TensorResNet

April 13, 2022

1 CS3244 Project: ResNet50 implementation to study leaf disease

Run the code below to make sure that your environtment is correctly set up before continuing running the main section below

```python
import sys
import os
import tensorflow.keras
import pandas as pd
import sklearn as sk
import tensorflow as tf
import seaborn as sn

print(f"Tensor Flow Version: {tf.__version__}")
print(f"Keras Version: {tensorflow.keras.__version__}")
print()
print(f"Python {sys.version}")
print(f"Pandas {pd.__version__}")
print(f"Scikit-Learn {sk.__version__}")
print(f"Seaborn {sn.__version__}")
gpu = len(tf.config.list_physical_devices('GPU'))>0
print("GPU is", "available" if gpu else "NOT AVAILABLE")
```

```
Init Plugin
Init Graph Optimizer
Init Kernel
Tensor Flow Version: 2.5.0
Keras Version: 2.5.0

Python 3.9.12 | packaged by conda-forge | (main, Mar 24 2022, 23:24:38)
[Clang 12.0.1 ]
Pandas 1.4.2
Scikit-Learn 1.0.2
Seaborn 0.11.2
GPU is available
```

1.1 Implementation set up

Import necessary library and methods

```
from tensorflow.keras.layers import Flatten, Dense, GlobalAveragePooling2D
from tensorflow.keras.applications.resnet50 import preprocess_input
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras.preprocessing import image_dataset_from_directory
from tensorflow.keras.applications.resnet50 import ResNet50
from tensorflow.keras.models import Sequential, Model, load_model
from tensorflow.keras.optimizers import Adam
import matplotlib.pyplot as plt
import numpy as np
```

The data is taken from Kaggle open data set New Plant Diseases Dataset. The data has been filtered and for this project the focus is only on Corn, Potato and Tomato because they are staple food and vegetable. This is so it is inline with the mission of the project which is detecting of disease plants in vertical farm.

The parameters of the image data we use is as follow: - Dimension: 256x256 - Colour space: RGB - Alpha channel: no

So there are a total of 3 channels for the image (corresponding to Red, Green, Blue)

The *_dir variable refer to the directory where the train data is at and where the test data is at.

The validation data from the dataset is being used as a test set because the original test data is not sufficient. We split the training set into a training set and a validation set using Keras API as shown in the code later on.

```
IMG_HEIGHT, IMG_WIDTH = (256, 256)
BATCH_SIZE = 64

train_data_dir = r"archive/data/train"
test_data_dir = r"archive/data/test"

train_corn_dir = os.path.join(train_data_dir, 'corn')
train_potato_dir = os.path.join(train_data_dir, 'potato')
train_tomato_dir = os.path.join(train_data_dir, 'tomato')

test_corn_dir = os.path.join(test_data_dir, 'corn')
test_potato_dir = os.path.join(test_data_dir, 'potato')
test_tomato_dir = os.path.join(test_data_dir, 'tomato')
```

To get a rough number of how many images are in each file we create a small get_number function.

```
def get_number(directory):
    count = 0

    for folder in os.listdir(directory):
        if folder.startswith('.'):
            continue
        tmp = os.path.join(directory, folder)
        count += len(os.listdir(tmp))
```

```
    return count

print(f"{len(os.listdir(train_corn_dir))-1} classes with␣
  ↪{get_number(train_corn_dir)} images in training corn folder")
print(f"{len(os.listdir(train_potato_dir))-1} classes with␣
  ↪{get_number(train_potato_dir)} images in training potato folder")
print(f"{len(os.listdir(train_tomato_dir))-1} classes with␣
  ↪{get_number(train_tomato_dir)} images in training tomato folder")
print('\n')
print(f"{len(os.listdir(test_corn_dir))-1} classes with␣
  ↪{get_number(test_corn_dir)} images in testing corn folder")
print(f"{len(os.listdir(test_potato_dir))-1} classes with␣
  ↪{get_number(test_potato_dir)} images in testing potato folder")
print(f"{len(os.listdir(test_tomato_dir))-1} classes with␣
  ↪{get_number(test_tomato_dir)} images in testing tomato folder")
```

```
4 classes with 7316 images in training corn folder
3 classes with 5702 images in training potato folder
10 classes with 18345 images in training tomato folder


4 classes with 1829 images in testing corn folder
3 classes with 1426 images in testing potato folder
10 classes with 4586 images in testing tomato folder
```

From the number we can see that the dataset has sufficient images. To save on both runtime and computational power, we choose an EPOCHS of 20 which will yield roughly 100 images per batch (or a batch size of 100).

```
[ ]: EPOCHS = 10
```

Here we use Keras API to clean and regenerate the dataset for us so that we can use them for training and testing.

```
[ ]: train_datagen = ImageDataGenerator(
    preprocessing_function=preprocess_input,
    shear_range=0.2,
    zoom_range=0.2,
    horizontal_flip=True,
    validation_split=0.2, #reserving 20% of the data for validation
)

def create_generator(ls):
  train = train_datagen.flow_from_directory(
      directory=ls,
      target_size=(IMG_HEIGHT, IMG_WIDTH),
      batch_size=BATCH_SIZE,
```

```python
        seed=17, #for reproducibility
        class_mode='categorical',
        subset='training'
        )

    valid = train_datagen.flow_from_directory(
        directory=ls,
        target_size=(IMG_HEIGHT, IMG_WIDTH),
        batch_size=BATCH_SIZE,
        seed=17, #for reproducibility
        class_mode='categorical',
        subset='validation'
        )

    return train, valid

train_corn_generator, valid_corn_generator = create_generator(train_corn_dir)
train_potato_generator, valid_potato_generator =␣
 ↪create_generator(train_potato_dir)
train_tomato_generator, valid_tomato_generator =␣
 ↪create_generator(train_tomato_dir)
```

```
Found 5855 images belonging to 4 classes.
Found 1461 images belonging to 4 classes.
Found 4564 images belonging to 3 classes.
Found 1138 images belonging to 3 classes.
Found 14678 images belonging to 10 classes.
Found 3667 images belonging to 10 classes.
```

```python
[ ]: test_datagen = ImageDataGenerator(
        preprocessing_function=preprocess_input
        )

def create_test(ls):
    return test_datagen.flow_from_directory(
        directory=ls,
        target_size=(IMG_HEIGHT, IMG_WIDTH),
        batch_size=1,
        class_mode="categorical"
        )
test_corn_generator = create_test(test_corn_dir)
test_potato_generator = create_test(test_potato_dir)
test_tomato_generator = create_test(test_tomato_dir)
```

```
Found 1829 images belonging to 4 classes.
Found 1426 images belonging to 3 classes.
Found 4585 images belonging to 10 classes.
```

```
def generate_ResNet50_model(train_generator, valid_generator, title):
    base_model = ResNet50(include_top=False, weights = "imagenet")
    x = base_model.output
    x = GlobalAveragePooling2D()(x)
    x = Dense(1024, activation='relu')(x)

    predictions = Dense(train_generator.num_classes, activation="softmax")(x)
    model = Model(inputs=base_model.input, outputs=predictions)

    for layer in base_model.layers: #prevent retraining of weight
        layer.trainable = False

    model.compile(
        optimizer='adam',
        loss='categorical_crossentropy',
        metrics=['accuracy']
        )
    model.summary()

    history = model.fit(
        train_generator,
        validation_data=valid_generator,
        epochs=EPOCHS,
        verbose=1
        )
    model.save(title)

    return history
```

```
def generate_accuracy_graph(history):
    plt.plot(history.history['accuracy'])
    plt.plot(history.history['val_accuracy'])
    plt.axis(ymin=0.9,ymax=1)
    plt.grid()
    plt.title('Model Accuracy')
    plt.ylabel('Accuracy')
    plt.xlabel('Epochs')
    plt.xticks([i for i in range(EPOCHS + 1)], [i for i in range(1,EPOCHS + 2)])
    plt.legend(['train', 'validation'])
    plt.show()
```

1.2 Model for corn

```
corn_history = generate_ResNet50_model(
    train_corn_generator,
    valid_corn_generator,
    "corn_model.h5"
```

```
    )
```

