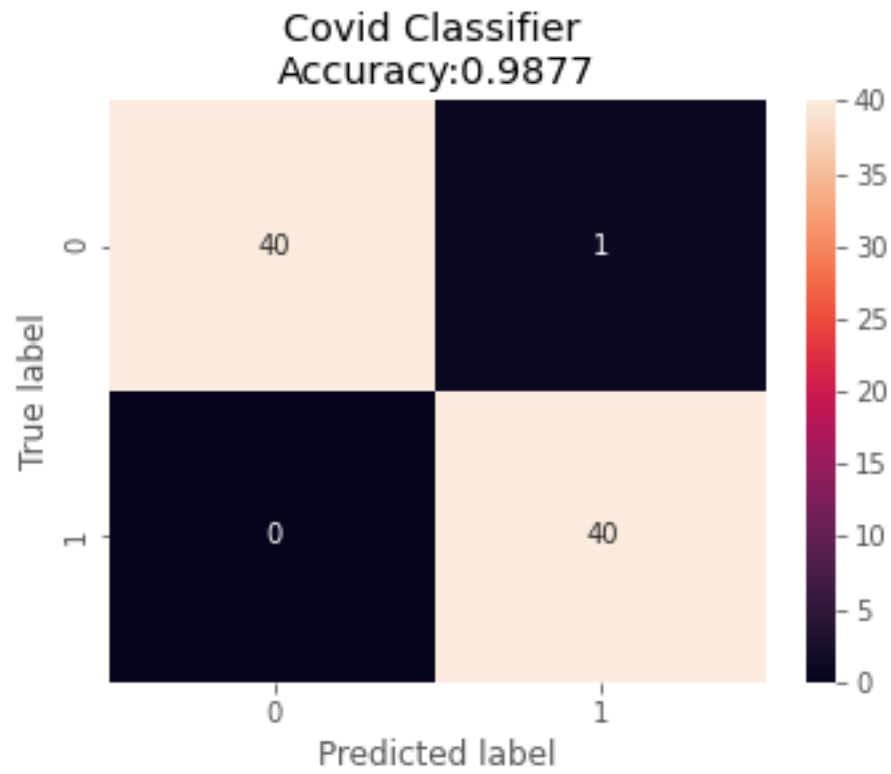


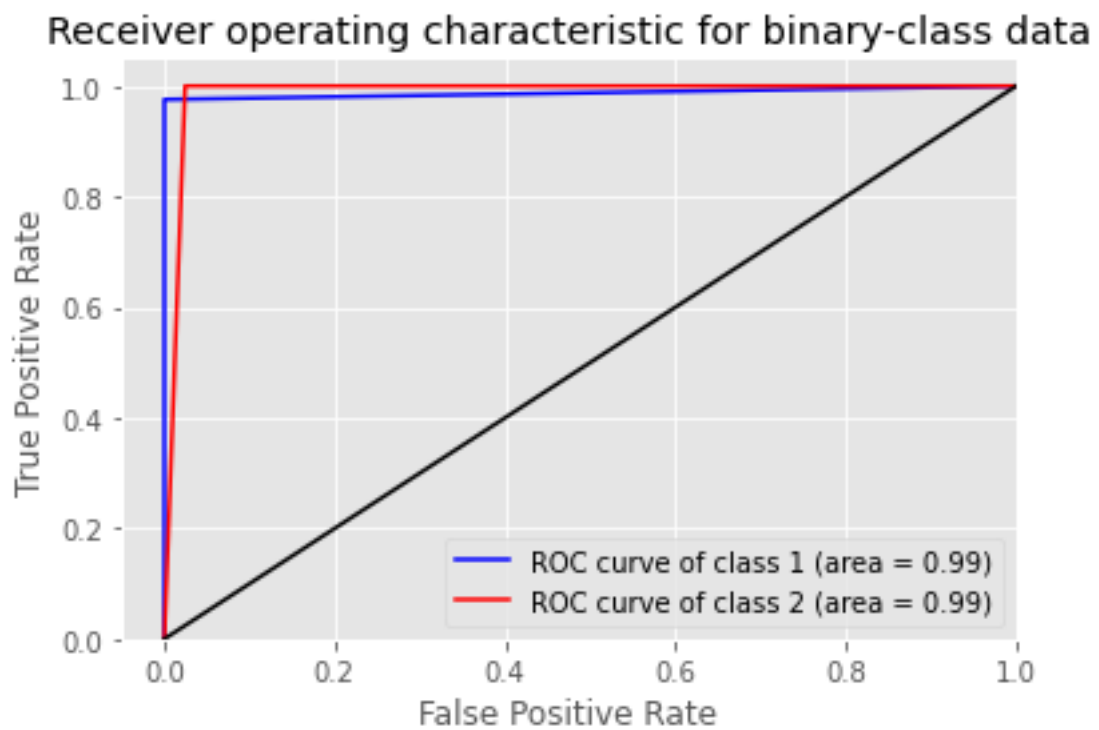



```

-----fold 2-----
Found 727 validated image filenames.
Found 81 validated image filenames.
Epoch 1/11
46/45 [=====] - 48s 1s/step - loss: 0.6416 - accuracy:
0.6630 - val_loss: 0.6215 - val_accuracy: 0.8642
Epoch 2/11
46/45 [=====] - 45s 974ms/step - loss: 0.4411 -
accuracy: 0.8817 - val_loss: 0.3507 - val_accuracy: 0.9506
Epoch 3/11
46/45 [=====] - 47s 1s/step - loss: 0.3116 - accuracy:
0.9615 - val_loss: 0.2568 - val_accuracy: 0.9877
Epoch 4/11
46/45 [=====] - 43s 945ms/step - loss: 0.2926 -
accuracy: 0.9739 - val_loss: 0.2604 - val_accuracy: 0.9753
Epoch 5/11
46/45 [=====] - 46s 1s/step - loss: 0.2851 - accuracy:
0.9711 - val_loss: 0.2418 - val_accuracy: 0.9753
Epoch 6/11
46/45 [=====] - 44s 966ms/step - loss: 0.2956 -
accuracy: 0.9601 - val_loss: 0.2374 - val_accuracy: 0.9753
Epoch 7/11
46/45 [=====] - 45s 987ms/step - loss: 0.2629 -
accuracy: 0.9862 - val_loss: 0.2340 - val_accuracy: 0.9753
Epoch 8/11
46/45 [=====] - 45s 971ms/step - loss: 0.2725 -
accuracy: 0.9807 - val_loss: 0.2360 - val_accuracy: 0.9753
Epoch 9/11
46/45 [=====] - 45s 971ms/step - loss: 0.2783 -
accuracy: 0.9780 - val_loss: 0.2586 - val_accuracy: 0.9630
Epoch 10/11
46/45 [=====] - 47s 1s/step - loss: 0.2573 - accuracy:
0.9917 - val_loss: 0.2143 - val_accuracy: 1.0000
Epoch 11/11
46/45 [=====] - 44s 955ms/step - loss: 0.2686 -
accuracy: 0.9821 - val_loss: 0.2318 - val_accuracy: 0.9753
INFO:tensorflow:Assets written to: final_model_2/assets
6/5 [=====] - 4s 589ms/step
f1 score is 0.9876543209876543

```

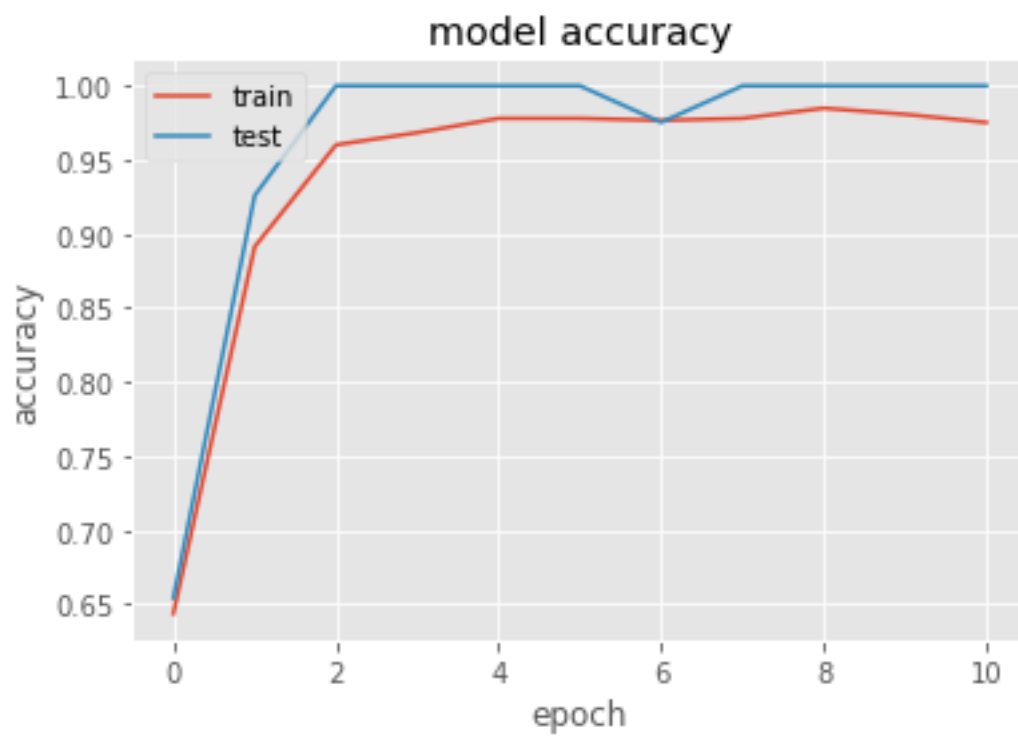
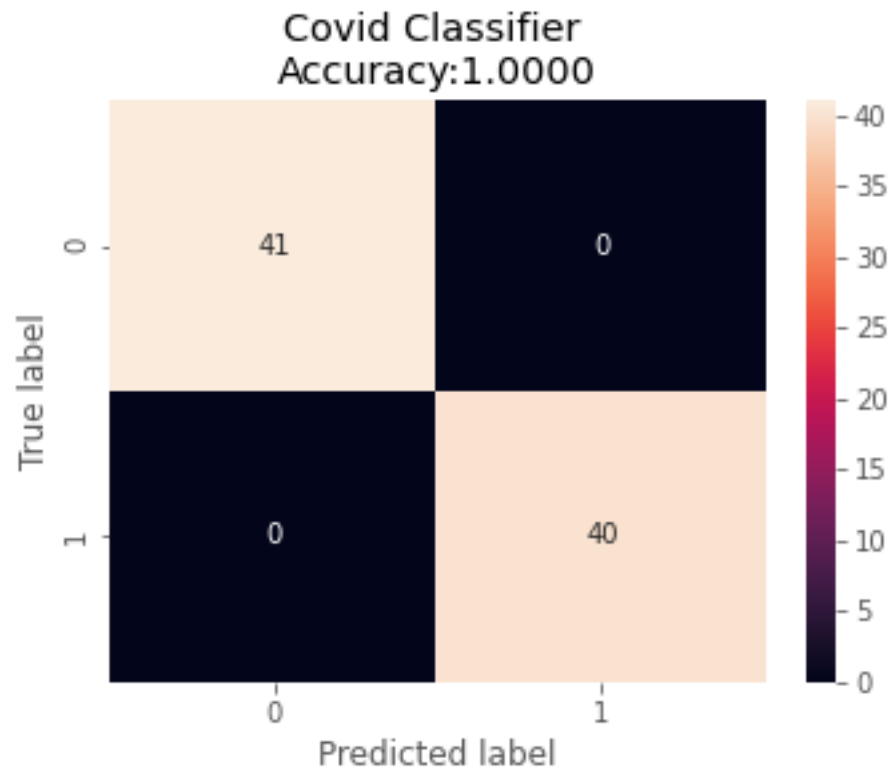