Model: "model_1"

```
_____
Layer (type)                    Output Shape         Param #     Connected to
==================================================================================================
input_2 (InputLayer)            [(None, None, None,  0
_____
conv1_pad (ZeroPadding2D)       (None, None, None, 3 0           input_2[0][0]
_____
conv1_conv (Conv2D)             (None, None, None, 6 9472        conv1_pad[0][0]
_____
conv1_bn (BatchNormalization)   (None, None, None, 6 256
conv1_conv[0][0]
_____
conv1_relu (Activation)         (None, None, None, 6 0           conv1_bn[0][0]
_____
pool1_pad (ZeroPadding2D)       (None, None, None, 6 0
conv1_relu[0][0]
_____
pool1_pool (MaxPooling2D)       (None, None, None, 6 0           pool1_pad[0][0]
_____
conv2_block1_1_conv (Conv2D)    (None, None, None, 6 4160
pool1_pool[0][0]
_____
conv2_block1_1_bn (BatchNormali (None, None, None, 6 256
conv2_block1_1_conv[0][0]
_____
conv2_block1_1_relu (Activation (None, None, None, 6 0
conv2_block1_1_bn[0][0]
_____
conv2_block1_2_conv (Conv2D)    (None, None, None, 6 36928
conv2_block1_1_relu[0][0]
_____
conv2_block1_2_bn (BatchNormali (None, None, None, 6 256
```

```
                                               conv2_block1_2_conv[0][0]
_____
_____
conv2_block1_2_relu (Activation  (None, None, None, 6 0
conv2_block1_2_bn[0][0]
_____
_____
conv2_block1_0_conv (Conv2D)     (None, None, None, 2 16640
pool1_pool[0][0]
_____
_____
conv2_block1_3_conv (Conv2D)     (None, None, None, 2 16640
conv2_block1_2_relu[0][0]
_____
_____
conv2_block1_0_bn (BatchNormali  (None, None, None, 2 1024
conv2_block1_0_conv[0][0]
_____
_____
conv2_block1_3_bn (BatchNormali  (None, None, None, 2 1024
conv2_block1_3_conv[0][0]
_____
_____
conv2_block1_add (Add)           (None, None, None, 2 0
conv2_block1_0_bn[0][0]
conv2_block1_3_bn[0][0]
_____
_____
conv2_block1_out (Activation)    (None, None, None, 2 0
conv2_block1_add[0][0]
_____
_____
conv2_block2_1_conv (Conv2D)     (None, None, None, 6 16448
conv2_block1_out[0][0]
_____
_____
conv2_block2_1_bn (BatchNormali  (None, None, None, 6 256
conv2_block2_1_conv[0][0]
_____
_____
conv2_block2_1_relu (Activation  (None, None, None, 6 0
conv2_block2_1_bn[0][0]
_____
_____
conv2_block2_2_conv (Conv2D)     (None, None, None, 6 36928
conv2_block2_1_relu[0][0]
_____
_____
```

```
conv2_block2_2_bn (BatchNormali (None, None, None, 6 256      conv2_block2_2_conv[0][0]
_____
_____
conv2_block2_2_relu (Activation (None, None, None, 6 0        conv2_block2_2_bn[0][0]
_____
_____
conv2_block2_3_conv (Conv2D)    (None, None, None, 2 16640    conv2_block2_2_relu[0][0]
_____
_____
conv2_block2_3_bn (BatchNormali (None, None, None, 2 1024     conv2_block2_3_conv[0][0]
_____
_____
conv2_block2_add (Add)          (None, None, None, 2 0        conv2_block1_out[0][0]
                                                             conv2_block2_3_bn[0][0]
_____
_____
conv2_block2_out (Activation)   (None, None, None, 2 0        conv2_block2_add[0][0]
_____
_____
conv2_block3_1_conv (Conv2D)    (None, None, None, 6 16448    conv2_block2_out[0][0]
_____
_____
conv2_block3_1_bn (BatchNormali (None, None, None, 6 256      conv2_block3_1_conv[0][0]
_____
_____
conv2_block3_1_relu (Activation (None, None, None, 6 0        conv2_block3_1_bn[0][0]
_____
_____
conv2_block3_2_conv (Conv2D)    (None, None, None, 6 36928    conv2_block3_1_relu[0][0]
_____
_____
conv2_block3_2_bn (BatchNormali (None, None, None, 6 256      conv2_block3_2_conv[0][0]
_____
_____
conv2_block3_2_relu (Activation (None, None, None, 6 0        conv2_block3_2_bn[0][0]
_____
```

```
------------------
conv2_block3_3_conv (Conv2D)    (None, None, None, 2 16640
conv2_block3_2_relu[0][0]
_____
------------------
conv2_block3_3_bn (BatchNormali (None, None, None, 2 1024
conv2_block3_3_conv[0][0]
_____
------------------
conv2_block3_add (Add)          (None, None, None, 2 0
conv2_block2_out[0][0]
conv2_block3_3_bn[0][0]
_____
------------------
conv2_block3_out (Activation)   (None, None, None, 2 0
conv2_block3_add[0][0]
_____
------------------
conv3_block1_1_conv (Conv2D)    (None, None, None, 1 32896
conv2_block3_out[0][0]
_____
------------------
conv3_block1_1_bn (BatchNormali (None, None, None, 1 512
conv3_block1_1_conv[0][0]
_____
------------------
conv3_block1_1_relu (Activation (None, None, None, 1 0
conv3_block1_1_bn[0][0]
_____
------------------
conv3_block1_2_conv (Conv2D)    (None, None, None, 1 147584
conv3_block1_1_relu[0][0]
_____
------------------
conv3_block1_2_bn (BatchNormali (None, None, None, 1 512
conv3_block1_2_conv[0][0]
_____
------------------
conv3_block1_2_relu (Activation (None, None, None, 1 0
conv3_block1_2_bn[0][0]
_____
------------------
conv3_block1_0_conv (Conv2D)    (None, None, None, 5 131584
conv2_block3_out[0][0]
_____
------------------
conv3_block1_3_conv (Conv2D)    (None, None, None, 5 66048
conv3_block1_2_relu[0][0]
```

```
--------------------------------------------------------------------------------
------------------
conv3_block1_0_bn (BatchNormali (None, None, None, 5 2048
conv3_block1_0_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block1_3_bn (BatchNormali (None, None, None, 5 2048
conv3_block1_3_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block1_add (Add)          (None, None, None, 5 0
conv3_block1_0_bn[0][0]
conv3_block1_3_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block1_out (Activation)   (None, None, None, 5 0
conv3_block1_add[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block2_1_conv (Conv2D)    (None, None, None, 1 65664
conv3_block1_out[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block2_1_bn (BatchNormali (None, None, None, 1 512
conv3_block2_1_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block2_1_relu (Activation (None, None, None, 1 0
conv3_block2_1_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block2_2_conv (Conv2D)    (None, None, None, 1 147584
conv3_block2_1_relu[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block2_2_bn (BatchNormali (None, None, None, 1 512
conv3_block2_2_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block2_2_relu (Activation (None, None, None, 1 0
conv3_block2_2_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block2_3_conv (Conv2D)    (None, None, None, 5 66048
conv3_block2_2_relu[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block2_3_bn (BatchNormali (None, None, None, 5 2048
```

```
                                                          conv3_block2_3_conv[0][0]
_____
_____
conv3_block2_add (Add)          (None, None, None, 5 0
conv3_block1_out[0][0]
conv3_block2_3_bn[0][0]
_____
_____
conv3_block2_out (Activation)   (None, None, None, 5 0
conv3_block2_add[0][0]
_____
_____
conv3_block3_1_conv (Conv2D)    (None, None, None, 1 65664
conv3_block2_out[0][0]
_____
_____
conv3_block3_1_bn (BatchNormali (None, None, None, 1 512
conv3_block3_1_conv[0][0]
_____
_____
conv3_block3_1_relu (Activation (None, None, None, 1 0
conv3_block3_1_bn[0][0]
_____
_____
conv3_block3_2_conv (Conv2D)    (None, None, None, 1 147584
conv3_block3_1_relu[0][0]
_____
_____
conv3_block3_2_bn (BatchNormali (None, None, None, 1 512
conv3_block3_2_conv[0][0]
_____
_____
conv3_block3_2_relu (Activation (None, None, None, 1 0
conv3_block3_2_bn[0][0]
_____
_____
conv3_block3_3_conv (Conv2D)    (None, None, None, 5 66048
conv3_block3_2_relu[0][0]
_____
_____
conv3_block3_3_bn (BatchNormali (None, None, None, 5 2048
conv3_block3_3_conv[0][0]
_____
_____
conv3_block3_add (Add)          (None, None, None, 5 0
conv3_block2_out[0][0]
conv3_block3_3_bn[0][0]
_____
```

```
------------------
conv3_block3_out (Activation)    (None, None, None, 5 0
conv3_block3_add[0][0]
_____
------------------
conv3_block4_1_conv (Conv2D)     (None, None, None, 1 65664
conv3_block3_out[0][0]
_____
------------------
conv3_block4_1_bn (BatchNormali (None, None, None, 1 512
conv3_block4_1_conv[0][0]
_____
------------------
conv3_block4_1_relu (Activation (None, None, None, 1 0
conv3_block4_1_bn[0][0]
_____
------------------
conv3_block4_2_conv (Conv2D)     (None, None, None, 1 147584
conv3_block4_1_relu[0][0]
_____
------------------
conv3_block4_2_bn (BatchNormali (None, None, None, 1 512
conv3_block4_2_conv[0][0]
_____
------------------
conv3_block4_2_relu (Activation (None, None, None, 1 0
conv3_block4_2_bn[0][0]
_____
------------------
conv3_block4_3_conv (Conv2D)     (None, None, None, 5 66048
conv3_block4_2_relu[0][0]
_____
------------------
conv3_block4_3_bn (BatchNormali (None, None, None, 5 2048
conv3_block4_3_conv[0][0]
_____
------------------
conv3_block4_add (Add)           (None, None, None, 5 0
conv3_block3_out[0][0]
conv3_block4_3_bn[0][0]
_____
------------------
conv3_block4_out (Activation)    (None, None, None, 5 0
conv3_block4_add[0][0]
_____
------------------
conv4_block1_1_conv (Conv2D)     (None, None, None, 2 131328
conv3_block4_out[0][0]
```

```
--------------------------------------------------------------------------------
------------------
conv4_block1_1_bn (BatchNormali (None, None, None, 2 1024
conv4_block1_1_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block1_1_relu (Activation (None, None, None, 2 0
conv4_block1_1_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block1_2_conv (Conv2D)    (None, None, None, 2 590080
conv4_block1_1_relu[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block1_2_bn (BatchNormali (None, None, None, 2 1024
conv4_block1_2_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block1_2_relu (Activation (None, None, None, 2 0
conv4_block1_2_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block1_0_conv (Conv2D)    (None, None, None, 1 525312
conv3_block4_out[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block1_3_conv (Conv2D)    (None, None, None, 1 263168
conv4_block1_2_relu[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block1_0_bn (BatchNormali (None, None, None, 1 4096
conv4_block1_0_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block1_3_bn (BatchNormali (None, None, None, 1 4096
conv4_block1_3_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block1_add (Add)          (None, None, None, 1 0
conv4_block1_0_bn[0][0]
conv4_block1_3_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block1_out (Activation)   (None, None, None, 1 0
conv4_block1_add[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block2_1_conv (Conv2D)    (None, None, None, 2 262400
```

```
conv4_block1_out[0][0]
_____
_____
conv4_block2_1_bn (BatchNormali (None, None, None, 2 1024
conv4_block2_1_conv[0][0]
_____
_____
conv4_block2_1_relu (Activation (None, None, None, 2 0
conv4_block2_1_bn[0][0]
_____
_____
conv4_block2_2_conv (Conv2D)    (None, None, None, 2 590080
conv4_block2_1_relu[0][0]
_____
_____
conv4_block2_2_bn (BatchNormali (None, None, None, 2 1024
conv4_block2_2_conv[0][0]
_____
_____
conv4_block2_2_relu (Activation (None, None, None, 2 0
conv4_block2_2_bn[0][0]
_____
_____
conv4_block2_3_conv (Conv2D)    (None, None, None, 1 263168
conv4_block2_2_relu[0][0]
_____
_____
conv4_block2_3_bn (BatchNormali (None, None, None, 1 4096
conv4_block2_3_conv[0][0]
_____
_____
conv4_block2_add (Add)          (None, None, None, 1 0
conv4_block1_out[0][0]
conv4_block2_3_bn[0][0]
_____
_____
conv4_block2_out (Activation)   (None, None, None, 1 0
conv4_block2_add[0][0]
_____
_____
conv4_block3_1_conv (Conv2D)    (None, None, None, 2 262400
conv4_block2_out[0][0]
_____
_____
conv4_block3_1_bn (BatchNormali (None, None, None, 2 1024
conv4_block3_1_conv[0][0]
_____
_____
```

```
conv4_block3_1_relu (Activation  (None, None, None, 2 0
conv4_block3_1_bn[0][0]
_____
_____
conv4_block3_2_conv (Conv2D)     (None, None, None, 2 590080
conv4_block3_1_relu[0][0]
_____
_____
conv4_block3_2_bn (BatchNormali  (None, None, None, 2 1024
conv4_block3_2_conv[0][0]
_____
_____
conv4_block3_2_relu (Activation  (None, None, None, 2 0
conv4_block3_2_bn[0][0]
_____
_____
conv4_block3_3_conv (Conv2D)     (None, None, None, 1 263168
conv4_block3_2_relu[0][0]
_____
_____
conv4_block3_3_bn (BatchNormali  (None, None, None, 1 4096
conv4_block3_3_conv[0][0]
_____
_____
conv4_block3_add (Add)           (None, None, None, 1 0
conv4_block2_out[0][0]
conv4_block3_3_bn[0][0]
_____
_____
conv4_block3_out (Activation)    (None, None, None, 1 0
conv4_block3_add[0][0]
_____
_____
conv4_block4_1_conv (Conv2D)     (None, None, None, 2 262400
conv4_block3_out[0][0]
_____
_____
conv4_block4_1_bn (BatchNormali  (None, None, None, 2 1024
conv4_block4_1_conv[0][0]
_____
_____
conv4_block4_1_relu (Activation  (None, None, None, 2 0
conv4_block4_1_bn[0][0]
_____
_____
conv4_block4_2_conv (Conv2D)     (None, None, None, 2 590080
conv4_block4_1_relu[0][0]
_____
```

```
------------------
conv4_block4_2_bn (BatchNormali (None, None, None, 2 1024
conv4_block4_2_conv[0][0]
_____
------------------
conv4_block4_2_relu (Activation (None, None, None, 2 0
conv4_block4_2_bn[0][0]
_____
------------------
conv4_block4_3_conv (Conv2D)    (None, None, None, 1 263168
conv4_block4_2_relu[0][0]
_____
------------------
conv4_block4_3_bn (BatchNormali (None, None, None, 1 4096
conv4_block4_3_conv[0][0]
_____
------------------
conv4_block4_add (Add)          (None, None, None, 1 0
conv4_block3_out[0][0]
conv4_block4_3_bn[0][0]
_____
------------------
conv4_block4_out (Activation)   (None, None, None, 1 0
conv4_block4_add[0][0]
_____
------------------
conv4_block5_1_conv (Conv2D)    (None, None, None, 2 262400
conv4_block4_out[0][0]
_____
------------------
conv4_block5_1_bn (BatchNormali (None, None, None, 2 1024
conv4_block5_1_conv[0][0]
_____
------------------
conv4_block5_1_relu (Activation (None, None, None, 2 0
conv4_block5_1_bn[0][0]
_____
------------------
conv4_block5_2_conv (Conv2D)    (None, None, None, 2 590080
conv4_block5_1_relu[0][0]
_____
------------------
conv4_block5_2_bn (BatchNormali (None, None, None, 2 1024
conv4_block5_2_conv[0][0]
_____
------------------
conv4_block5_2_relu (Activation (None, None, None, 2 0
conv4_block5_2_bn[0][0]
```

```
--------------------------------------------------------------------------------
------------------
conv4_block5_3_conv (Conv2D)     (None, None, None, 1 263168
conv4_block5_2_relu[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block5_3_bn (BatchNormali (None, None, None, 1 4096
conv4_block5_3_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block5_add (Add)          (None, None, None, 1 0
conv4_block4_out[0][0]
conv4_block5_3_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block5_out (Activation)   (None, None, None, 1 0
conv4_block5_add[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block6_1_conv (Conv2D)    (None, None, None, 2 262400
conv4_block5_out[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block6_1_bn (BatchNormali (None, None, None, 2 1024
conv4_block6_1_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block6_1_relu (Activation (None, None, None, 2 0
conv4_block6_1_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block6_2_conv (Conv2D)    (None, None, None, 2 590080
conv4_block6_1_relu[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block6_2_bn (BatchNormali (None, None, None, 2 1024
conv4_block6_2_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block6_2_relu (Activation (None, None, None, 2 0
conv4_block6_2_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block6_3_conv (Conv2D)    (None, None, None, 1 263168
conv4_block6_2_relu[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block6_3_bn (BatchNormali (None, None, None, 1 4096
```

```
conv4_block6_3_conv[0][0]
_____
_____
conv4_block6_add (Add)          (None, None, None, 1 0
conv4_block5_out[0][0]
conv4_block6_3_bn[0][0]
_____
_____
conv4_block6_out (Activation)   (None, None, None, 1 0
conv4_block6_add[0][0]
_____
_____
conv5_block1_1_conv (Conv2D)    (None, None, None, 5 524800
conv4_block6_out[0][0]
_____
_____
conv5_block1_1_bn (BatchNormali (None, None, None, 5 2048
conv5_block1_1_conv[0][0]
_____
_____
conv5_block1_1_relu (Activation (None, None, None, 5 0
conv5_block1_1_bn[0][0]
_____
_____
conv5_block1_2_conv (Conv2D)    (None, None, None, 5 2359808
conv5_block1_1_relu[0][0]
_____
_____
conv5_block1_2_bn (BatchNormali (None, None, None, 5 2048
conv5_block1_2_conv[0][0]
_____
_____
conv5_block1_2_relu (Activation (None, None, None, 5 0
conv5_block1_2_bn[0][0]
_____
_____
conv5_block1_0_conv (Conv2D)    (None, None, None, 2 2099200
conv4_block6_out[0][0]
_____
_____
conv5_block1_3_conv (Conv2D)    (None, None, None, 2 1050624
conv5_block1_2_relu[0][0]
_____
_____
conv5_block1_0_bn (BatchNormali (None, None, None, 2 8192
conv5_block1_0_conv[0][0]
_____
_____
```

```
conv5_block1_3_bn (BatchNormali (None, None, None, 2 8192
conv5_block1_3_conv[0][0]
_____
_____
conv5_block1_add (Add)          (None, None, None, 2 0
conv5_block1_0_bn[0][0]
conv5_block1_3_bn[0][0]
_____
_____
conv5_block1_out (Activation)   (None, None, None, 2 0
conv5_block1_add[0][0]
_____
_____
conv5_block2_1_conv (Conv2D)    (None, None, None, 5 1049088
conv5_block1_out[0][0]
_____
_____
conv5_block2_1_bn (BatchNormali (None, None, None, 5 2048
conv5_block2_1_conv[0][0]
_____
_____
conv5_block2_1_relu (Activation (None, None, None, 5 0
conv5_block2_1_bn[0][0]
_____
_____
conv5_block2_2_conv (Conv2D)    (None, None, None, 5 2359808
conv5_block2_1_relu[0][0]
_____
_____
conv5_block2_2_bn (BatchNormali (None, None, None, 5 2048
conv5_block2_2_conv[0][0]
_____
_____
conv5_block2_2_relu (Activation (None, None, None, 5 0
conv5_block2_2_bn[0][0]
_____
_____
conv5_block2_3_conv (Conv2D)    (None, None, None, 2 1050624
conv5_block2_2_relu[0][0]
_____
_____
conv5_block2_3_bn (BatchNormali (None, None, None, 2 8192
conv5_block2_3_conv[0][0]
_____
_____
conv5_block2_add (Add)          (None, None, None, 2 0
conv5_block1_out[0][0]
conv5_block2_3_bn[0][0]
```

```
--------------------------------------------------------------------------------
------------------
conv5_block2_out (Activation)   (None, None, None, 2 0
conv5_block2_add[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block3_1_conv (Conv2D)    (None, None, None, 5 1049088
conv5_block2_out[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block3_1_bn (BatchNormali (None, None, None, 5 2048
conv5_block3_1_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block3_1_relu (Activation (None, None, None, 5 0
conv5_block3_1_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block3_2_conv (Conv2D)    (None, None, None, 5 2359808
conv5_block3_1_relu[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block3_2_bn (BatchNormali (None, None, None, 5 2048
conv5_block3_2_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block3_2_relu (Activation (None, None, None, 5 0
conv5_block3_2_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block3_3_conv (Conv2D)    (None, None, None, 2 1050624
conv5_block3_2_relu[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block3_3_bn (BatchNormali (None, None, None, 2 8192
conv5_block3_3_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block3_add (Add)          (None, None, None, 2 0
conv5_block2_out[0][0]
conv5_block3_3_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block3_out (Activation)   (None, None, None, 2 0
conv5_block3_add[0][0]
--------------------------------------------------------------------------------
------------------
global_average_pooling2d_1 (Glo (None, 2048)         0
```

```
conv5_block3_out[0][0]
--------------------------------------------------------------------------------
------------------
dense_2 (Dense)                    (None, 1024)           2098176
global_average_pooling2d_1[0][0]
--------------------------------------------------------------------------------
------------------
dense_3 (Dense)                    (None, 4)              4100       dense_2[0][0]
================================================================================
==================
Total params: 25,689,988
Trainable params: 2,102,276
Non-trainable params: 23,587,712
--------------------------------------------------------------------------------
------------------
2022-04-13 17:25:44.882288: I
tensorflow/compiler/mlir/mlir_graph_optimization_pass.cc:176] None of the MLIR
Optimization Passes are enabled (registered 2)
2022-04-13 17:25:44.883586: W
tensorflow/core/platform/profile_utils/cpu_utils.cc:128] Failed to get CPU
frequency: 0 Hz

Epoch 1/10

2022-04-13 17:25:45.970800: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

92/92 [==============================] - ETA: 0s - loss: 0.2108 - accuracy:
0.9375

2022-04-13 17:26:32.017898: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

92/92 [==============================] - 59s 613ms/step - loss: 0.2108 -
accuracy: 0.9375 - val_loss: 0.0882 - val_accuracy: 0.9665
Epoch 2/10
92/92 [==============================] - 58s 625ms/step - loss: 0.0946 -
accuracy: 0.9674 - val_loss: 0.1026 - val_accuracy: 0.9658
Epoch 3/10
92/92 [==============================] - 57s 613ms/step - loss: 0.0535 -
accuracy: 0.9792 - val_loss: 0.0864 - val_accuracy: 0.9658
Epoch 4/10
92/92 [==============================] - 57s 604ms/step - loss: 0.0456 -
accuracy: 0.9824 - val_loss: 0.0566 - val_accuracy: 0.9795
Epoch 5/10
92/92 [==============================] - 56s 603ms/step - loss: 0.0376 -
accuracy: 0.9857 - val_loss: 0.0593 - val_accuracy: 0.9754
Epoch 6/10
```

```
92/92 [==============================] - 58s 618ms/step - loss: 0.0404 -
accuracy: 0.9855 - val_loss: 0.0658 - val_accuracy: 0.9788
Epoch 7/10
92/92 [==============================] - 57s 605ms/step - loss: 0.0350 -
accuracy: 0.9880 - val_loss: 0.0640 - val_accuracy: 0.9719
Epoch 8/10
92/92 [==============================] - 57s 614ms/step - loss: 0.0320 -
accuracy: 0.9865 - val_loss: 0.0589 - val_accuracy: 0.9754
Epoch 9/10
92/92 [==============================] - 57s 607ms/step - loss: 0.0292 -
accuracy: 0.9875 - val_loss: 0.1168 - val_accuracy: 0.9624
Epoch 10/10
92/92 [==============================] - 57s 604ms/step - loss: 0.0347 -
accuracy: 0.9868 - val_loss: 0.0713 - val_accuracy: 0.9713
```

```
/Users/yuuki/.pyenv/versions/miniforge3/envs/tensorflow/lib/python3.9/site-
packages/tensorflow/python/keras/utils/generic_utils.py:494: CustomMaskWarning:
Custom mask layers require a config and must override get_config. When loading,
the custom mask layer must be passed to the custom_objects argument.
  warnings.warn('Custom mask layers require a config and must override '
```

[ ]: `generate_accuracy_graph(corn_history)`
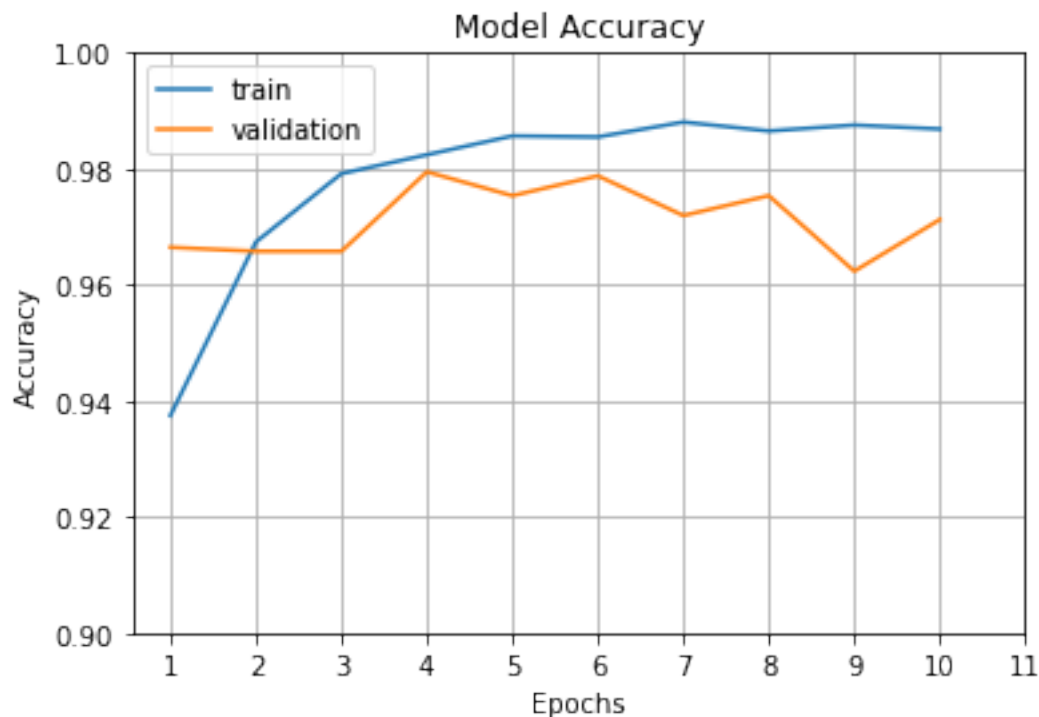
```python
saved_model = load_model('corn_model.h5')
test_loss, test_acc = saved_model.evaluate(test_corn_generator, verbose=2)
print(f"\nTest accuracy: {test_acc}")
```