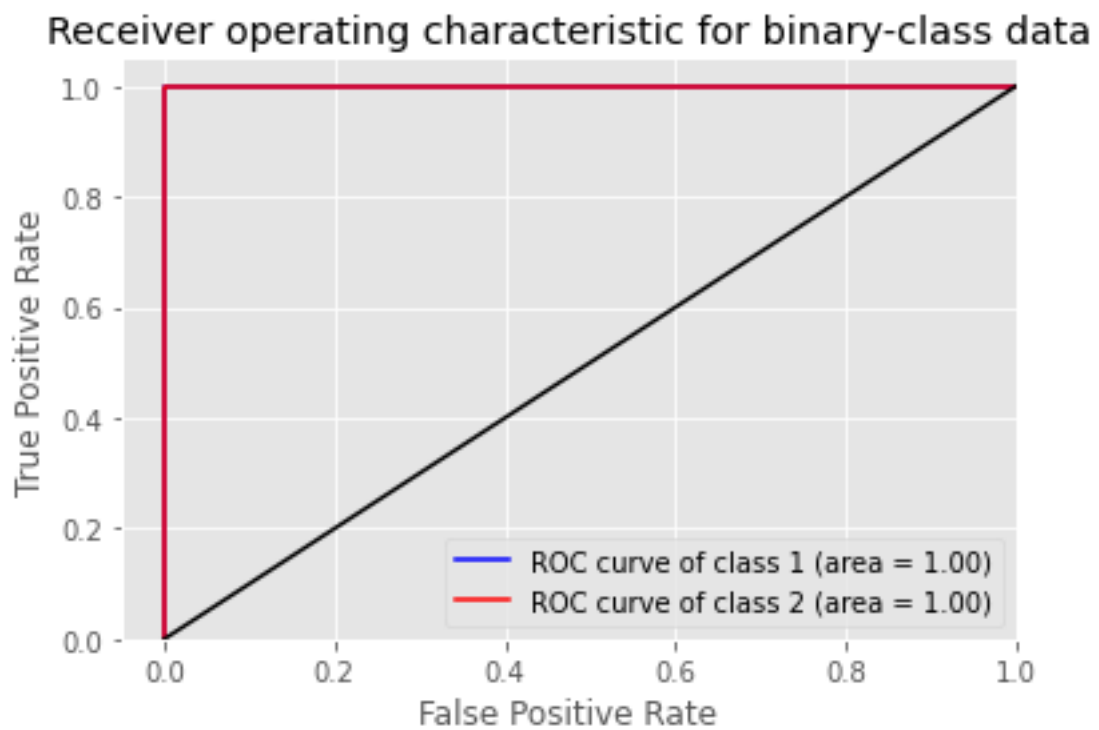
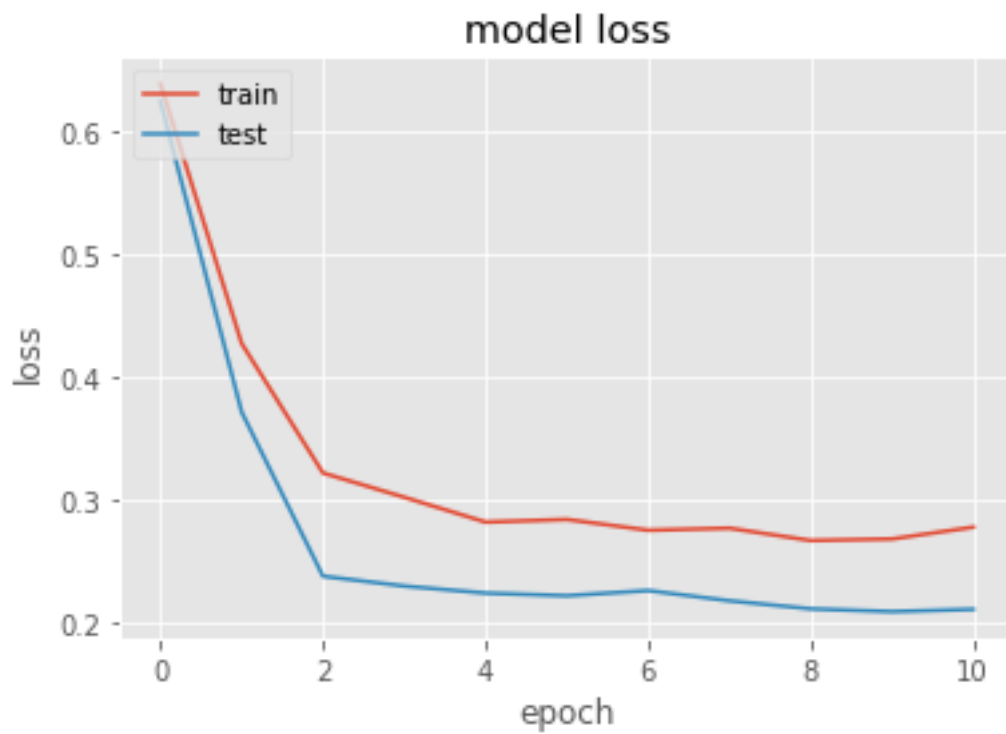


```

-----fold 3-----
Found 727 validated image filenames.
Found 81 validated image filenames.
Epoch 1/11
46/45 [=====] - 48s 1s/step - loss: 0.6378 - accuracy:
0.6437 - val_loss: 0.6236 - val_accuracy: 0.6543
Epoch 2/11
46/45 [=====] - 46s 1s/step - loss: 0.4267 - accuracy:
0.8913 - val_loss: 0.3709 - val_accuracy: 0.9259
Epoch 3/11
46/45 [=====] - 45s 973ms/step - loss: 0.3214 -
accuracy: 0.9601 - val_loss: 0.2375 - val_accuracy: 1.0000
Epoch 4/11
46/45 [=====] - 47s 1s/step - loss: 0.3017 - accuracy:
0.9684 - val_loss: 0.2295 - val_accuracy: 1.0000
Epoch 5/11
46/45 [=====] - 44s 963ms/step - loss: 0.2815 -
accuracy: 0.9780 - val_loss: 0.2238 - val_accuracy: 1.0000
Epoch 6/11
46/45 [=====] - 45s 983ms/step - loss: 0.2836 -
accuracy: 0.9780 - val_loss: 0.2216 - val_accuracy: 1.0000
Epoch 7/11
46/45 [=====] - 46s 1s/step - loss: 0.2749 - accuracy:
0.9766 - val_loss: 0.2258 - val_accuracy: 0.9753
Epoch 8/11
46/45 [=====] - 46s 996ms/step - loss: 0.2765 -
accuracy: 0.9780 - val_loss: 0.2175 - val_accuracy: 1.0000
Epoch 9/11
46/45 [=====] - 46s 1s/step - loss: 0.2665 - accuracy:
0.9849 - val_loss: 0.2110 - val_accuracy: 1.0000
Epoch 10/11
46/45 [=====] - 44s 959ms/step - loss: 0.2678 -
accuracy: 0.9807 - val_loss: 0.2087 - val_accuracy: 1.0000
Epoch 11/11
46/45 [=====] - 42s 916ms/step - loss: 0.2774 -
accuracy: 0.9752 - val_loss: 0.2106 - val_accuracy: 1.0000
INFO:tensorflow:Assets written to: final_model_3/assets
6/5 [=====] - 3s 570ms/step
f1 score is 1.0

```

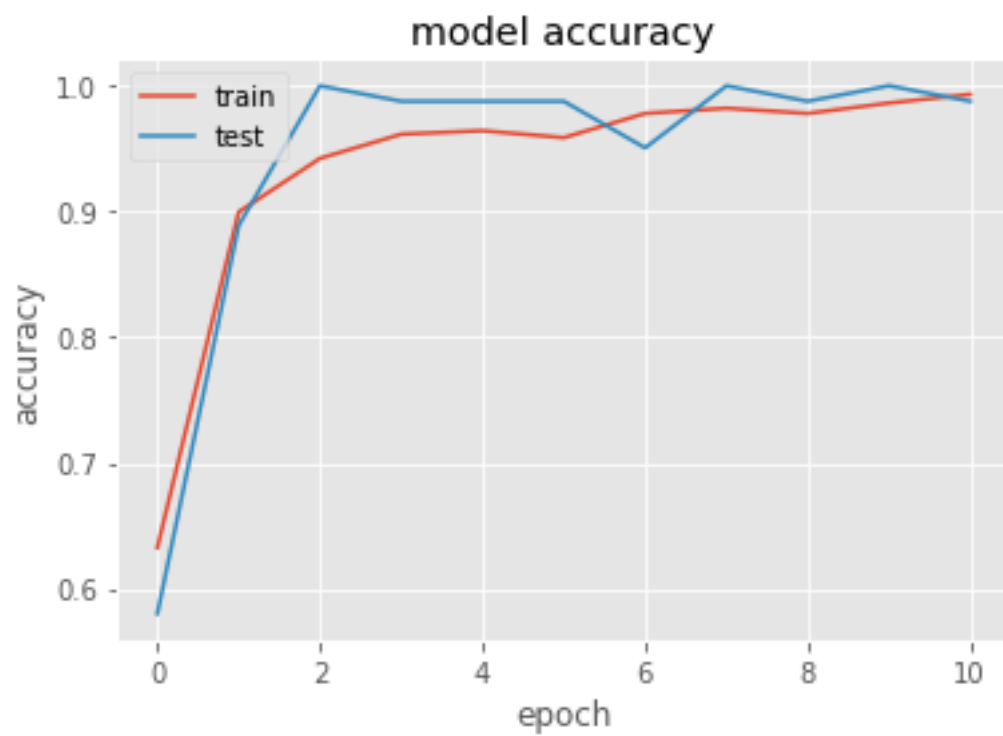
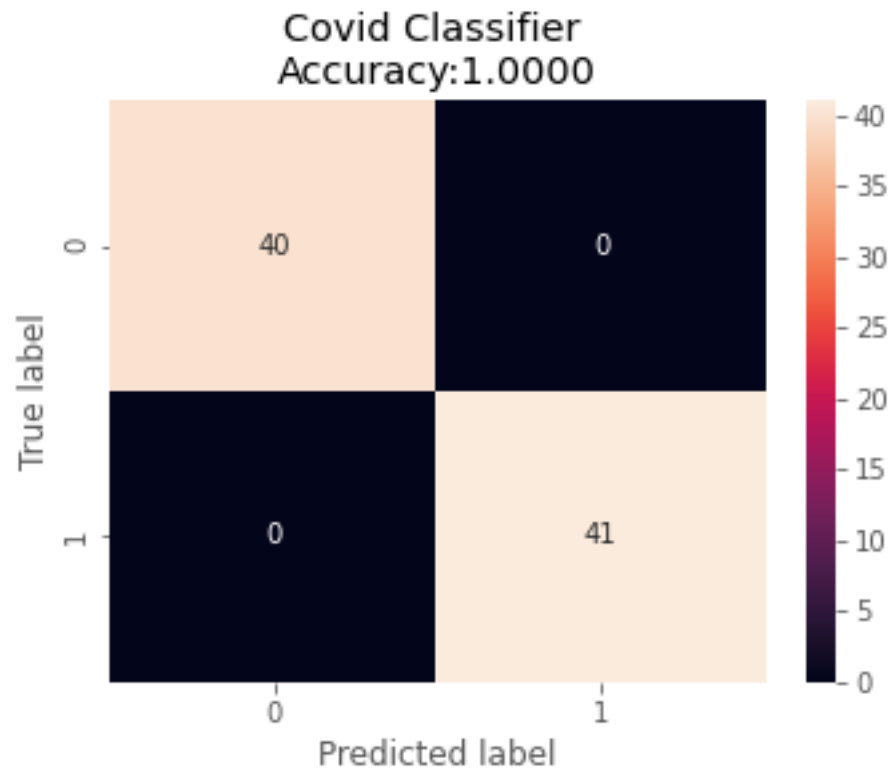


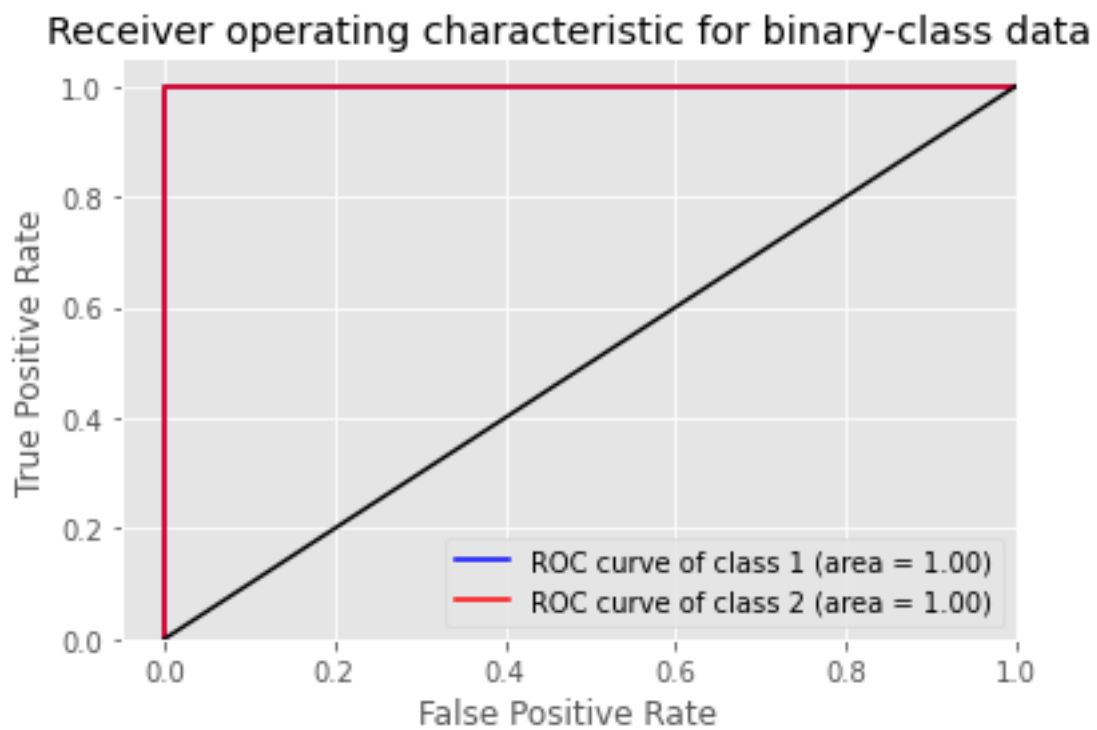
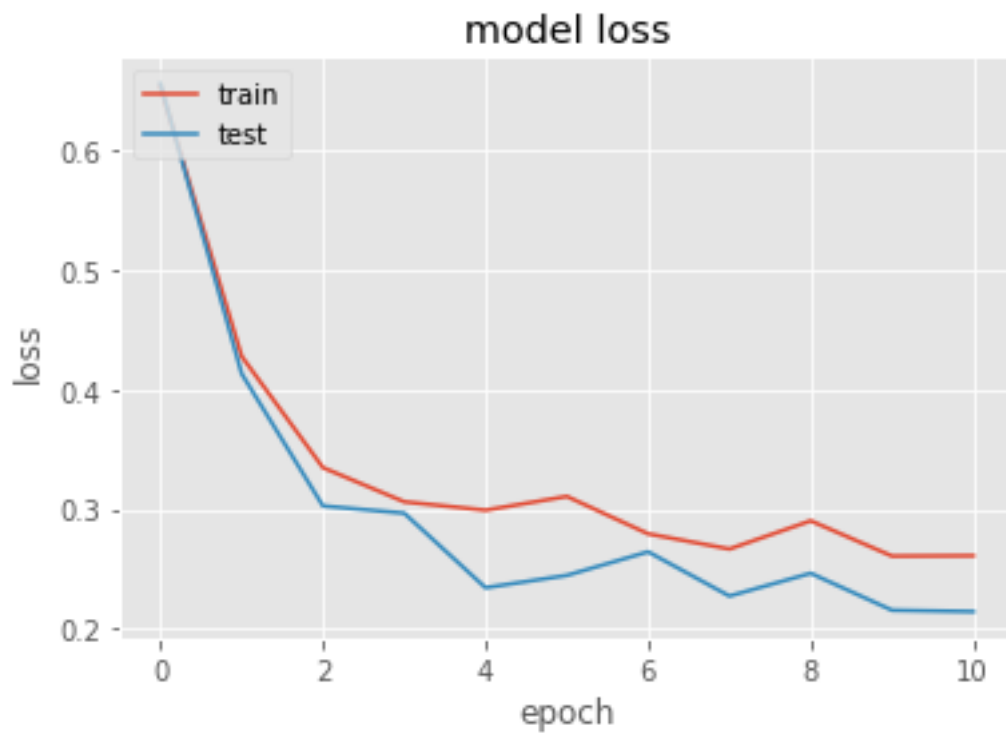


```

-----fold 4-----
Found 727 validated image filenames.
Found 81 validated image filenames.
Epoch 1/11
46/45 [=====] - 48s 1s/step - loss: 0.6530 - accuracy:
0.6327 - val_loss: 0.6554 - val_accuracy: 0.5802
Epoch 2/11
46/45 [=====] - 47s 1s/step - loss: 0.4276 - accuracy:
0.8996 - val_loss: 0.4131 - val_accuracy: 0.8889
Epoch 3/11
46/45 [=====] - 45s 987ms/step - loss: 0.3346 -
accuracy: 0.9422 - val_loss: 0.3025 - val_accuracy: 1.0000
Epoch 4/11
46/45 [=====] - 46s 995ms/step - loss: 0.3060 -
accuracy: 0.9615 - val_loss: 0.2965 - val_accuracy: 0.9877
Epoch 5/11
46/45 [=====] - 46s 991ms/step - loss: 0.2990 -
accuracy: 0.9642 - val_loss: 0.2342 - val_accuracy: 0.9877
Epoch 6/11
46/45 [=====] - 43s 942ms/step - loss: 0.3106 -
accuracy: 0.9587 - val_loss: 0.2445 - val_accuracy: 0.9877
Epoch 7/11
46/45 [=====] - 43s 933ms/step - loss: 0.2793 -
accuracy: 0.9780 - val_loss: 0.2643 - val_accuracy: 0.9506
Epoch 8/11
46/45 [=====] - 46s 996ms/step - loss: 0.2666 -
accuracy: 0.9821 - val_loss: 0.2273 - val_accuracy: 1.0000
Epoch 9/11
46/45 [=====] - 44s 958ms/step - loss: 0.2902 -
accuracy: 0.9780 - val_loss: 0.2463 - val_accuracy: 0.9877
Epoch 10/11
46/45 [=====] - 45s 975ms/step - loss: 0.2607 -
accuracy: 0.9862 - val_loss: 0.2154 - val_accuracy: 1.0000
Epoch 11/11
46/45 [=====] - 45s 976ms/step - loss: 0.2610 -
accuracy: 0.9931 - val_loss: 0.2143 - val_accuracy: 0.9877
INFO:tensorflow:Assets written to: final_model_4/assets
6/5 [=====] - 3s 523ms/step
f1 score is 1.0

```

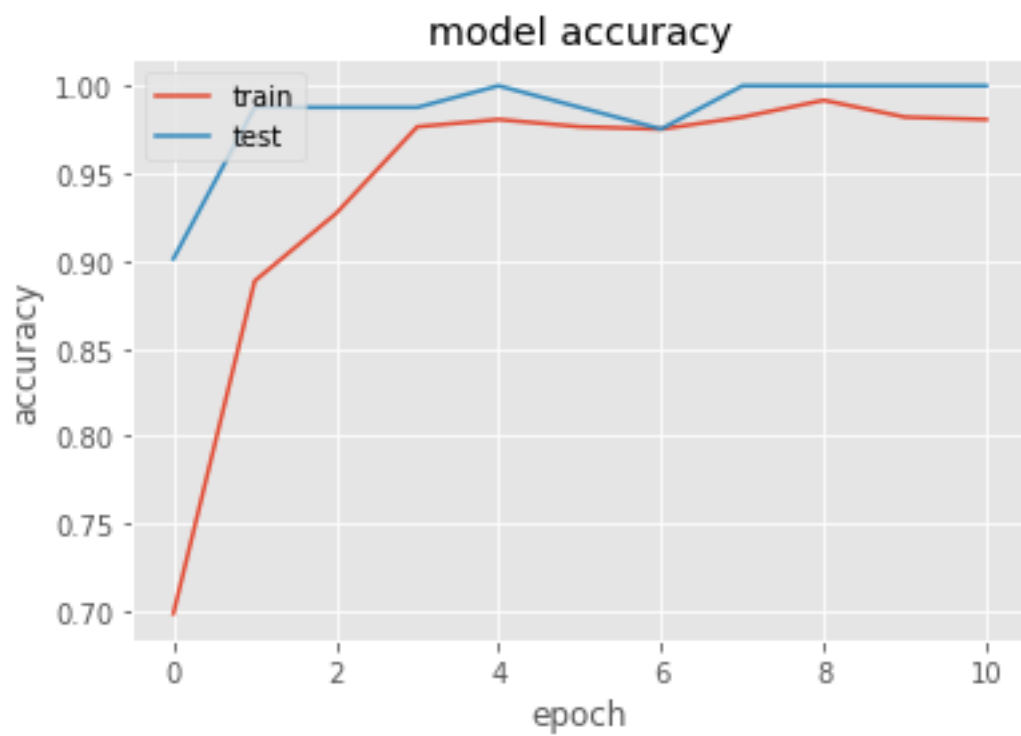
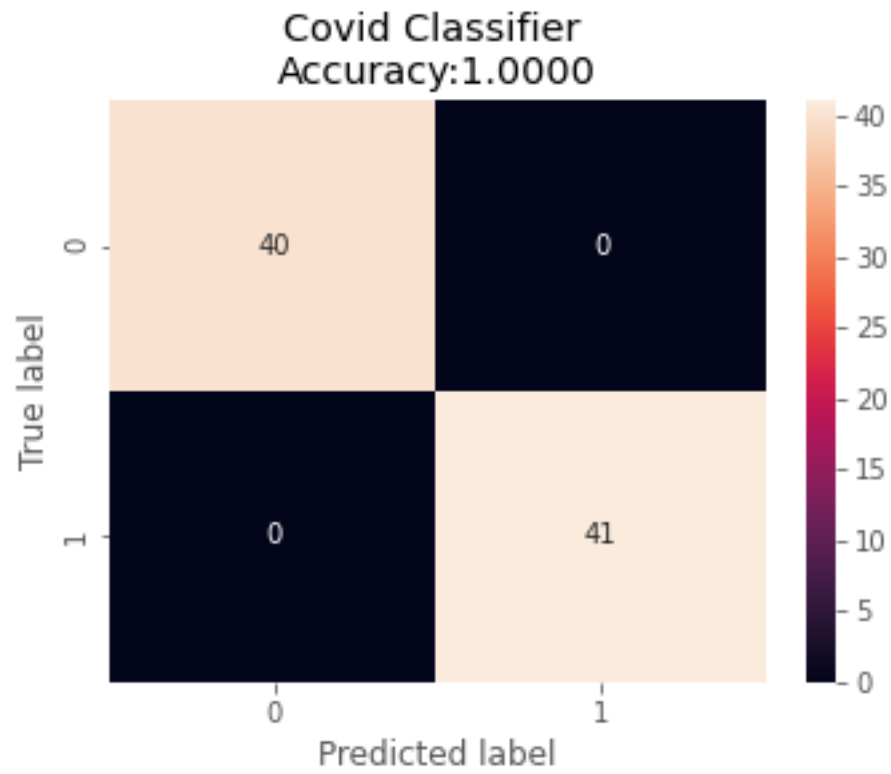