2022-04-13 18:28:04.900626: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

1829/1829 - 39s - loss: 0.0512 - accuracy: 0.9792

Test accuracy: 0.9792236685752869

1.3 Model for potato

```python
potato_history = generate_ResNet50_model(
    train_potato_generator,
    valid_potato_generator,
    "potato_model.h5"
    )
```

Model: "model_3"
```
_____
_____
Layer (type)                    Output Shape         Param #     Connected to
==================================================================================
==================
input_4 (InputLayer)            [(None, None, None,   0

_____
_____
conv1_pad (ZeroPadding2D)       (None, None, None, 3  0           input_4[0][0]

_____
_____
conv1_conv (Conv2D)             (None, None, None, 6  9472        conv1_pad[0][0]

_____
_____
conv1_bn (BatchNormalization)   (None, None, None, 6  256
conv1_conv[0][0]

_____
_____
conv1_relu (Activation)         (None, None, None, 6  0           conv1_bn[0][0]

_____
_____
pool1_pad (ZeroPadding2D)       (None, None, None, 6  0
conv1_relu[0][0]

_____
_____
pool1_pool (MaxPooling2D)       (None, None, None, 6  0           pool1_pad[0][0]

_____
_____
```

```
conv2_block1_1_conv (Conv2D)    (None, None, None, 6 4160
pool1_pool[0][0]
_____
_____
conv2_block1_1_bn (BatchNormali (None, None, None, 6 256
conv2_block1_1_conv[0][0]
_____
_____
conv2_block1_1_relu (Activation (None, None, None, 6 0
conv2_block1_1_bn[0][0]
_____
_____
conv2_block1_2_conv (Conv2D)    (None, None, None, 6 36928
conv2_block1_1_relu[0][0]
_____
_____
conv2_block1_2_bn (BatchNormali (None, None, None, 6 256
conv2_block1_2_conv[0][0]
_____
_____
conv2_block1_2_relu (Activation (None, None, None, 6 0
conv2_block1_2_bn[0][0]
_____
_____
conv2_block1_0_conv (Conv2D)    (None, None, None, 2 16640
pool1_pool[0][0]
_____
_____
conv2_block1_3_conv (Conv2D)    (None, None, None, 2 16640
conv2_block1_2_relu[0][0]
_____
_____
conv2_block1_0_bn (BatchNormali (None, None, None, 2 1024
conv2_block1_0_conv[0][0]
_____
_____
conv2_block1_3_bn (BatchNormali (None, None, None, 2 1024
conv2_block1_3_conv[0][0]
_____
_____
conv2_block1_add (Add)          (None, None, None, 2 0
conv2_block1_0_bn[0][0]
conv2_block1_3_bn[0][0]
_____
_____
conv2_block1_out (Activation)   (None, None, None, 2 0
conv2_block1_add[0][0]
_____
_____
```

```
------------------
conv2_block2_1_conv (Conv2D)     (None, None, None, 6 16448
conv2_block1_out[0][0]
_____
------------------
conv2_block2_1_bn (BatchNormali (None, None, None, 6 256
conv2_block2_1_conv[0][0]
_____
------------------
conv2_block2_1_relu (Activation (None, None, None, 6 0
conv2_block2_1_bn[0][0]
_____
------------------
conv2_block2_2_conv (Conv2D)     (None, None, None, 6 36928
conv2_block2_1_relu[0][0]
_____
------------------
conv2_block2_2_bn (BatchNormali (None, None, None, 6 256
conv2_block2_2_conv[0][0]
_____
------------------
conv2_block2_2_relu (Activation (None, None, None, 6 0
conv2_block2_2_bn[0][0]
_____
------------------
conv2_block2_3_conv (Conv2D)     (None, None, None, 2 16640
conv2_block2_2_relu[0][0]
_____
------------------
conv2_block2_3_bn (BatchNormali (None, None, None, 2 1024
conv2_block2_3_conv[0][0]
_____
------------------
conv2_block2_add (Add)          (None, None, None, 2 0
conv2_block1_out[0][0]
conv2_block2_3_bn[0][0]
_____
------------------
conv2_block2_out (Activation)   (None, None, None, 2 0
conv2_block2_add[0][0]
_____
------------------
conv2_block3_1_conv (Conv2D)     (None, None, None, 6 16448
conv2_block2_out[0][0]
_____
------------------
conv2_block3_1_bn (BatchNormali (None, None, None, 6 256
conv2_block3_1_conv[0][0]
```

```
--------------------------------------------------------------------------------
------------------
conv2_block3_1_relu (Activation (None, None, None, 6 0
conv2_block3_1_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv2_block3_2_conv (Conv2D)    (None, None, None, 6 36928
conv2_block3_1_relu[0][0]
--------------------------------------------------------------------------------
------------------
conv2_block3_2_bn (BatchNormali (None, None, None, 6 256
conv2_block3_2_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv2_block3_2_relu (Activation (None, None, None, 6 0
conv2_block3_2_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv2_block3_3_conv (Conv2D)    (None, None, None, 2 16640
conv2_block3_2_relu[0][0]
--------------------------------------------------------------------------------
------------------
conv2_block3_3_bn (BatchNormali (None, None, None, 2 1024
conv2_block3_3_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv2_block3_add (Add)          (None, None, None, 2 0
conv2_block2_out[0][0]
conv2_block3_3_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv2_block3_out (Activation)   (None, None, None, 2 0
conv2_block3_add[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block1_1_conv (Conv2D)    (None, None, None, 1 32896
conv2_block3_out[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block1_1_bn (BatchNormali (None, None, None, 1 512
conv3_block1_1_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block1_1_relu (Activation (None, None, None, 1 0
conv3_block1_1_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block1_2_conv (Conv2D)    (None, None, None, 1 147584
```

```
conv3_block1_1_relu[0][0]
_____
_____
conv3_block1_2_bn (BatchNormali (None, None, None, 1 512
conv3_block1_2_conv[0][0]
_____
_____
conv3_block1_2_relu (Activation (None, None, None, 1 0
conv3_block1_2_bn[0][0]
_____
_____
conv3_block1_0_conv (Conv2D)    (None, None, None, 5 131584
conv2_block3_out[0][0]
_____
_____
conv3_block1_3_conv (Conv2D)    (None, None, None, 5 66048
conv3_block1_2_relu[0][0]
_____
_____
conv3_block1_0_bn (BatchNormali (None, None, None, 5 2048
conv3_block1_0_conv[0][0]
_____
_____
conv3_block1_3_bn (BatchNormali (None, None, None, 5 2048
conv3_block1_3_conv[0][0]
_____
_____
conv3_block1_add (Add)          (None, None, None, 5 0
conv3_block1_0_bn[0][0]
conv3_block1_3_bn[0][0]
_____
_____
conv3_block1_out (Activation)   (None, None, None, 5 0
conv3_block1_add[0][0]
_____
_____
conv3_block2_1_conv (Conv2D)    (None, None, None, 1 65664
conv3_block1_out[0][0]
_____
_____
conv3_block2_1_bn (BatchNormali (None, None, None, 1 512
conv3_block2_1_conv[0][0]
_____
_____
conv3_block2_1_relu (Activation (None, None, None, 1 0
conv3_block2_1_bn[0][0]
_____
_____
```

```
conv3_block2_2_conv (Conv2D)     (None, None, None, 1 147584
conv3_block2_1_relu[0][0]
_____
_____
conv3_block2_2_bn (BatchNormali (None, None, None, 1 512
conv3_block2_2_conv[0][0]
_____
_____
conv3_block2_2_relu (Activation (None, None, None, 1 0
conv3_block2_2_bn[0][0]
_____
_____
conv3_block2_3_conv (Conv2D)     (None, None, None, 5 66048
conv3_block2_2_relu[0][0]
_____
_____
conv3_block2_3_bn (BatchNormali (None, None, None, 5 2048
conv3_block2_3_conv[0][0]
_____
_____
conv3_block2_add (Add)          (None, None, None, 5 0
conv3_block1_out[0][0]
conv3_block2_3_bn[0][0]
_____
_____
conv3_block2_out (Activation)    (None, None, None, 5 0
conv3_block2_add[0][0]
_____
_____
conv3_block3_1_conv (Conv2D)     (None, None, None, 1 65664
conv3_block2_out[0][0]
_____
_____
conv3_block3_1_bn (BatchNormali (None, None, None, 1 512
conv3_block3_1_conv[0][0]
_____
_____
conv3_block3_1_relu (Activation (None, None, None, 1 0
conv3_block3_1_bn[0][0]
_____
_____
conv3_block3_2_conv (Conv2D)     (None, None, None, 1 147584
conv3_block3_1_relu[0][0]
_____
_____
conv3_block3_2_bn (BatchNormali (None, None, None, 1 512
conv3_block3_2_conv[0][0]
_____
```

```
------------------
conv3_block3_2_relu (Activation (None, None, None, 1 0
conv3_block3_2_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block3_3_conv (Conv2D)    (None, None, None, 5 66048
conv3_block3_2_relu[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block3_3_bn (BatchNormali (None, None, None, 5 2048
conv3_block3_3_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block3_add (Add)          (None, None, None, 5 0
conv3_block2_out[0][0]
conv3_block3_3_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block3_out (Activation)   (None, None, None, 5 0
conv3_block3_add[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block4_1_conv (Conv2D)    (None, None, None, 1 65664
conv3_block3_out[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block4_1_bn (BatchNormali (None, None, None, 1 512
conv3_block4_1_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block4_1_relu (Activation (None, None, None, 1 0
conv3_block4_1_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block4_2_conv (Conv2D)    (None, None, None, 1 147584
conv3_block4_1_relu[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block4_2_bn (BatchNormali (None, None, None, 1 512
conv3_block4_2_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block4_2_relu (Activation (None, None, None, 1 0
conv3_block4_2_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block4_3_conv (Conv2D)    (None, None, None, 5 66048
conv3_block4_2_relu[0][0]
```

```
--------------------------------------------------------------------------------
------------------
conv3_block4_3_bn (BatchNormali (None, None, None, 5 2048
conv3_block4_3_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block4_add (Add)          (None, None, None, 5 0
conv3_block3_out[0][0]
conv3_block4_3_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block4_out (Activation)   (None, None, None, 5 0
conv3_block4_add[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block1_1_conv (Conv2D)    (None, None, None, 2 131328
conv3_block4_out[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block1_1_bn (BatchNormali (None, None, None, 2 1024
conv4_block1_1_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block1_1_relu (Activation (None, None, None, 2 0
conv4_block1_1_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block1_2_conv (Conv2D)    (None, None, None, 2 590080
conv4_block1_1_relu[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block1_2_bn (BatchNormali (None, None, None, 2 1024
conv4_block1_2_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block1_2_relu (Activation (None, None, None, 2 0
conv4_block1_2_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block1_0_conv (Conv2D)    (None, None, None, 1 525312
conv3_block4_out[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block1_3_conv (Conv2D)    (None, None, None, 1 263168
conv4_block1_2_relu[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block1_0_bn (BatchNormali (None, None, None, 1 4096
```

```
                                                        conv4_block1_0_conv[0][0]
_____
_____
conv4_block1_3_bn (BatchNormali (None, None, None, 1 4096
conv4_block1_3_conv[0][0]
_____
_____
conv4_block1_add (Add)          (None, None, None, 1 0
conv4_block1_0_bn[0][0]
conv4_block1_3_bn[0][0]
_____
_____
conv4_block1_out (Activation)   (None, None, None, 1 0
conv4_block1_add[0][0]
_____
_____
conv4_block2_1_conv (Conv2D)    (None, None, None, 2 262400
conv4_block1_out[0][0]
_____
_____
conv4_block2_1_bn (BatchNormali (None, None, None, 2 1024
conv4_block2_1_conv[0][0]
_____
_____
conv4_block2_1_relu (Activation (None, None, None, 2 0
conv4_block2_1_bn[0][0]
_____
_____
conv4_block2_2_conv (Conv2D)    (None, None, None, 2 590080
conv4_block2_1_relu[0][0]
_____
_____
conv4_block2_2_bn (BatchNormali (None, None, None, 2 1024
conv4_block2_2_conv[0][0]
_____
_____
conv4_block2_2_relu (Activation (None, None, None, 2 0
conv4_block2_2_bn[0][0]
_____
_____
conv4_block2_3_conv (Conv2D)    (None, None, None, 1 263168
conv4_block2_2_relu[0][0]
_____
_____
conv4_block2_3_bn (BatchNormali (None, None, None, 1 4096
conv4_block2_3_conv[0][0]
_____
_____
```

```
conv4_block2_add (Add)          (None, None, None, 1 0
conv4_block1_out[0][0]
conv4_block2_3_bn[0][0]

--------------------------------------------------------------------------------
------------------
conv4_block2_out (Activation)   (None, None, None, 1 0
conv4_block2_add[0][0]

--------------------------------------------------------------------------------
------------------
conv4_block3_1_conv (Conv2D)    (None, None, None, 2 262400
conv4_block2_out[0][0]

--------------------------------------------------------------------------------
------------------
conv4_block3_1_bn (BatchNormali (None, None, None, 2 1024
conv4_block3_1_conv[0][0]