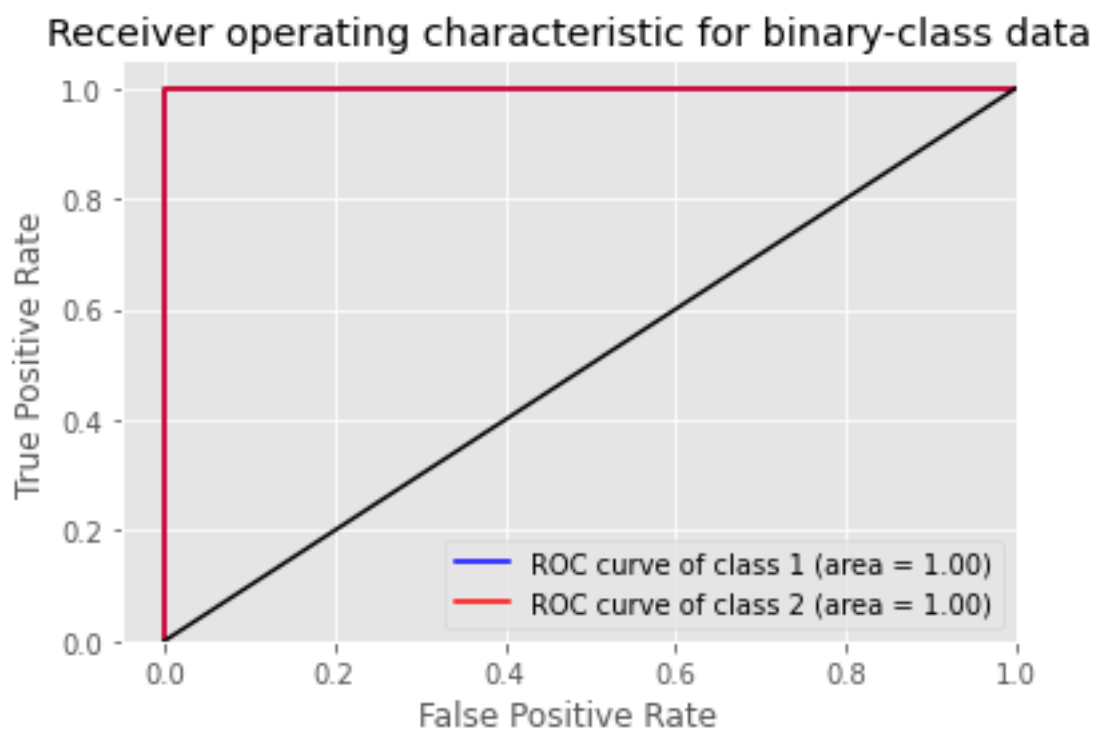
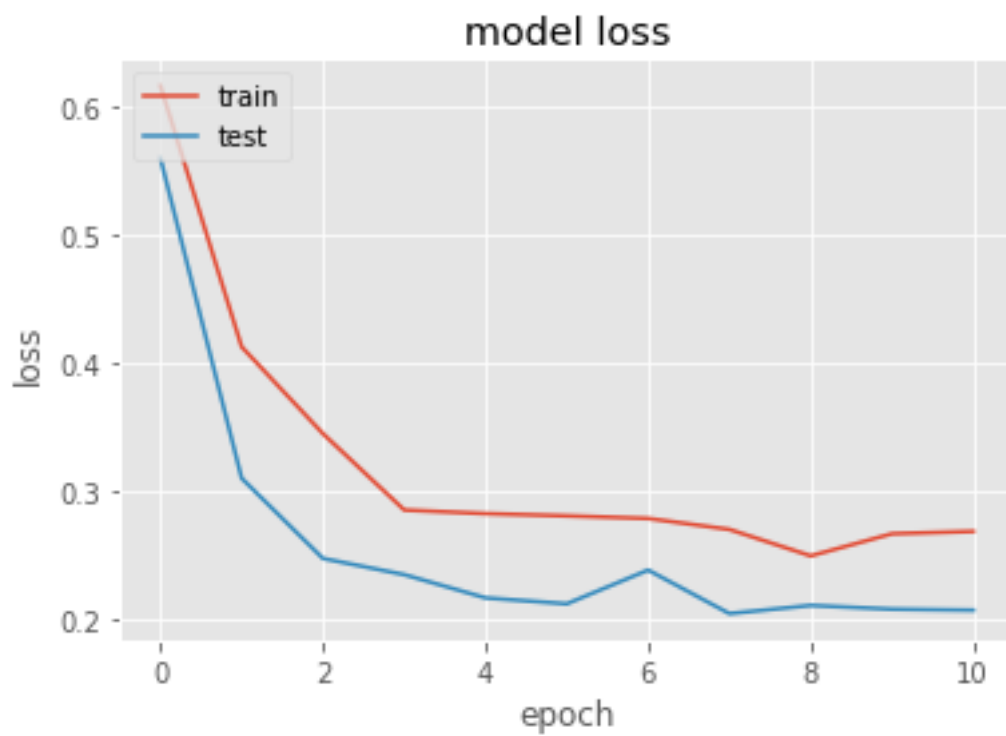


```

-----fold 5-----
Found 727 validated image filenames.
Found 81 validated image filenames.
Epoch 1/11
46/45 [=====] - 48s 1s/step - loss: 0.6171 - accuracy:
0.6988 - val_loss: 0.5607 - val_accuracy: 0.9012
Epoch 2/11
46/45 [=====] - 46s 990ms/step - loss: 0.4134 -
accuracy: 0.8886 - val_loss: 0.3109 - val_accuracy: 0.9877
Epoch 3/11
46/45 [=====] - 45s 973ms/step - loss: 0.3457 -
accuracy: 0.9271 - val_loss: 0.2483 - val_accuracy: 0.9877
Epoch 4/11
46/45 [=====] - 45s 985ms/step - loss: 0.2861 -
accuracy: 0.9766 - val_loss: 0.2357 - val_accuracy: 0.9877
Epoch 5/11
46/45 [=====] - 44s 966ms/step - loss: 0.2833 -
accuracy: 0.9807 - val_loss: 0.2176 - val_accuracy: 1.0000
Epoch 6/11
46/45 [=====] - 45s 980ms/step - loss: 0.2816 -
accuracy: 0.9766 - val_loss: 0.2129 - val_accuracy: 0.9877
Epoch 7/11
46/45 [=====] - 44s 962ms/step - loss: 0.2795 -
accuracy: 0.9752 - val_loss: 0.2393 - val_accuracy: 0.9753
Epoch 8/11
46/45 [=====] - 45s 969ms/step - loss: 0.2710 -
accuracy: 0.9821 - val_loss: 0.2053 - val_accuracy: 1.0000
Epoch 9/11
46/45 [=====] - 43s 945ms/step - loss: 0.2503 -
accuracy: 0.9917 - val_loss: 0.2117 - val_accuracy: 1.0000
Epoch 10/11
46/45 [=====] - 43s 932ms/step - loss: 0.2676 -
accuracy: 0.9821 - val_loss: 0.2088 - val_accuracy: 1.0000
Epoch 11/11
46/45 [=====] - 43s 931ms/step - loss: 0.2694 -
accuracy: 0.9807 - val_loss: 0.2080 - val_accuracy: 1.0000
INFO:tensorflow:Assets written to: final_model_5/assets
6/5 [=====] - 3s 541ms/step
f1 score is 1.0

```

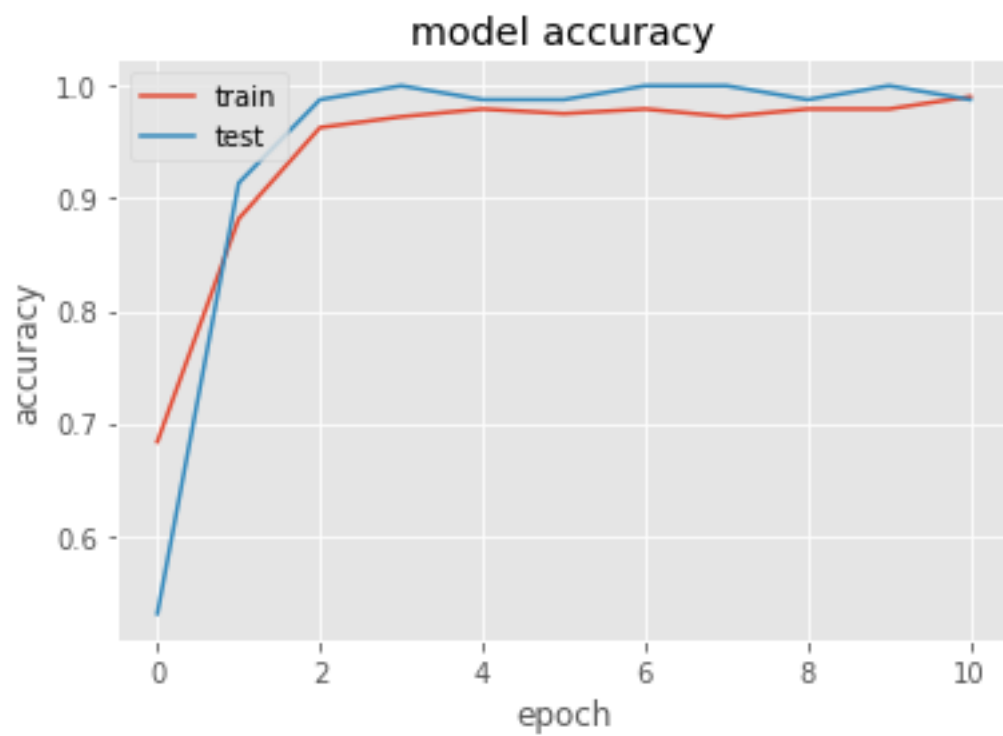
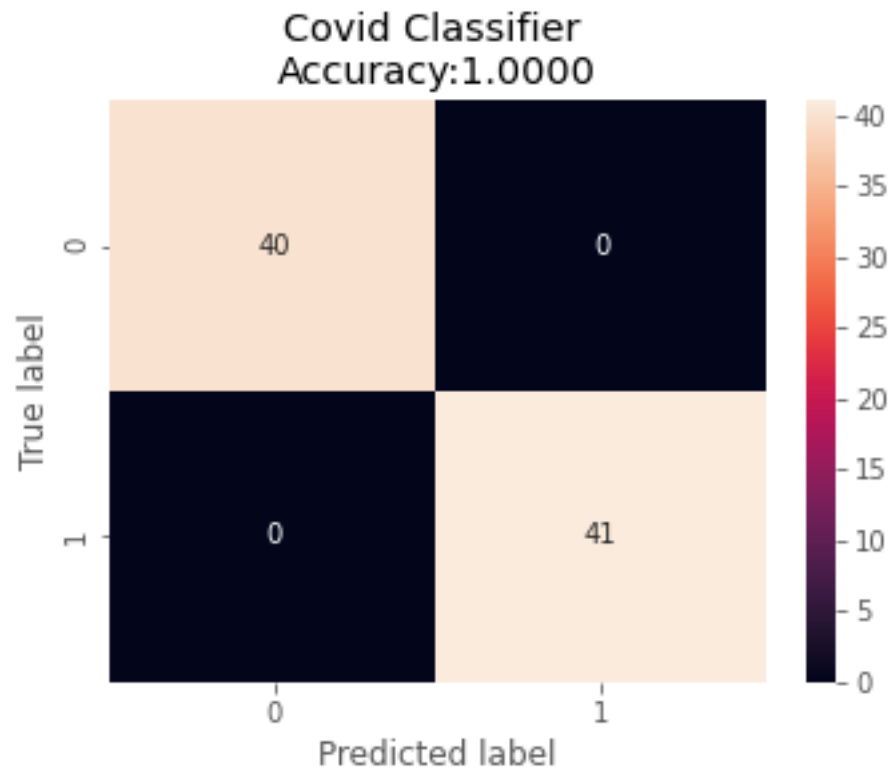


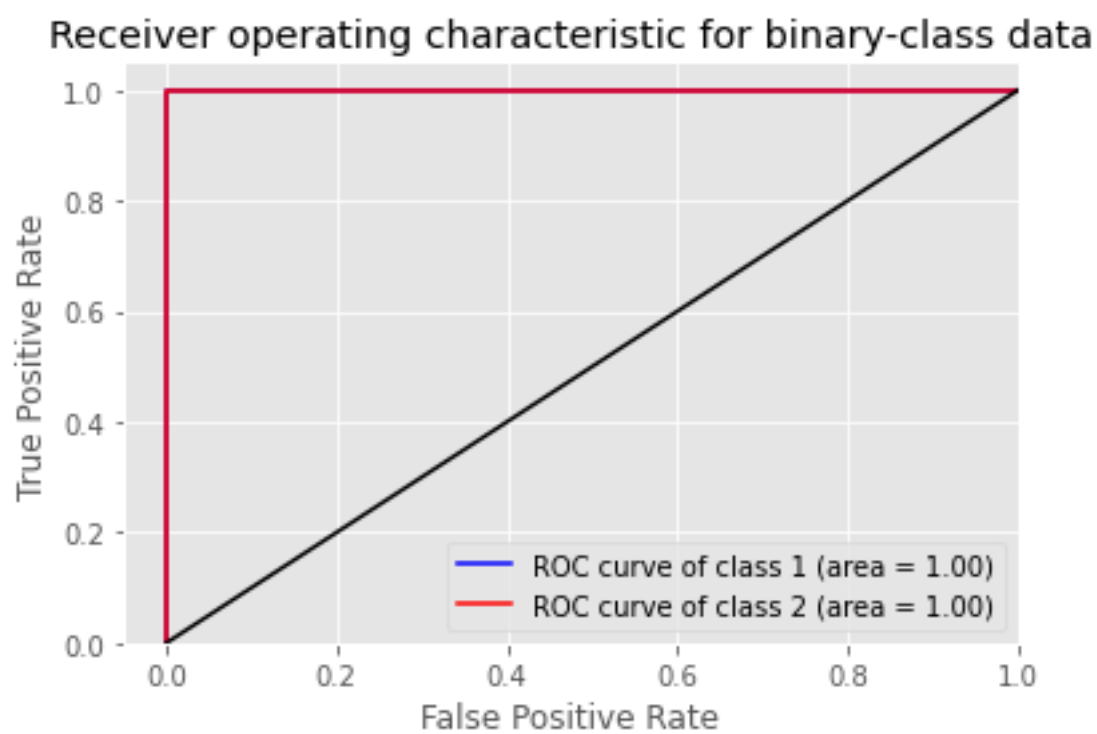
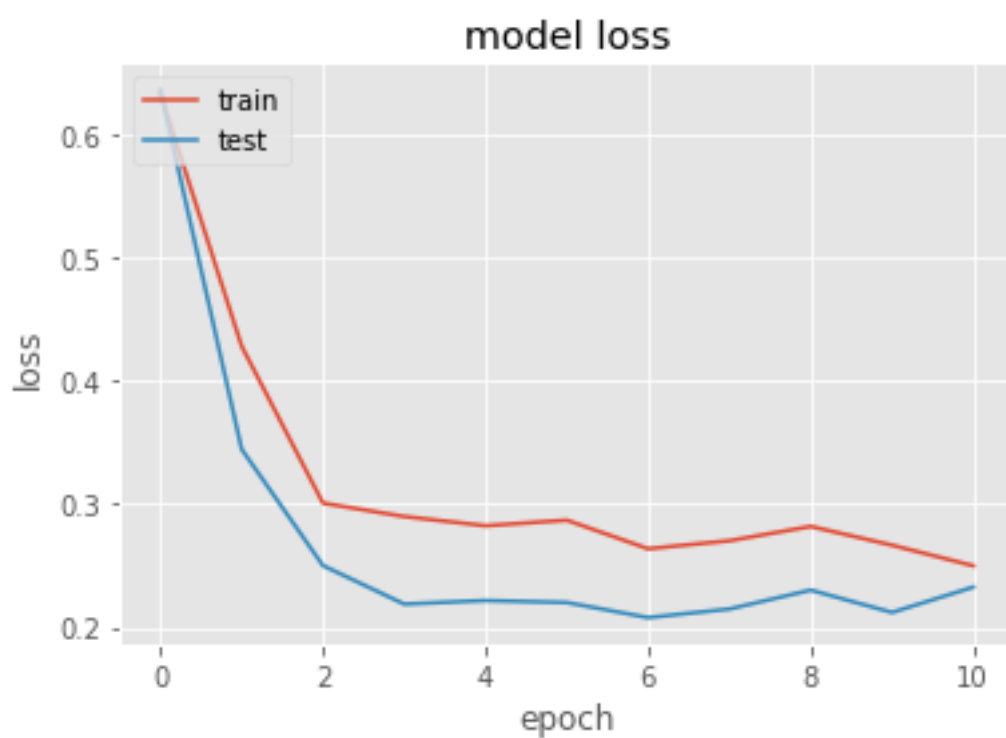


```

-----fold 6-----
Found 727 validated image filenames.
Found 81 validated image filenames.
Epoch 1/11
46/45 [=====] - 48s 1s/step - loss: 0.6330 - accuracy:
0.6836 - val_loss: 0.6363 - val_accuracy: 0.5309
Epoch 2/11
46/45 [=====] - 46s 1s/step - loss: 0.4282 - accuracy:
0.8817 - val_loss: 0.3445 - val_accuracy: 0.9136
Epoch 3/11
46/45 [=====] - 45s 978ms/step - loss: 0.3007 -
accuracy: 0.9629 - val_loss: 0.2500 - val_accuracy: 0.9877
Epoch 4/11
46/45 [=====] - 45s 979ms/step - loss: 0.2898 -
accuracy: 0.9725 - val_loss: 0.2187 - val_accuracy: 1.0000
Epoch 5/11
46/45 [=====] - 43s 936ms/step - loss: 0.2823 -
accuracy: 0.9794 - val_loss: 0.2216 - val_accuracy: 0.9877
Epoch 6/11
46/45 [=====] - 43s 927ms/step - loss: 0.2869 -
accuracy: 0.9752 - val_loss: 0.2200 - val_accuracy: 0.9877
Epoch 7/11
46/45 [=====] - 45s 978ms/step - loss: 0.2636 -
accuracy: 0.9794 - val_loss: 0.2078 - val_accuracy: 1.0000
Epoch 8/11
46/45 [=====] - 44s 958ms/step - loss: 0.2702 -
accuracy: 0.9725 - val_loss: 0.2147 - val_accuracy: 1.0000
Epoch 9/11
46/45 [=====] - 45s 972ms/step - loss: 0.2818 -
accuracy: 0.9794 - val_loss: 0.2301 - val_accuracy: 0.9877
Epoch 10/11
46/45 [=====] - 44s 959ms/step - loss: 0.2666 -
accuracy: 0.9794 - val_loss: 0.2120 - val_accuracy: 1.0000
Epoch 11/11
46/45 [=====] - 42s 917ms/step - loss: 0.2499 -
accuracy: 0.9904 - val_loss: 0.2325 - val_accuracy: 0.9877
INFO:tensorflow:Assets written to: final_model_6/assets
6/5 [=====] - 3s 532ms/step
f1 score is 1.0

```

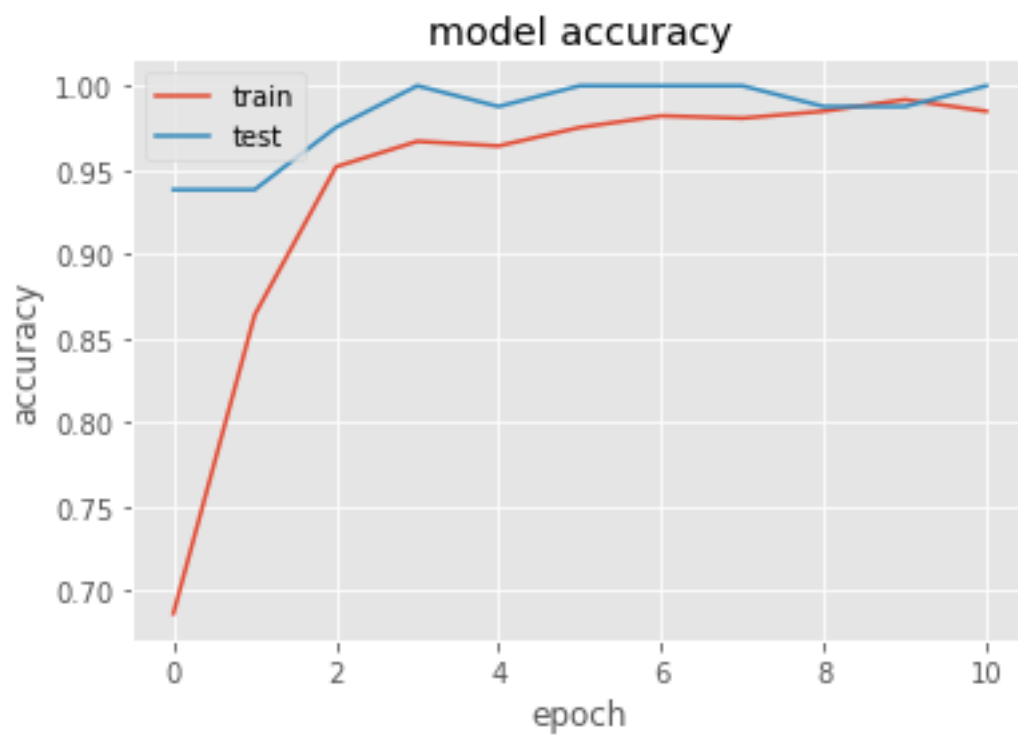
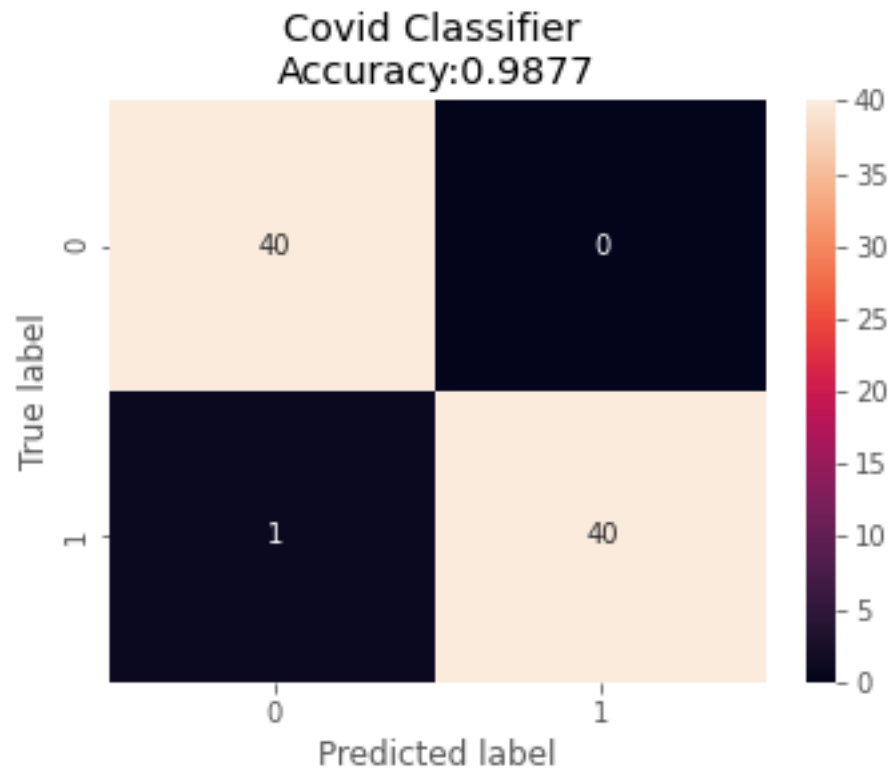


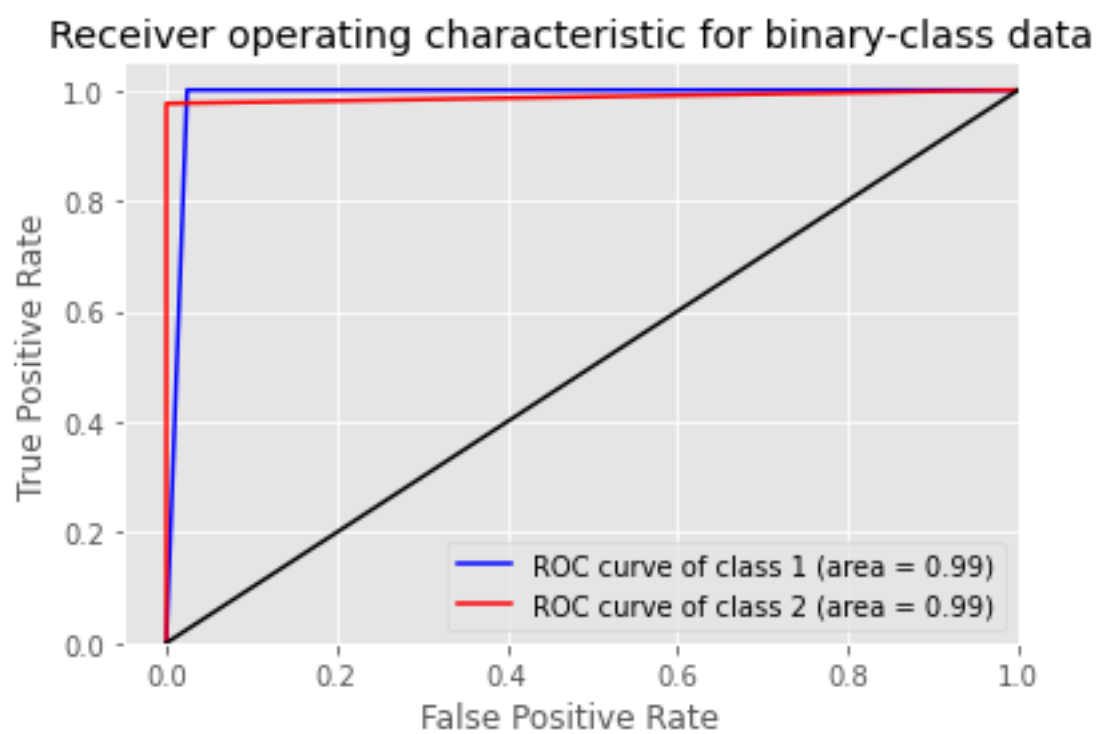
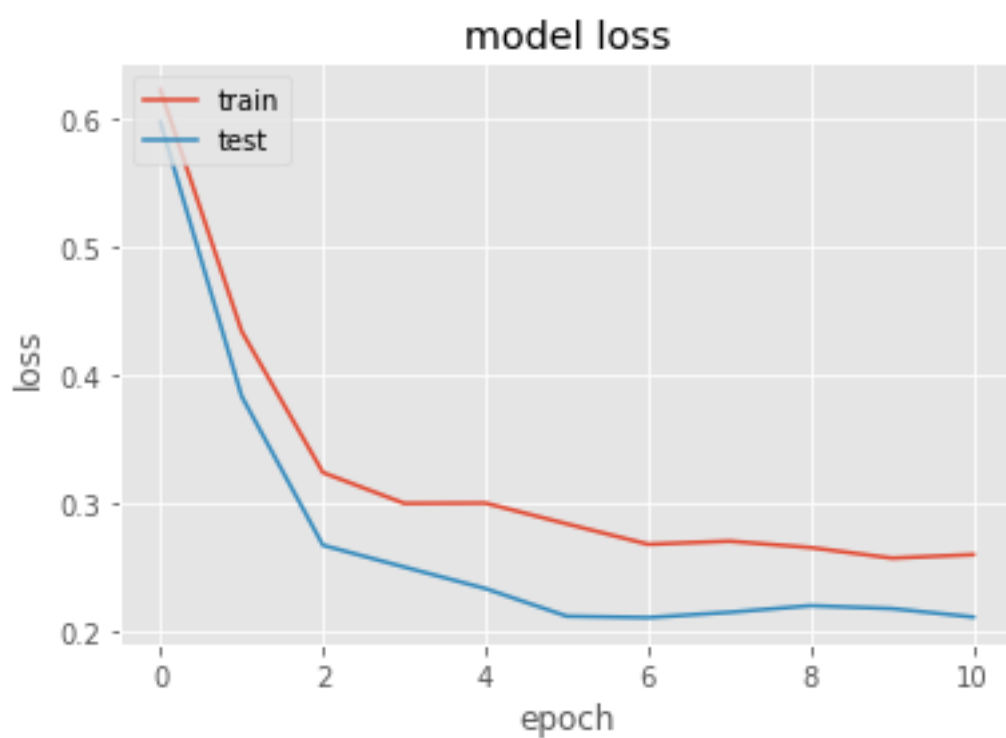


```

-----fold 7-----
Found 727 validated image filenames.
Found 81 validated image filenames.
Epoch 1/11
46/45 [=====] - 47s 1s/step - loss: 0.6232 - accuracy:
0.6864 - val_loss: 0.5979 - val_accuracy: 0.9383
Epoch 2/11
46/45 [=====] - 46s 999ms/step - loss: 0.4347 -
accuracy: 0.8638 - val_loss: 0.3840 - val_accuracy: 0.9383
Epoch 3/11
46/45 [=====] - 46s 994ms/step - loss: 0.3245 -
accuracy: 0.9519 - val_loss: 0.2677 - val_accuracy: 0.9753
Epoch 4/11
46/45 [=====] - 46s 1s/step - loss: 0.3004 - accuracy:
0.9670 - val_loss: 0.2507 - val_accuracy: 1.0000
Epoch 5/11
46/45 [=====] - 45s 978ms/step - loss: 0.3006 -
accuracy: 0.9642 - val_loss: 0.2339 - val_accuracy: 0.9877
Epoch 6/11
46/45 [=====] - 44s 964ms/step - loss: 0.2844 -
accuracy: 0.9752 - val_loss: 0.2123 - val_accuracy: 1.0000
Epoch 7/11
46/45 [=====] - 46s 1s/step - loss: 0.2685 - accuracy:
0.9821 - val_loss: 0.2113 - val_accuracy: 1.0000
Epoch 8/11
46/45 [=====] - 43s 945ms/step - loss: 0.2709 -
accuracy: 0.9807 - val_loss: 0.2154 - val_accuracy: 1.0000
Epoch 9/11
46/45 [=====] - 45s 973ms/step - loss: 0.2659 -
accuracy: 0.9849 - val_loss: 0.2206 - val_accuracy: 0.9877
Epoch 10/11
46/45 [=====] - 43s 931ms/step - loss: 0.2577 -
accuracy: 0.9917 - val_loss: 0.2183 - val_accuracy: 0.9877
Epoch 11/11
46/45 [=====] - 44s 967ms/step - loss: 0.2604 -
accuracy: 0.9849 - val_loss: 0.2117 - val_accuracy: 1.0000
INFO:tensorflow:Assets written to: final_model_7/assets
6/5 [=====] - 3s 503ms/step
f1 score is 0.9876543209876543