--------------------------------------------------------------------------------
------------------
conv4_block3_1_relu (Activation (None, None, None, 2 0
conv4_block3_1_bn[0][0]

--------------------------------------------------------------------------------
------------------
conv4_block3_2_conv (Conv2D)    (None, None, None, 2 590080
conv4_block3_1_relu[0][0]

--------------------------------------------------------------------------------
------------------
conv4_block3_2_bn (BatchNormali (None, None, None, 2 1024
conv4_block3_2_conv[0][0]

--------------------------------------------------------------------------------
------------------
conv4_block3_2_relu (Activation (None, None, None, 2 0
conv4_block3_2_bn[0][0]

--------------------------------------------------------------------------------
------------------
conv4_block3_3_conv (Conv2D)    (None, None, None, 1 263168
conv4_block3_2_relu[0][0]

--------------------------------------------------------------------------------
------------------
conv4_block3_3_bn (BatchNormali (None, None, None, 1 4096
conv4_block3_3_conv[0][0]

--------------------------------------------------------------------------------
------------------
conv4_block3_add (Add)          (None, None, None, 1 0
conv4_block2_out[0][0]
conv4_block3_3_bn[0][0]

--------------------------------------------------------------------------------
------------------
conv4_block3_out (Activation)   (None, None, None, 1 0
conv4_block3_add[0][0]
```

```
--------------------------------------------------------------------------------
------------------
conv4_block4_1_conv (Conv2D)     (None, None, None, 2 262400
conv4_block3_out[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block4_1_bn (BatchNormali (None, None, None, 2 1024
conv4_block4_1_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block4_1_relu (Activation (None, None, None, 2 0
conv4_block4_1_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block4_2_conv (Conv2D)     (None, None, None, 2 590080
conv4_block4_1_relu[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block4_2_bn (BatchNormali (None, None, None, 2 1024
conv4_block4_2_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block4_2_relu (Activation (None, None, None, 2 0
conv4_block4_2_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block4_3_conv (Conv2D)     (None, None, None, 1 263168
conv4_block4_2_relu[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block4_3_bn (BatchNormali (None, None, None, 1 4096
conv4_block4_3_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block4_add (Add)          (None, None, None, 1 0
conv4_block3_out[0][0]
conv4_block4_3_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block4_out (Activation)    (None, None, None, 1 0
conv4_block4_add[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block5_1_conv (Conv2D)     (None, None, None, 2 262400
conv4_block4_out[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block5_1_bn (BatchNormali (None, None, None, 2 1024
```

```
                                                     conv4_block5_1_conv[0][0]
_____
_____
conv4_block5_1_relu (Activation (None, None, None, 2 0
conv4_block5_1_bn[0][0]
_____
_____
conv4_block5_2_conv (Conv2D)    (None, None, None, 2 590080
conv4_block5_1_relu[0][0]
_____
_____
conv4_block5_2_bn (BatchNormali (None, None, None, 2 1024
conv4_block5_2_conv[0][0]
_____
_____
conv4_block5_2_relu (Activation (None, None, None, 2 0
conv4_block5_2_bn[0][0]
_____
_____
conv4_block5_3_conv (Conv2D)    (None, None, None, 1 263168
conv4_block5_2_relu[0][0]
_____
_____
conv4_block5_3_bn (BatchNormali (None, None, None, 1 4096
conv4_block5_3_conv[0][0]
_____
_____
conv4_block5_add (Add)          (None, None, None, 1 0
conv4_block4_out[0][0]
conv4_block5_3_bn[0][0]
_____
_____
conv4_block5_out (Activation)   (None, None, None, 1 0
conv4_block5_add[0][0]
_____
_____
conv4_block6_1_conv (Conv2D)    (None, None, None, 2 262400
conv4_block5_out[0][0]
_____
_____
conv4_block6_1_bn (BatchNormali (None, None, None, 2 1024
conv4_block6_1_conv[0][0]
_____
_____
conv4_block6_1_relu (Activation (None, None, None, 2 0
conv4_block6_1_bn[0][0]
_____
_____
```

```
conv4_block6_2_conv (Conv2D)      (None, None, None, 2 590080
conv4_block6_1_relu[0][0]
_____
_____
conv4_block6_2_bn (BatchNormali (None, None, None, 2 1024
conv4_block6_2_conv[0][0]
_____
_____
conv4_block6_2_relu (Activation (None, None, None, 2 0
conv4_block6_2_bn[0][0]
_____
_____
conv4_block6_3_conv (Conv2D)      (None, None, None, 1 263168
conv4_block6_2_relu[0][0]
_____
_____
conv4_block6_3_bn (BatchNormali (None, None, None, 1 4096
conv4_block6_3_conv[0][0]
_____
_____
conv4_block6_add (Add)            (None, None, None, 1 0
conv4_block5_out[0][0]
conv4_block6_3_bn[0][0]
_____
_____
conv4_block6_out (Activation)     (None, None, None, 1 0
conv4_block6_add[0][0]
_____
_____
conv5_block1_1_conv (Conv2D)      (None, None, None, 5 524800
conv4_block6_out[0][0]
_____
_____
conv5_block1_1_bn (BatchNormali (None, None, None, 5 2048
conv5_block1_1_conv[0][0]
_____
_____
conv5_block1_1_relu (Activation (None, None, None, 5 0
conv5_block1_1_bn[0][0]
_____
_____
conv5_block1_2_conv (Conv2D)      (None, None, None, 5 2359808
conv5_block1_1_relu[0][0]
_____
_____
conv5_block1_2_bn (BatchNormali (None, None, None, 5 2048
conv5_block1_2_conv[0][0]
_____
_____
```

```
------------------
conv5_block1_2_relu (Activation (None, None, None, 5 0
conv5_block1_2_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block1_0_conv (Conv2D)    (None, None, None, 2 2099200
conv4_block6_out[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block1_3_conv (Conv2D)    (None, None, None, 2 1050624
conv5_block1_2_relu[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block1_0_bn (BatchNormali (None, None, None, 2 8192
conv5_block1_0_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block1_3_bn (BatchNormali (None, None, None, 2 8192
conv5_block1_3_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block1_add (Add)          (None, None, None, 2 0
conv5_block1_0_bn[0][0]
conv5_block1_3_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block1_out (Activation)   (None, None, None, 2 0
conv5_block1_add[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block2_1_conv (Conv2D)    (None, None, None, 5 1049088
conv5_block1_out[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block2_1_bn (BatchNormali (None, None, None, 5 2048
conv5_block2_1_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block2_1_relu (Activation (None, None, None, 5 0
conv5_block2_1_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block2_2_conv (Conv2D)    (None, None, None, 5 2359808
conv5_block2_1_relu[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block2_2_bn (BatchNormali (None, None, None, 5 2048
conv5_block2_2_conv[0][0]
```

```
--------------------------------------------------------------------------------
------------------
conv5_block2_2_relu (Activation (None, None, None, 5 0
conv5_block2_2_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block2_3_conv (Conv2D)    (None, None, None, 2 1050624
conv5_block2_2_relu[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block2_3_bn (BatchNormali (None, None, None, 2 8192
conv5_block2_3_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block2_add (Add)          (None, None, None, 2 0
conv5_block1_out[0][0]
conv5_block2_3_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block2_out (Activation)   (None, None, None, 2 0
conv5_block2_add[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block3_1_conv (Conv2D)    (None, None, None, 5 1049088
conv5_block2_out[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block3_1_bn (BatchNormali (None, None, None, 5 2048
conv5_block3_1_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block3_1_relu (Activation (None, None, None, 5 0
conv5_block3_1_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block3_2_conv (Conv2D)    (None, None, None, 5 2359808
conv5_block3_1_relu[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block3_2_bn (BatchNormali (None, None, None, 5 2048
conv5_block3_2_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block3_2_relu (Activation (None, None, None, 5 0
conv5_block3_2_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block3_3_conv (Conv2D)    (None, None, None, 2 1050624
```

```
                                     conv5_block3_2_relu[0][0]

----------------------------------------------------------------------------
------------------
conv5_block3_3_bn (BatchNormali (None, None, None, 2 8192
conv5_block3_3_conv[0][0]

----------------------------------------------------------------------------
------------------
conv5_block3_add (Add)          (None, None, None, 2 0
conv5_block2_out[0][0]
                                                         conv5_block3_3_bn[0][0]

----------------------------------------------------------------------------
------------------
conv5_block3_out (Activation)   (None, None, None, 2 0
conv5_block3_add[0][0]

----------------------------------------------------------------------------
------------------
global_average_pooling2d_3 (Glo (None, 2048)         0
conv5_block3_out[0][0]

----------------------------------------------------------------------------
------------------
dense_6 (Dense)                 (None, 1024)         2098176
global_average_pooling2d_3[0][0]

----------------------------------------------------------------------------
------------------
dense_7 (Dense)                 (None, 3)            3075       dense_6[0][0]
============================================================================
==================
Total params: 25,688,963
Trainable params: 2,101,251
Non-trainable params: 23,587,712

----------------------------------------------------------------------------
------------------
Epoch 1/10

2022-04-13 18:32:23.800773: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

72/72 [==============================] - ETA: 0s - loss: 0.5123 - accuracy:
0.8753

2022-04-13 18:33:02.642954: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

72/72 [==============================] - 49s 656ms/step - loss: 0.5123 -
accuracy: 0.8753 - val_loss: 0.0585 - val_accuracy: 0.9807
Epoch 2/10
72/72 [==============================] - 47s 646ms/step - loss: 0.0325 -
accuracy: 0.9897 - val_loss: 0.0391 - val_accuracy: 0.9912
```

```
Epoch 3/10
72/72 [==============================] - 47s 630ms/step - loss: 0.0171 -
accuracy: 0.9947 - val_loss: 0.0318 - val_accuracy: 0.9868
Epoch 4/10
72/72 [==============================] - 47s 640ms/step - loss: 0.0206 -
accuracy: 0.9928 - val_loss: 0.0152 - val_accuracy: 0.9930
Epoch 5/10
72/72 [==============================] - 48s 655ms/step - loss: 0.0100 -
accuracy: 0.9974 - val_loss: 0.0122 - val_accuracy: 0.9947
Epoch 6/10
72/72 [==============================] - 51s 690ms/step - loss: 0.0067 -
accuracy: 0.9987 - val_loss: 0.0169 - val_accuracy: 0.9938
Epoch 7/10
72/72 [==============================] - 50s 672ms/step - loss: 0.0047 -
accuracy: 0.9991 - val_loss: 0.0187 - val_accuracy: 0.9947
Epoch 8/10
72/72 [==============================] - 47s 645ms/step - loss: 0.0048 -
accuracy: 0.9982 - val_loss: 0.0157 - val_accuracy: 0.9930
Epoch 9/10
72/72 [==============================] - 46s 615ms/step - loss: 0.0051 -
accuracy: 0.9985 - val_loss: 0.0099 - val_accuracy: 0.9982
Epoch 10/10
72/72 [==============================] - 46s 618ms/step - loss: 0.0039 -
accuracy: 0.9991 - val_loss: 0.0080 - val_accuracy: 0.9965

/Users/yuuki/.pyenv/versions/miniforge3/envs/tensorflow/lib/python3.9/site-
packages/tensorflow/python/keras/utils/generic_utils.py:494: CustomMaskWarning:
Custom mask layers require a config and must override get_config. When loading,
the custom mask layer must be passed to the custom_objects argument.
  warnings.warn('Custom mask layers require a config and must override '
```

```
[ ]: generate_accuracy_graph(potato_history)
```
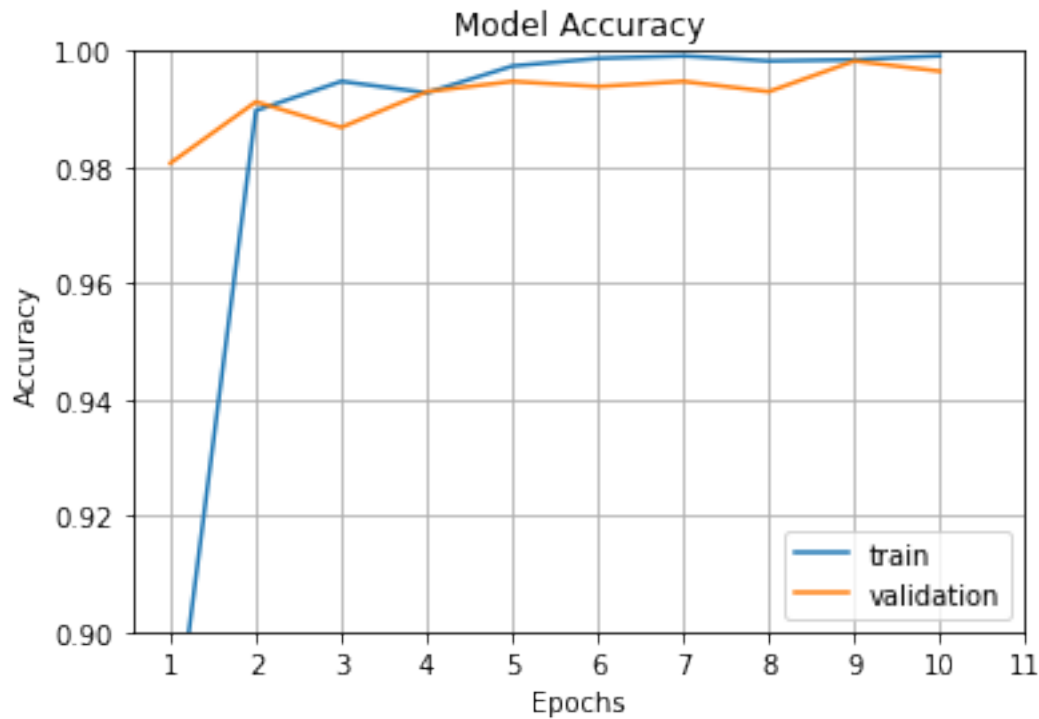
Model Accuracy

```
saved_model = load_model('potato_model.h5')
test_loss, test_acc = saved_model.evaluate(test_potato_generator, verbose=2)
print(f"\nTest accuracy: {test_acc}")
```

```
2022-04-13 18:40:37.651294: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
```

```
1426/1426 - 32s - loss: 0.0047 - accuracy: 0.9986
```

```
Test accuracy: 0.9985974431037903
```