```

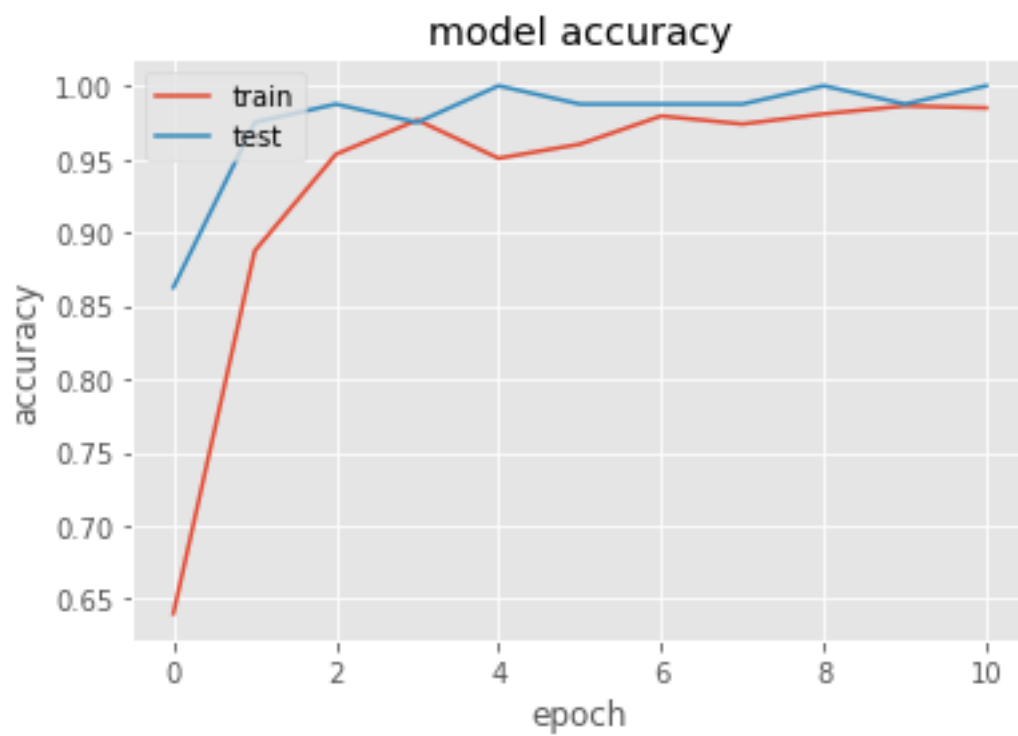
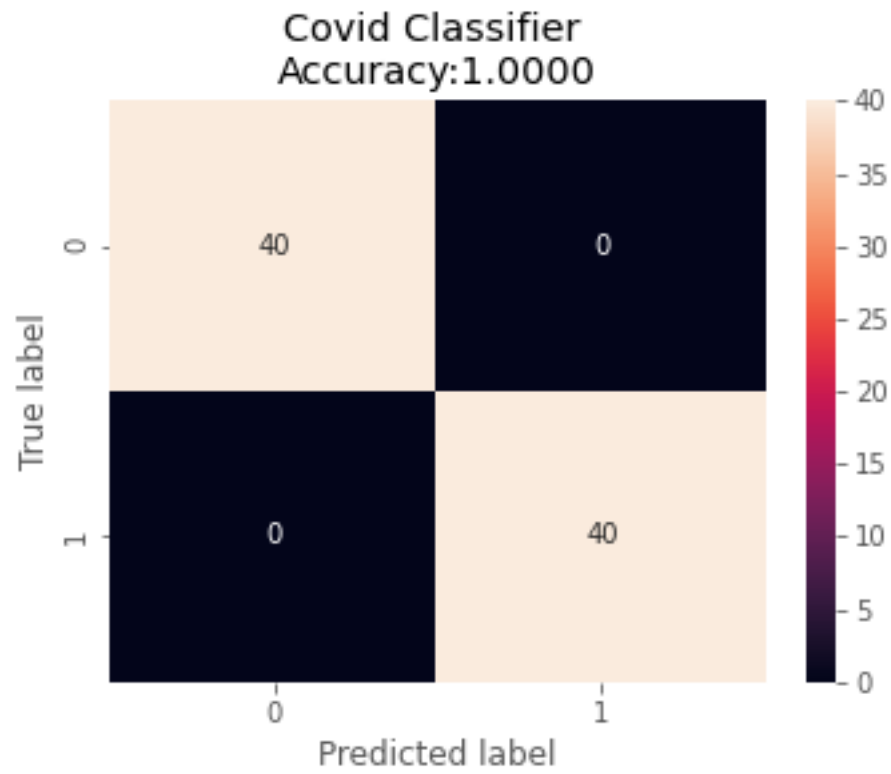



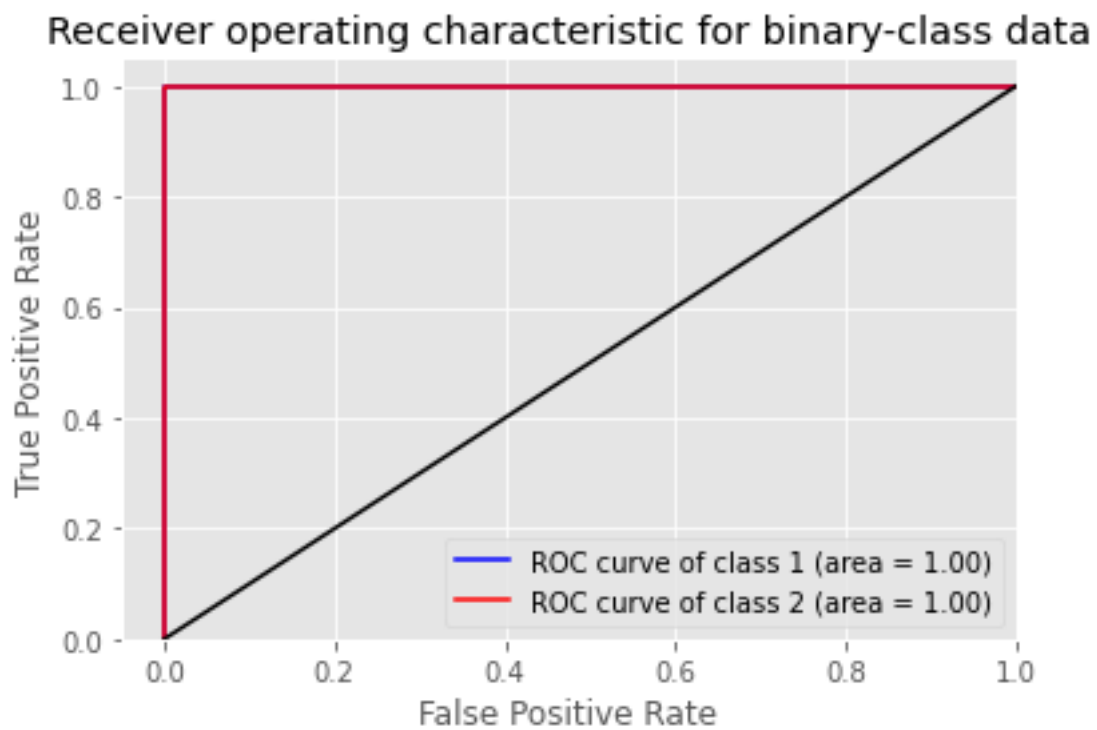
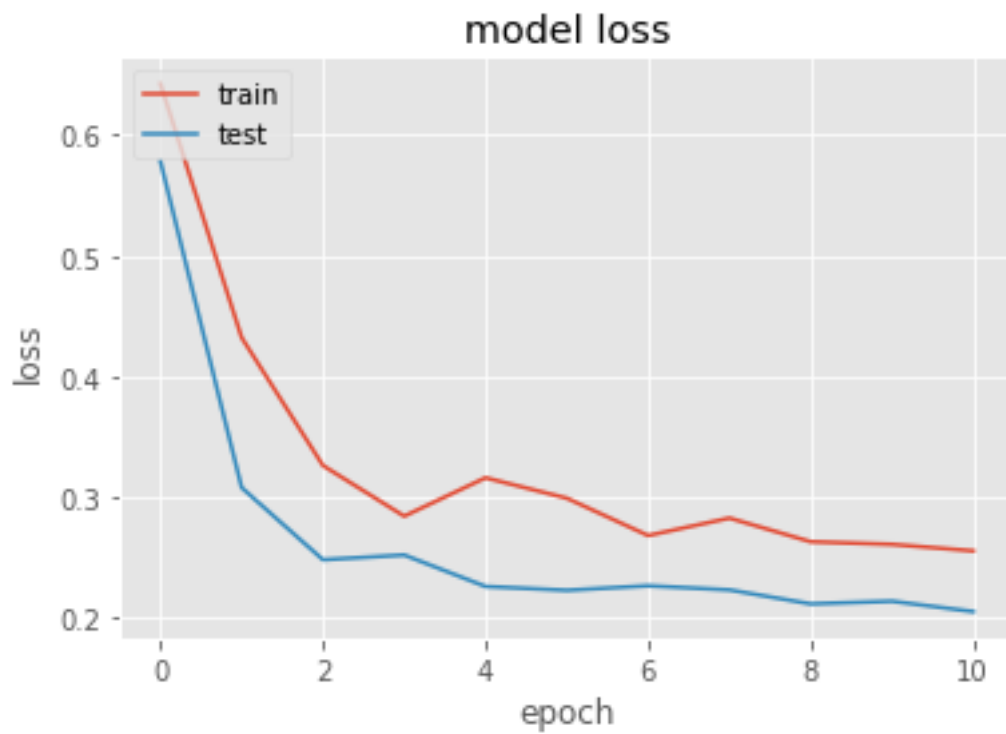


```

-----fold 8-----
Found 728 validated image filenames.
Found 80 validated image filenames.
Epoch 1/11
46/45 [=====] - 47s 1s/step - loss: 0.6424 - accuracy:
0.6401 - val_loss: 0.5784 - val_accuracy: 0.8625
Epoch 2/11
46/45 [=====] - 44s 958ms/step - loss: 0.4322 -
accuracy: 0.8874 - val_loss: 0.3080 - val_accuracy: 0.9750
Epoch 3/11
46/45 [=====] - 45s 982ms/step - loss: 0.3263 -
accuracy: 0.9533 - val_loss: 0.2483 - val_accuracy: 0.9875
Epoch 4/11
46/45 [=====] - 43s 940ms/step - loss: 0.2844 -
accuracy: 0.9766 - val_loss: 0.2523 - val_accuracy: 0.9750
Epoch 5/11
46/45 [=====] - 44s 951ms/step - loss: 0.3162 -
accuracy: 0.9505 - val_loss: 0.2262 - val_accuracy: 1.0000
Epoch 6/11
46/45 [=====] - 45s 973ms/step - loss: 0.2993 -
accuracy: 0.9602 - val_loss: 0.2231 - val_accuracy: 0.9875
Epoch 7/11
46/45 [=====] - 42s 908ms/step - loss: 0.2684 -
accuracy: 0.9794 - val_loss: 0.2268 - val_accuracy: 0.9875
Epoch 8/11
46/45 [=====] - 43s 930ms/step - loss: 0.2828 -
accuracy: 0.9739 - val_loss: 0.2234 - val_accuracy: 0.9875
Epoch 9/11
46/45 [=====] - 43s 941ms/step - loss: 0.2633 -
accuracy: 0.9808 - val_loss: 0.2118 - val_accuracy: 1.0000
Epoch 10/11
46/45 [=====] - 44s 946ms/step - loss: 0.2611 -
accuracy: 0.9863 - val_loss: 0.2140 - val_accuracy: 0.9875
Epoch 11/11
46/45 [=====] - 46s 992ms/step - loss: 0.2557 -
accuracy: 0.9849 - val_loss: 0.2054 - val_accuracy: 1.0000
INFO:tensorflow:Assets written to: final_model_8/assets
5/5 [=====] - 3s 571ms/step
f1 score is 1.0

```

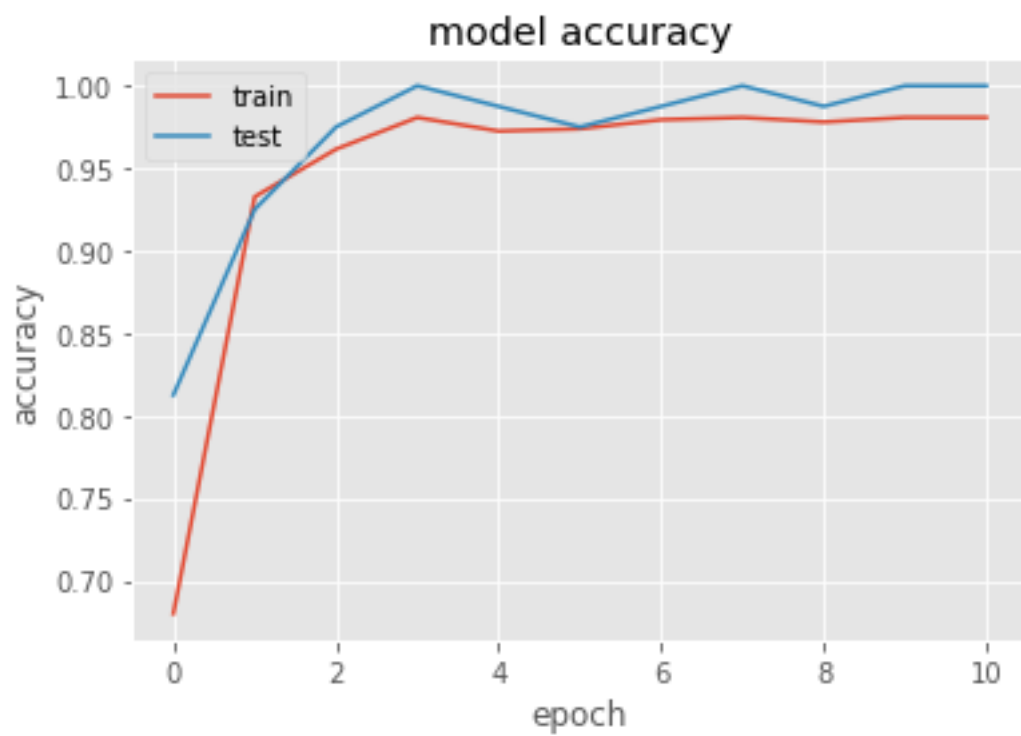
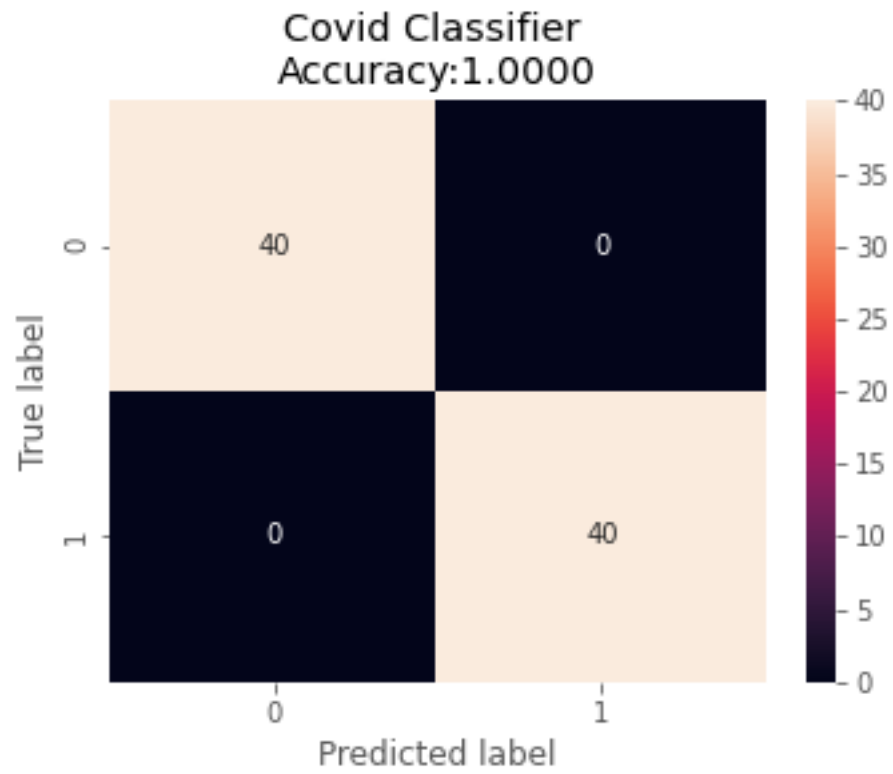


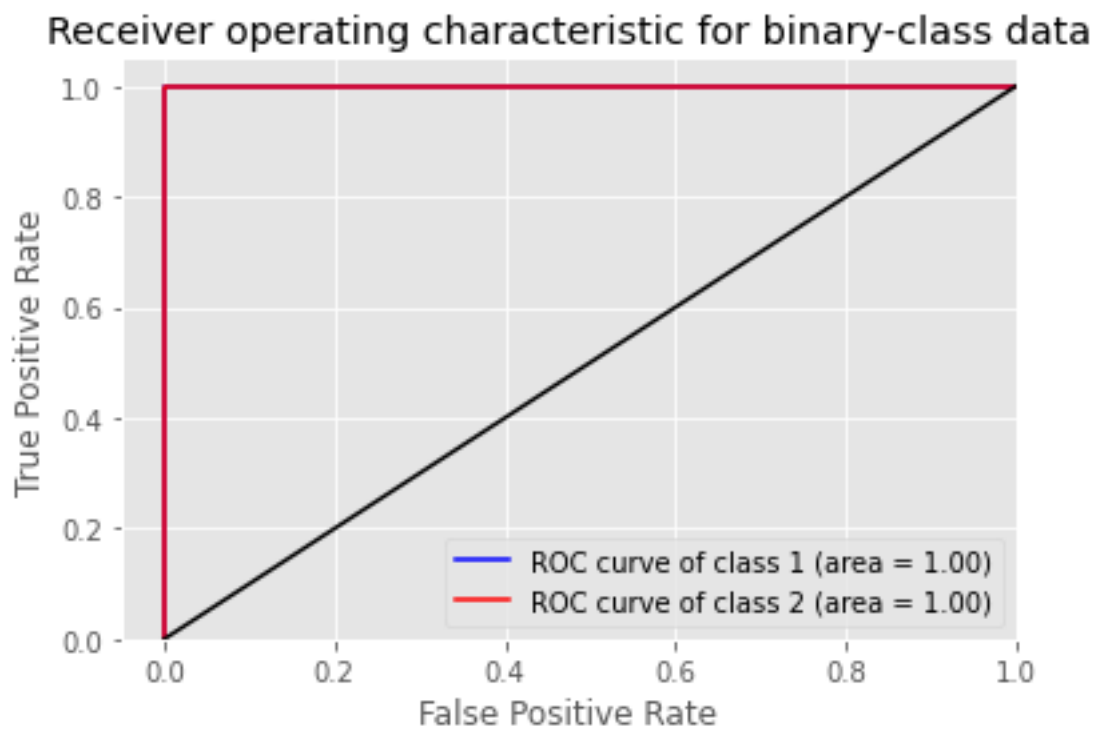
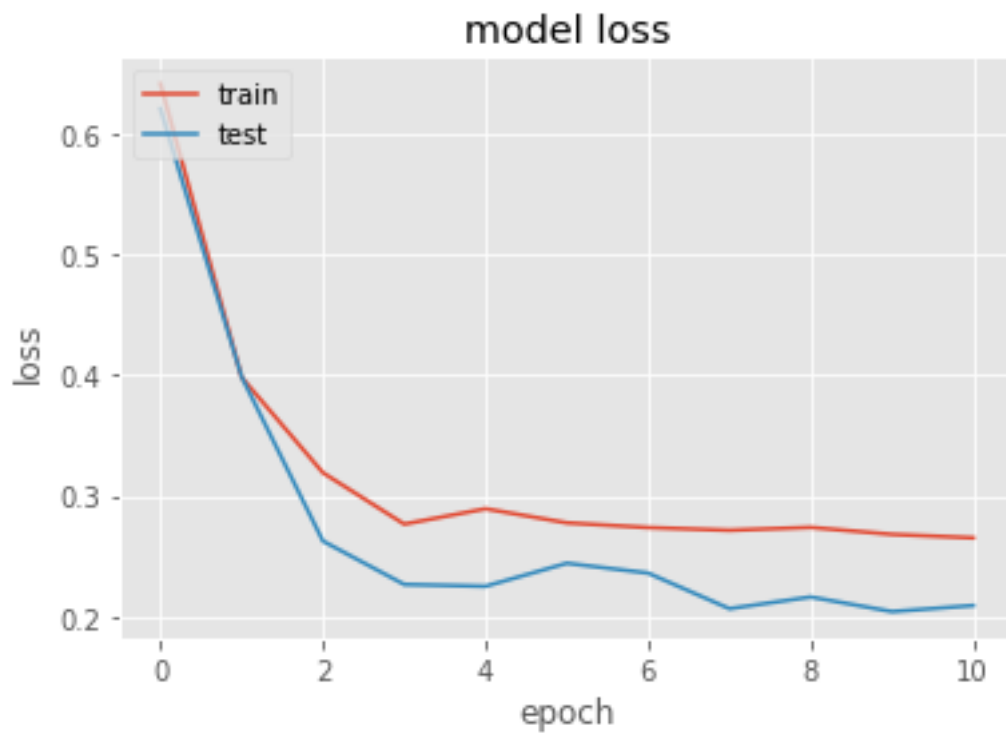


```

-----fold 9-----
Found 728 validated image filenames.
Found 80 validated image filenames.
Epoch 1/11
46/45 [=====] - 46s 996ms/step - loss: 0.6411 -
accuracy: 0.6799 - val_loss: 0.6204 - val_accuracy: 0.8125
Epoch 2/11
46/45 [=====] - 44s 963ms/step - loss: 0.3981 -
accuracy: 0.9327 - val_loss: 0.3986 - val_accuracy: 0.9250
Epoch 3/11
46/45 [=====] - 45s 971ms/step - loss: 0.3192 -
accuracy: 0.9615 - val_loss: 0.2626 - val_accuracy: 0.9750
Epoch 4/11
46/45 [=====] - 46s 989ms/step - loss: 0.2766 -
accuracy: 0.9808 - val_loss: 0.2267 - val_accuracy: 1.0000
Epoch 5/11
46/45 [=====] - 45s 986ms/step - loss: 0.2894 -
accuracy: 0.9725 - val_loss: 0.2252 - val_accuracy: 0.9875
Epoch 6/11
46/45 [=====] - 44s 961ms/step - loss: 0.2777 -
accuracy: 0.9739 - val_loss: 0.2443 - val_accuracy: 0.9750
Epoch 7/11
46/45 [=====] - 43s 945ms/step - loss: 0.2738 -
accuracy: 0.9794 - val_loss: 0.2362 - val_accuracy: 0.9875
Epoch 8/11
46/45 [=====] - 44s 953ms/step - loss: 0.2716 -
accuracy: 0.9808 - val_loss: 0.2067 - val_accuracy: 1.0000
Epoch 9/11
46/45 [=====] - 44s 951ms/step - loss: 0.2739 -
accuracy: 0.9780 - val_loss: 0.2164 - val_accuracy: 0.9875
Epoch 10/11
46/45 [=====] - 47s 1s/step - loss: 0.2682 - accuracy:
0.9808 - val_loss: 0.2043 - val_accuracy: 1.0000
Epoch 11/11
46/45 [=====] - 45s 975ms/step - loss: 0.2653 -
accuracy: 0.9808 - val_loss: 0.2093 - val_accuracy: 1.0000
INFO:tensorflow:Assets written to: final_model_9/assets
5/5 [=====] - 3s 617ms/step
f1 score is 1.0