1.4   Model for tomato

```
tomato_history = generate_ResNet50_model(
    train_tomato_generator,
    valid_tomato_generator,
    "tomato_model.h5"
    )
```

```
Model: "model_4"
_____
_____
Layer (type)                    Output Shape         Param #     Connected to
=================================================================================
```

```
==================
input_5 (InputLayer)            [(None, None, None,  0
---------------------------------------------------------------------------
------------------
conv1_pad (ZeroPadding2D)       (None, None, None, 3 0           input_5[0][0]
---------------------------------------------------------------------------
------------------
conv1_conv (Conv2D)             (None, None, None, 6 9472        conv1_pad[0][0]
---------------------------------------------------------------------------
------------------
conv1_bn (BatchNormalization)   (None, None, None, 6 256
conv1_conv[0][0]
---------------------------------------------------------------------------
------------------
conv1_relu (Activation)         (None, None, None, 6 0           conv1_bn[0][0]
---------------------------------------------------------------------------
------------------
pool1_pad (ZeroPadding2D)       (None, None, None, 6 0
conv1_relu[0][0]
---------------------------------------------------------------------------
------------------
pool1_pool (MaxPooling2D)       (None, None, None, 6 0           pool1_pad[0][0]
---------------------------------------------------------------------------
------------------
conv2_block1_1_conv (Conv2D)    (None, None, None, 6 4160
pool1_pool[0][0]
---------------------------------------------------------------------------
------------------
conv2_block1_1_bn (BatchNormali (None, None, None, 6 256
conv2_block1_1_conv[0][0]
---------------------------------------------------------------------------
------------------
conv2_block1_1_relu (Activation (None, None, None, 6 0
conv2_block1_1_bn[0][0]
---------------------------------------------------------------------------
------------------
conv2_block1_2_conv (Conv2D)    (None, None, None, 6 36928
conv2_block1_1_relu[0][0]
---------------------------------------------------------------------------
------------------
conv2_block1_2_bn (BatchNormali (None, None, None, 6 256
conv2_block1_2_conv[0][0]
---------------------------------------------------------------------------
------------------
conv2_block1_2_relu (Activation (None, None, None, 6 0
conv2_block1_2_bn[0][0]
---------------------------------------------------------------------------
------------------
```

```
conv2_block1_0_conv (Conv2D)    (None, None, None, 2 16640
pool1_pool[0][0]
--------------------------------------------------------------------------------
------------------
conv2_block1_3_conv (Conv2D)    (None, None, None, 2 16640
conv2_block1_2_relu[0][0]
--------------------------------------------------------------------------------
------------------
conv2_block1_0_bn (BatchNormali (None, None, None, 2 1024
conv2_block1_0_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv2_block1_3_bn (BatchNormali (None, None, None, 2 1024
conv2_block1_3_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv2_block1_add (Add)          (None, None, None, 2 0
conv2_block1_0_bn[0][0]
conv2_block1_3_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv2_block1_out (Activation)   (None, None, None, 2 0
conv2_block1_add[0][0]
--------------------------------------------------------------------------------
------------------
conv2_block2_1_conv (Conv2D)    (None, None, None, 6 16448
conv2_block1_out[0][0]
--------------------------------------------------------------------------------
------------------
conv2_block2_1_bn (BatchNormali (None, None, None, 6 256
conv2_block2_1_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv2_block2_1_relu (Activation (None, None, None, 6 0
conv2_block2_1_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv2_block2_2_conv (Conv2D)    (None, None, None, 6 36928
conv2_block2_1_relu[0][0]
--------------------------------------------------------------------------------
------------------
conv2_block2_2_bn (BatchNormali (None, None, None, 6 256
conv2_block2_2_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv2_block2_2_relu (Activation (None, None, None, 6 0
conv2_block2_2_bn[0][0]
--------------------------------------------------------------------------------
```

```
------------------
conv2_block2_3_conv (Conv2D)    (None, None, None, 2 16640
conv2_block2_2_relu[0][0]

--------------------------------------------------------------------------------
------------------
conv2_block2_3_bn (BatchNormali (None, None, None, 2 1024
conv2_block2_3_conv[0][0]

--------------------------------------------------------------------------------
------------------
conv2_block2_add (Add)          (None, None, None, 2 0
conv2_block1_out[0][0]
conv2_block2_3_bn[0][0]

--------------------------------------------------------------------------------
------------------
conv2_block2_out (Activation)   (None, None, None, 2 0
conv2_block2_add[0][0]

--------------------------------------------------------------------------------
------------------
conv2_block3_1_conv (Conv2D)    (None, None, None, 6 16448
conv2_block2_out[0][0]

--------------------------------------------------------------------------------
------------------
conv2_block3_1_bn (BatchNormali (None, None, None, 6 256
conv2_block3_1_conv[0][0]

--------------------------------------------------------------------------------
------------------
conv2_block3_1_relu (Activation (None, None, None, 6 0
conv2_block3_1_bn[0][0]

--------------------------------------------------------------------------------
------------------
conv2_block3_2_conv (Conv2D)    (None, None, None, 6 36928
conv2_block3_1_relu[0][0]

--------------------------------------------------------------------------------
------------------
conv2_block3_2_bn (BatchNormali (None, None, None, 6 256
conv2_block3_2_conv[0][0]

--------------------------------------------------------------------------------
------------------
conv2_block3_2_relu (Activation (None, None, None, 6 0
conv2_block3_2_bn[0][0]

--------------------------------------------------------------------------------
------------------
conv2_block3_3_conv (Conv2D)    (None, None, None, 2 16640
conv2_block3_2_relu[0][0]

--------------------------------------------------------------------------------
------------------
conv2_block3_3_bn (BatchNormali (None, None, None, 2 1024
conv2_block3_3_conv[0][0]
```

```
--------------------------------------------------------------------------------
------------------
conv2_block3_add (Add)          (None, None, None, 2 0
conv2_block2_out[0][0]
conv2_block3_3_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv2_block3_out (Activation)   (None, None, None, 2 0
conv2_block3_add[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block1_1_conv (Conv2D)    (None, None, None, 1 32896
conv2_block3_out[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block1_1_bn (BatchNormali (None, None, None, 1 512
conv3_block1_1_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block1_1_relu (Activation (None, None, None, 1 0
conv3_block1_1_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block1_2_conv (Conv2D)    (None, None, None, 1 147584
conv3_block1_1_relu[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block1_2_bn (BatchNormali (None, None, None, 1 512
conv3_block1_2_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block1_2_relu (Activation (None, None, None, 1 0
conv3_block1_2_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block1_0_conv (Conv2D)    (None, None, None, 5 131584
conv2_block3_out[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block1_3_conv (Conv2D)    (None, None, None, 5 66048
conv3_block1_2_relu[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block1_0_bn (BatchNormali (None, None, None, 5 2048
conv3_block1_0_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block1_3_bn (BatchNormali (None, None, None, 5 2048
```

```
conv3_block1_3_conv[0][0]
_____
_____
conv3_block1_add (Add)          (None, None, None, 5 0
conv3_block1_0_bn[0][0]
conv3_block1_3_bn[0][0]
_____
_____
conv3_block1_out (Activation)   (None, None, None, 5 0
conv3_block1_add[0][0]
_____
_____
conv3_block2_1_conv (Conv2D)    (None, None, None, 1 65664
conv3_block1_out[0][0]
_____
_____
conv3_block2_1_bn (BatchNormali (None, None, None, 1 512
conv3_block2_1_conv[0][0]
_____
_____
conv3_block2_1_relu (Activation (None, None, None, 1 0
conv3_block2_1_bn[0][0]
_____
_____
conv3_block2_2_conv (Conv2D)    (None, None, None, 1 147584
conv3_block2_1_relu[0][0]
_____
_____
conv3_block2_2_bn (BatchNormali (None, None, None, 1 512
conv3_block2_2_conv[0][0]
_____
_____
conv3_block2_2_relu (Activation (None, None, None, 1 0
conv3_block2_2_bn[0][0]
_____
_____
conv3_block2_3_conv (Conv2D)    (None, None, None, 5 66048
conv3_block2_2_relu[0][0]
_____
_____
conv3_block2_3_bn (BatchNormali (None, None, None, 5 2048
conv3_block2_3_conv[0][0]
_____
_____
conv3_block2_add (Add)          (None, None, None, 5 0
conv3_block1_out[0][0]
conv3_block2_3_bn[0][0]
_____
```

```
------------------
conv3_block2_out (Activation)   (None, None, None, 5 0
conv3_block2_add[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block3_1_conv (Conv2D)    (None, None, None, 1 65664
conv3_block2_out[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block3_1_bn (BatchNormali (None, None, None, 1 512
conv3_block3_1_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block3_1_relu (Activation (None, None, None, 1 0
conv3_block3_1_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block3_2_conv (Conv2D)    (None, None, None, 1 147584
conv3_block3_1_relu[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block3_2_bn (BatchNormali (None, None, None, 1 512
conv3_block3_2_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block3_2_relu (Activation (None, None, None, 1 0
conv3_block3_2_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block3_3_conv (Conv2D)    (None, None, None, 5 66048
conv3_block3_2_relu[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block3_3_bn (BatchNormali (None, None, None, 5 2048
conv3_block3_3_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block3_add (Add)          (None, None, None, 5 0
conv3_block2_out[0][0]
conv3_block3_3_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block3_out (Activation)   (None, None, None, 5 0
conv3_block3_add[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block4_1_conv (Conv2D)    (None, None, None, 1 65664
conv3_block3_out[0][0]
```

```
--------------------------------------------------------------------------------
------------------
conv3_block4_1_bn (BatchNormali (None, None, None, 1 512
conv3_block4_1_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block4_1_relu (Activation (None, None, None, 1 0
conv3_block4_1_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block4_2_conv (Conv2D)    (None, None, None, 1 147584
conv3_block4_1_relu[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block4_2_bn (BatchNormali (None, None, None, 1 512
conv3_block4_2_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block4_2_relu (Activation (None, None, None, 1 0
conv3_block4_2_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block4_3_conv (Conv2D)    (None, None, None, 5 66048
conv3_block4_2_relu[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block4_3_bn (BatchNormali (None, None, None, 5 2048
conv3_block4_3_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block4_add (Add)          (None, None, None, 5 0
conv3_block3_out[0][0]
conv3_block4_3_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv3_block4_out (Activation)   (None, None, None, 5 0
conv3_block4_add[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block1_1_conv (Conv2D)    (None, None, None, 2 131328
conv3_block4_out[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block1_1_bn (BatchNormali (None, None, None, 2 1024
conv4_block1_1_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block1_1_relu (Activation (None, None, None, 2 0
```

```
conv4_block1_1_bn[0][0]
_____
_____
conv4_block1_2_conv (Conv2D)    (None, None, None, 2 590080
conv4_block1_1_relu[0][0]
_____
_____
conv4_block1_2_bn (BatchNormali (None, None, None, 2 1024