```






```
[42]: accuracy
```

```
[42]: [1.0,
      0.9876543209876543,
      0.9876543209876543,
      1.0,
      1.0,
      1.0,
      1.0,
      0.9876543209876543,
      1.0,
      1.0,
      0.9948979591836735]
```

```
[43]: print(np.mean(accuracy))
```

```
0.9961691747406032
```

```
[44]: f1_scores
```

```
[44]: [1.0,
      0.9876467896904071,
      0.9876543209876543,
      1.0,
      1.0,
      1.0,
      1.0,
      0.9876543209876543,
      1.0,
      1.0]
```

```
[46]: np.mean(f1_scores)
```

```
[46]: 0.9962955431665715
```

```
[47]: for i in range(10):
      print('-----FOLD {}-----'.format(i))
      print(classification_reports[i])
```

```
-----FOLD 0-----
              precision    recall  f1-score   support

   covid      1.000000      1.000000      1.000000         41
   normal      1.000000      1.000000      1.000000         40

 micro avg      1.000000      1.000000      1.000000         81
```

macro avg	1.000000	1.000000	1.000000	81
weighted avg	1.000000	1.000000	1.000000	81
samples avg	1.000000	1.000000	1.000000	81

-----FOLD 1-----

	precision	recall	f1-score	support
covid	0.976190	1.000000	0.987952	41
normal	1.000000	0.975000	0.987342	40
micro avg	0.987654	0.987654	0.987654	81
macro avg	0.988095	0.987500	0.987647	81
weighted avg	0.987948	0.987654	0.987651	81
samples avg	0.987654	0.987654	0.987654	81

-----FOLD 2-----

	precision	recall	f1-score	support
covid	1.000000	0.975610	0.987654	41
normal	0.975610	1.000000	0.987654	40
micro avg	0.987654	0.987654	0.987654	81
macro avg	0.987805	0.987805	0.987654	81
weighted avg	0.987955	0.987654	0.987654	81
samples avg	0.987654	0.987654	0.987654	81

-----FOLD 3-----

	precision	recall	f1-score	support
covid	1.000000	1.000000	1.000000	41
normal	1.000000	1.000000	1.000000	40
micro avg	1.000000	1.000000	1.000000	81
macro avg	1.000000	1.000000	1.000000	81
weighted avg	1.000000	1.000000	1.000000	81
samples avg	1.000000	1.000000	1.000000	81

-----FOLD 4-----

	precision	recall	f1-score	support
covid	1.000000	1.000000	1.000000	40
normal	1.000000	1.000000	1.000000	41
micro avg	1.000000	1.000000	1.000000	81
macro avg	1.000000	1.000000	1.000000	81
weighted avg	1.000000	1.000000	1.000000	81
samples avg	1.000000	1.000000	1.000000	81

```

-----FOLD 5-----
      precision    recall  f1-score   support

    covid      1.000000      1.000000      1.000000         40
    normal      1.000000      1.000000      1.000000         41

   micro avg      1.000000      1.000000      1.000000         81
   macro avg      1.000000      1.000000      1.000000         81
weighted avg      1.000000      1.000000      1.000000         81
   samples avg      1.000000      1.000000      1.000000         81

-----FOLD 6-----
      precision    recall  f1-score   support

    covid      1.000000      1.000000      1.000000         40
    normal      1.000000      1.000000      1.000000         41

   micro avg      1.000000      1.000000      1.000000         81
   macro avg      1.000000      1.000000      1.000000         81
weighted avg      1.000000      1.000000      1.000000         81
   samples avg      1.000000      1.000000      1.000000         81

-----FOLD 7-----
      precision    recall  f1-score   support

    covid      0.975610      1.000000      0.987654         40
    normal      1.000000      0.975610      0.987654         41

   micro avg      0.987654      0.987654      0.987654         81
   macro avg      0.987805      0.987805      0.987654         81
weighted avg      0.987955      0.987654      0.987654         81
   samples avg      0.987654      0.987654      0.987654         81

-----FOLD 8-----
      precision    recall  f1-score   support

    covid      1.000000      1.000000      1.000000         40
    normal      1.000000      1.000000      1.000000         40

   micro avg      1.000000      1.000000      1.000000         80
   macro avg      1.000000      1.000000      1.000000         80
weighted avg      1.000000      1.000000      1.000000         80
   samples avg      1.000000      1.000000      1.000000         80

-----FOLD 9-----
      precision    recall  f1-score   support

    covid      1.000000      1.000000      1.000000         40

```

normal	1.000000	1.000000	1.000000	40
micro avg	1.000000	1.000000	1.000000	80
macro avg	1.000000	1.000000	1.000000	80
weighted avg	1.000000	1.000000	1.000000	80
samples avg	1.000000	1.000000	1.000000	80

```
[52]: val=df1.iloc[:,:]
      va_generator=data_gen.flow_from_dataframe(val,directory='data1',
      ↪target_size=(img_shape,img_shape),
      ↪x_col="file",
      ↪y_col=['covid','normal'],
      ↪class_mode='raw',
      ↪shuffle=False,
      ↪batch_size=batch_size)
```

Found 196 validated image filenames.

```
[51]: import tensorflow as tf
      model=tf.keras.models.load_model("final_model_9",compile=False)
```

```
[53]: y_pred=model.predict(va_generator,steps=va_generator.n/batch_size,verbose=1)
y_pred=y_pred.round().astype(int)
y_true=val.iloc[:,2:]
print(classification_report(y_true,
↪y_pred,target_names=['covid','normal'],digits=6))
accuracy.append(accuracy_score(y_true,y_pred))
f1=f1_score(y_true,y_pred,average='macro')
print('f1 score is ', f1)
cm=confusion_matrix(y_true.values.argmax(axis=1), y_pred.argmax(axis=1))
plt.figure(figsize=(5.5,4))
sns.heatmap(cm, annot=True)
plt.title('Covid Classifier \nAccuracy:{0:.4f}'.format(accuracy_score(y_true,
↪y_pred)))
plt.ylabel('True label')
plt.xlabel('Predicted label')
plt.show()

from itertools import cycle
plt.style.use('ggplot')
fpr = dict()
tpr = dict()
roc_auc = dict()
```

```

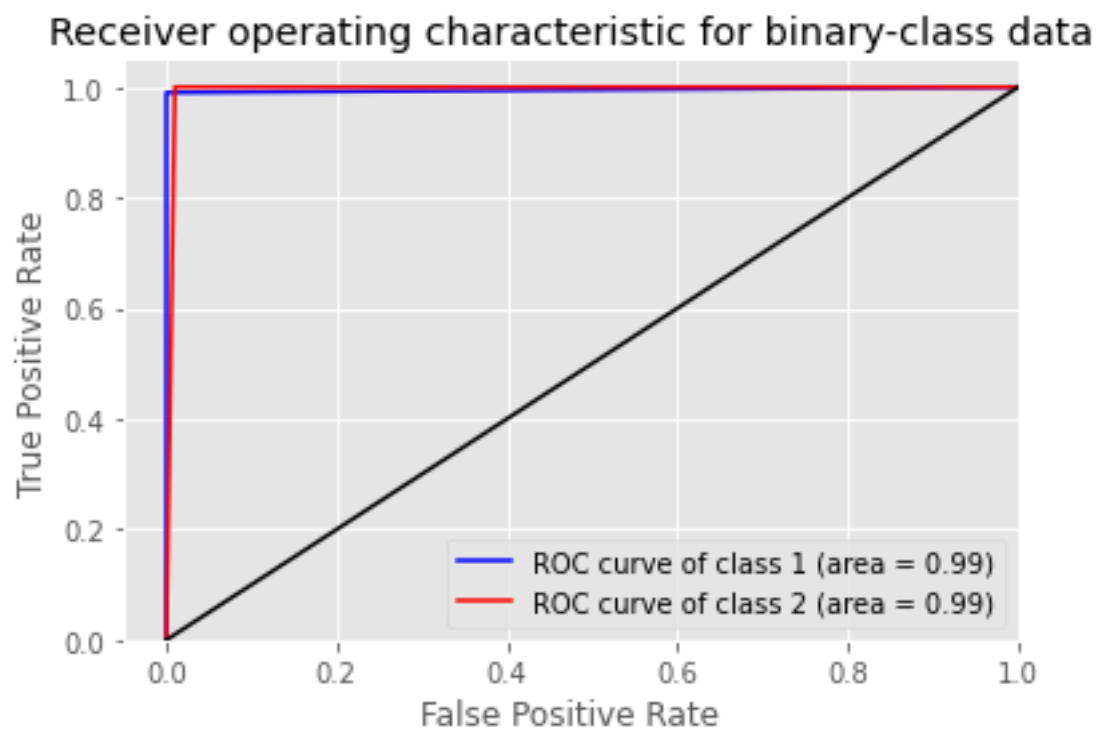
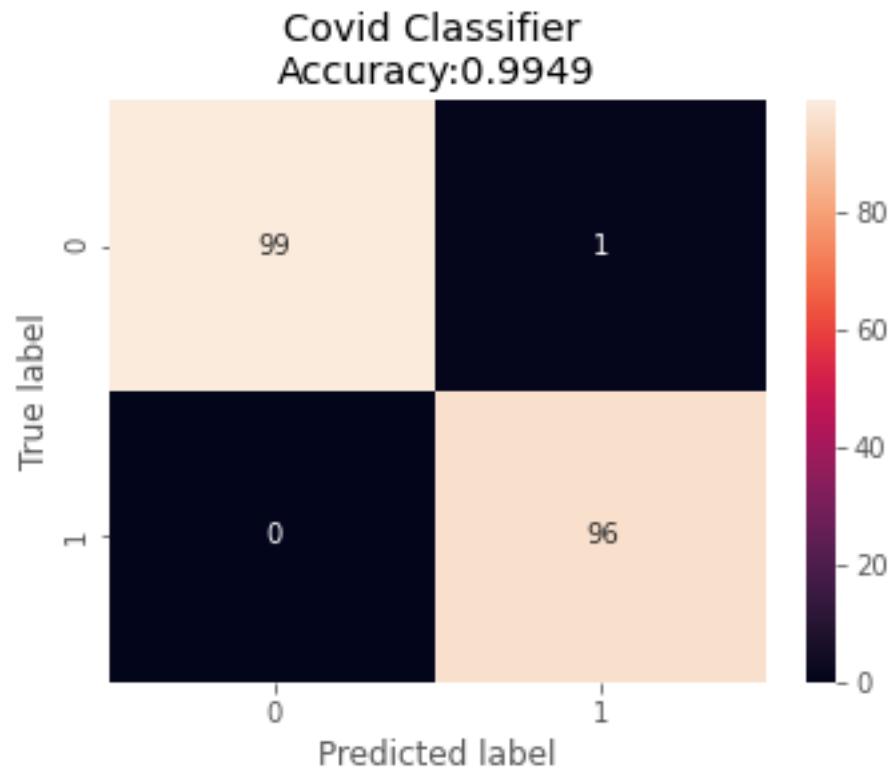
n_classes=2
for i in range(n_classes):
    fpr[i], tpr[i], _ = roc_curve(y_true.values[:, i], y_pred[:, i])
    roc_auc[i] = auc(fpr[i], tpr[i])
    colors = cycle(['blue', 'red'])
    for i, color in zip(range(n_classes), colors):
        plt.plot(fpr[i], tpr[i], color=color, lw=1.5, label='ROC curve of class {0}_
→(area = {1:0.2f})' ''.format(i+1, roc_auc[i]))
plt.plot([0, 1], [0, 1], 'k-', lw=1.5)
plt.xlim([-0.05, 1.0])
plt.ylim([0.0, 1.05])
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver operating characteristic for binary-class data')
plt.legend(loc="lower right")
plt.show()
del model
tf.keras.backend.clear_session()
gc.collect()

```

13/12 [=====] - 9s 698ms/step

	precision	recall	f1-score	support
covid	1.000000	0.990000	0.994975	100
normal	0.989691	1.000000	0.994819	96
micro avg	0.994898	0.994898	0.994898	196
macro avg	0.994845	0.995000	0.994897	196
weighted avg	0.994951	0.994898	0.994898	196
samples avg	0.994898	0.994898	0.994898	196

f1 score is 0.9948967636108001



[53] : 805156

[41] :