conv4_block1_2_conv[0][0]
_____
_____
conv4_block1_2_relu (Activation (None, None, None, 2 0
conv4_block1_2_bn[0][0]
_____
_____
conv4_block1_0_conv (Conv2D)    (None, None, None, 1 525312
conv3_block4_out[0][0]
_____
_____
conv4_block1_3_conv (Conv2D)    (None, None, None, 1 263168
conv4_block1_2_relu[0][0]
_____
_____
conv4_block1_0_bn (BatchNormali (None, None, None, 1 4096
conv4_block1_0_conv[0][0]
_____
_____
conv4_block1_3_bn (BatchNormali (None, None, None, 1 4096
conv4_block1_3_conv[0][0]
_____
_____
conv4_block1_add (Add)          (None, None, None, 1 0
conv4_block1_0_bn[0][0]
conv4_block1_3_bn[0][0]
_____
_____
conv4_block1_out (Activation)   (None, None, None, 1 0
conv4_block1_add[0][0]
_____
_____
conv4_block2_1_conv (Conv2D)    (None, None, None, 2 262400
conv4_block1_out[0][0]
_____
_____
conv4_block2_1_bn (BatchNormali (None, None, None, 2 1024
conv4_block2_1_conv[0][0]
_____
_____
```

```
conv4_block2_1_relu (Activation (None, None, None, 2 0
conv4_block2_1_bn[0][0]
_____
_____
conv4_block2_2_conv (Conv2D)     (None, None, None, 2 590080
conv4_block2_1_relu[0][0]
_____
_____
conv4_block2_2_bn (BatchNormali (None, None, None, 2 1024
conv4_block2_2_conv[0][0]
_____
_____
conv4_block2_2_relu (Activation (None, None, None, 2 0
conv4_block2_2_bn[0][0]
_____
_____
conv4_block2_3_conv (Conv2D)     (None, None, None, 1 263168
conv4_block2_2_relu[0][0]
_____
_____
conv4_block2_3_bn (BatchNormali (None, None, None, 1 4096
conv4_block2_3_conv[0][0]
_____
_____
conv4_block2_add (Add)           (None, None, None, 1 0
conv4_block1_out[0][0]
conv4_block2_3_bn[0][0]
_____
_____
conv4_block2_out (Activation)    (None, None, None, 1 0
conv4_block2_add[0][0]
_____
_____
conv4_block3_1_conv (Conv2D)     (None, None, None, 2 262400
conv4_block2_out[0][0]
_____
_____
conv4_block3_1_bn (BatchNormali (None, None, None, 2 1024
conv4_block3_1_conv[0][0]
_____
_____
conv4_block3_1_relu (Activation (None, None, None, 2 0
conv4_block3_1_bn[0][0]
_____
_____
conv4_block3_2_conv (Conv2D)     (None, None, None, 2 590080
conv4_block3_1_relu[0][0]
_____
_____
```

```
------------------
conv4_block3_2_bn (BatchNormali (None, None, None, 2 1024
conv4_block3_2_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block3_2_relu (Activation (None, None, None, 2 0
conv4_block3_2_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block3_3_conv (Conv2D)    (None, None, None, 1 263168
conv4_block3_2_relu[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block3_3_bn (BatchNormali (None, None, None, 1 4096
conv4_block3_3_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block3_add (Add)          (None, None, None, 1 0
conv4_block2_out[0][0]
conv4_block3_3_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block3_out (Activation)   (None, None, None, 1 0
conv4_block3_add[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block4_1_conv (Conv2D)    (None, None, None, 2 262400
conv4_block3_out[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block4_1_bn (BatchNormali (None, None, None, 2 1024
conv4_block4_1_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block4_1_relu (Activation (None, None, None, 2 0
conv4_block4_1_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block4_2_conv (Conv2D)    (None, None, None, 2 590080
conv4_block4_1_relu[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block4_2_bn (BatchNormali (None, None, None, 2 1024
conv4_block4_2_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block4_2_relu (Activation (None, None, None, 2 0
conv4_block4_2_bn[0][0]
```

```
--------------------------------------------------------------------------------
------------------
conv4_block4_3_conv (Conv2D)     (None, None, None, 1 263168
conv4_block4_2_relu[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block4_3_bn (BatchNormali (None, None, None, 1 4096
conv4_block4_3_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block4_add (Add)          (None, None, None, 1 0
conv4_block3_out[0][0]
conv4_block4_3_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block4_out (Activation)   (None, None, None, 1 0
conv4_block4_add[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block5_1_conv (Conv2D)     (None, None, None, 2 262400
conv4_block4_out[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block5_1_bn (BatchNormali (None, None, None, 2 1024
conv4_block5_1_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block5_1_relu (Activation (None, None, None, 2 0
conv4_block5_1_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block5_2_conv (Conv2D)     (None, None, None, 2 590080
conv4_block5_1_relu[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block5_2_bn (BatchNormali (None, None, None, 2 1024
conv4_block5_2_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block5_2_relu (Activation (None, None, None, 2 0
conv4_block5_2_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block5_3_conv (Conv2D)     (None, None, None, 1 263168
conv4_block5_2_relu[0][0]
--------------------------------------------------------------------------------
------------------
conv4_block5_3_bn (BatchNormali (None, None, None, 1 4096
```

```
conv4_block5_3_conv[0][0]
_____
_____
conv4_block5_add (Add)          (None, None, None, 1 0
conv4_block4_out[0][0]
conv4_block5_3_bn[0][0]
_____
_____
conv4_block5_out (Activation)   (None, None, None, 1 0
conv4_block5_add[0][0]
_____
_____
conv4_block6_1_conv (Conv2D)    (None, None, None, 2 262400
conv4_block5_out[0][0]
_____
_____
conv4_block6_1_bn (BatchNormali (None, None, None, 2 1024
conv4_block6_1_conv[0][0]
_____
_____
conv4_block6_1_relu (Activation (None, None, None, 2 0
conv4_block6_1_bn[0][0]
_____
_____
conv4_block6_2_conv (Conv2D)    (None, None, None, 2 590080
conv4_block6_1_relu[0][0]
_____
_____
conv4_block6_2_bn (BatchNormali (None, None, None, 2 1024
conv4_block6_2_conv[0][0]
_____
_____
conv4_block6_2_relu (Activation (None, None, None, 2 0
conv4_block6_2_bn[0][0]
_____
_____
conv4_block6_3_conv (Conv2D)    (None, None, None, 1 263168
conv4_block6_2_relu[0][0]
_____
_____
conv4_block6_3_bn (BatchNormali (None, None, None, 1 4096
conv4_block6_3_conv[0][0]
_____
_____
conv4_block6_add (Add)          (None, None, None, 1 0
conv4_block5_out[0][0]
conv4_block6_3_bn[0][0]
_____
_____
```

```
------------------
conv4_block6_out (Activation)   (None, None, None, 1 0
conv4_block6_add[0][0]
_____
------------------
conv5_block1_1_conv (Conv2D)    (None, None, None, 5 524800
conv4_block6_out[0][0]
_____
------------------
conv5_block1_1_bn (BatchNormali (None, None, None, 5 2048
conv5_block1_1_conv[0][0]
_____
------------------
conv5_block1_1_relu (Activation (None, None, None, 5 0
conv5_block1_1_bn[0][0]
_____
------------------
conv5_block1_2_conv (Conv2D)    (None, None, None, 5 2359808
conv5_block1_1_relu[0][0]
_____
------------------
conv5_block1_2_bn (BatchNormali (None, None, None, 5 2048
conv5_block1_2_conv[0][0]
_____
------------------
conv5_block1_2_relu (Activation (None, None, None, 5 0
conv5_block1_2_bn[0][0]
_____
------------------
conv5_block1_0_conv (Conv2D)    (None, None, None, 2 2099200
conv4_block6_out[0][0]
_____
------------------
conv5_block1_3_conv (Conv2D)    (None, None, None, 2 1050624
conv5_block1_2_relu[0][0]
_____
------------------
conv5_block1_0_bn (BatchNormali (None, None, None, 2 8192
conv5_block1_0_conv[0][0]
_____
------------------
conv5_block1_3_bn (BatchNormali (None, None, None, 2 8192
conv5_block1_3_conv[0][0]
_____
------------------
conv5_block1_add (Add)          (None, None, None, 2 0
conv5_block1_0_bn[0][0]
conv5_block1_3_bn[0][0]
```

```
--------------------------------------------------------------------------------
------------------
conv5_block1_out (Activation)   (None, None, None, 2 0
conv5_block1_add[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block2_1_conv (Conv2D)    (None, None, None, 5 1049088
conv5_block1_out[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block2_1_bn (BatchNormali (None, None, None, 5 2048
conv5_block2_1_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block2_1_relu (Activation (None, None, None, 5 0
conv5_block2_1_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block2_2_conv (Conv2D)    (None, None, None, 5 2359808
conv5_block2_1_relu[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block2_2_bn (BatchNormali (None, None, None, 5 2048
conv5_block2_2_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block2_2_relu (Activation (None, None, None, 5 0
conv5_block2_2_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block2_3_conv (Conv2D)    (None, None, None, 2 1050624
conv5_block2_2_relu[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block2_3_bn (BatchNormali (None, None, None, 2 8192
conv5_block2_3_conv[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block2_add (Add)          (None, None, None, 2 0
conv5_block1_out[0][0]
conv5_block2_3_bn[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block2_out (Activation)   (None, None, None, 2 0
conv5_block2_add[0][0]
--------------------------------------------------------------------------------
------------------
conv5_block3_1_conv (Conv2D)    (None, None, None, 5 1049088
```

```
conv5_block2_out[0][0]
_____
_____
conv5_block3_1_bn (BatchNormali (None, None, None, 5 2048
conv5_block3_1_conv[0][0]
_____
_____
conv5_block3_1_relu (Activation (None, None, None, 5 0
conv5_block3_1_bn[0][0]
_____
_____
conv5_block3_2_conv (Conv2D)    (None, None, None, 5 2359808
conv5_block3_1_relu[0][0]
_____
_____
conv5_block3_2_bn (BatchNormali (None, None, None, 5 2048
conv5_block3_2_conv[0][0]
_____
_____
conv5_block3_2_relu (Activation (None, None, None, 5 0
conv5_block3_2_bn[0][0]
_____
_____
conv5_block3_3_conv (Conv2D)    (None, None, None, 2 1050624
conv5_block3_2_relu[0][0]
_____
_____
conv5_block3_3_bn (BatchNormali (None, None, None, 2 8192
conv5_block3_3_conv[0][0]
_____
_____
conv5_block3_add (Add)          (None, None, None, 2 0
conv5_block2_out[0][0]
conv5_block3_3_bn[0][0]
_____
_____
conv5_block3_out (Activation)   (None, None, None, 2 0
conv5_block3_add[0][0]
_____
_____
global_average_pooling2d_4 (Glo (None, 2048)         0
conv5_block3_out[0][0]
_____
_____
dense_8 (Dense)                 (None, 1024)         2098176
global_average_pooling2d_4[0][0]
_____
_____
```

```
dense_9 (Dense)                  (None, 10)            10250       dense_8[0][0]
================================================================================
==================
Total params: 25,696,138
Trainable params: 2,108,426
Non-trainable params: 23,587,712
_____
_____
Epoch 1/10

2022-04-13 18:41:11.840838: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

230/230 [==============================] - ETA: 0s - loss: 0.4180 - accuracy:
0.8704

2022-04-13 18:43:09.326148: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

230/230 [==============================] - 149s 634ms/step - loss: 0.4180 -
accuracy: 0.8704 - val_loss: 0.4991 - val_accuracy: 0.8315
Epoch 2/10
230/230 [==============================] - 136s 585ms/step - loss: 0.1625 -
accuracy: 0.9442 - val_loss: 0.1637 - val_accuracy: 0.9386
Epoch 3/10
230/230 [==============================] - 136s 590ms/step - loss: 0.0983 -
accuracy: 0.9671 - val_loss: 0.1240 - val_accuracy: 0.9550
Epoch 4/10
230/230 [==============================] - 135s 584ms/step - loss: 0.0938 -
accuracy: 0.9688 - val_loss: 0.1345 - val_accuracy: 0.9542
Epoch 5/10
230/230 [==============================] - 133s 577ms/step - loss: 0.0779 -
accuracy: 0.9724 - val_loss: 0.1959 - val_accuracy: 0.9384
Epoch 6/10
230/230 [==============================] - 135s 584ms/step - loss: 0.0742 -
accuracy: 0.9728 - val_loss: 0.2134 - val_accuracy: 0.9346
Epoch 7/10
230/230 [==============================] - 134s 579ms/step - loss: 0.0662 -
accuracy: 0.9756 - val_loss: 0.1198 - val_accuracy: 0.9577
Epoch 8/10
230/230 [==============================] - 133s 579ms/step - loss: 0.0561 -
accuracy: 0.9819 - val_loss: 0.1288 - val_accuracy: 0.9569
Epoch 9/10
230/230 [==============================] - 136s 589ms/step - loss: 0.0508 -
accuracy: 0.9804 - val_loss: 0.1202 - val_accuracy: 0.9624
Epoch 10/10
230/230 [==============================] - 134s 581ms/step - loss: 0.0478 -
accuracy: 0.9830 - val_loss: 0.1766 - val_accuracy: 0.9441
```

```
[ ]: generate_accuracy_graph(tomato_history)
```
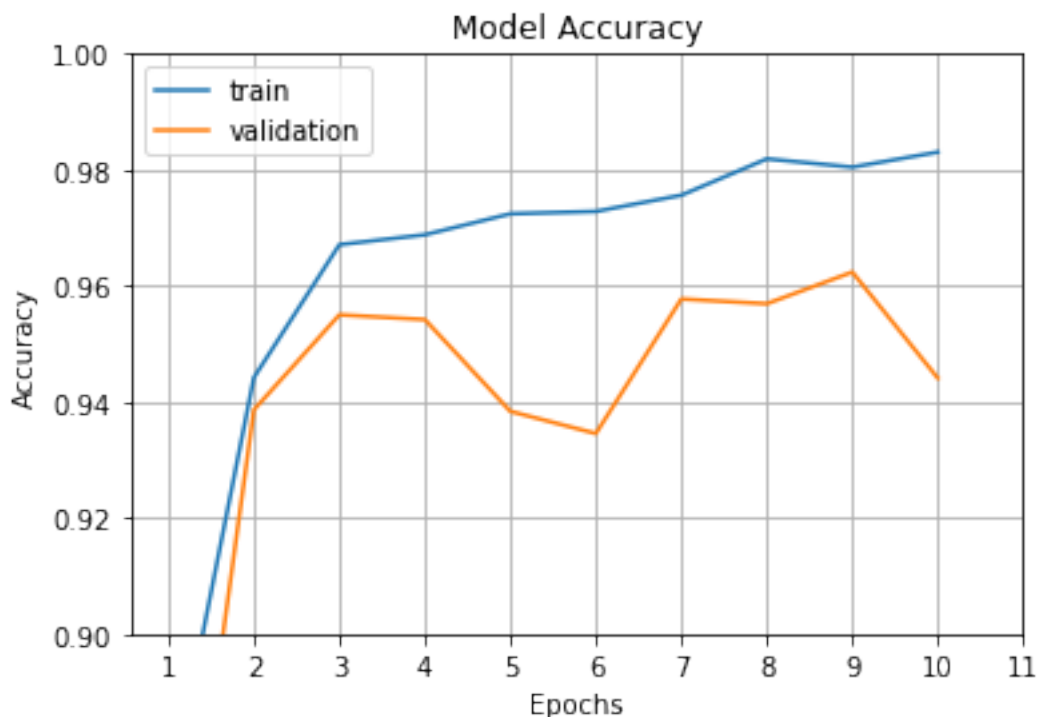

Model Accuracy

```
[ ]: saved_model = load_model('tomato_model.h5')
     test_loss, test_acc = saved_model.evaluate(test_tomato_generator, verbose=2)
     print(f"\nTest accuracy: {test_acc}")
```

2022-04-13 19:03:55.009864: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

4585/4585 - 100s - loss: 0.2075 - accuracy: 0.9381

Test accuracy: 0.9380588531494141

1.5   Graph representation of the result

```
[ ]: corn_model10 = load_model("model10/corn_model.h5")
     potato_model10 = load_model("model10/potato_model.h5")
     tomato_model10 = load_model("model10/tomato_model.h5")

     corn_model20 = load_model("model20/corn_model.h5")
     potato_model20 = load_model("model20/potato_model.h5")
     tomato_model20 = load_model("model20/tomato_model.h5")
```

```python
def generate_graph(model, test_generator):
    # filenames = test_generator.filenames
    nb_samples = len(test_generator)
    y_prob=[]
    y_act=[]
    test_generator.reset()

    for _ in range(nb_samples):
      x,y = test_generator.next()
      y_act.append(y)
      y_prob.append(model.predict(x))

    predicted_class = [list(test_generator.class_indices.keys())[i.argmax()] for
    ↪i in y_prob]
    actual_class = [list(test_generator.class_indices.keys())[i.argmax()] for i
    ↪in y_act]

    out_df = pd.DataFrame(
      np.vstack([predicted_class, actual_class]).T,
      columns=['Predicted', 'Actual']
      )

    confusion_matrix = pd.crosstab(
      out_df['Actual'],
      out_df['Predicted'],
      rownames=['Actual'],
      colnames=['Predicted']
      )

    sn.heatmap(
      confusion_matrix,
      cmap='Blues',
      annot=True, fmt='d'
    )

    plt.show()

    print("Test accuracy: {}".format((np.diagonal(confusion_matrix).sum() /
    ↪confusion_matrix.sum().sum()*100)))
```

1.5.1 Corn graph

10 epochs result

```python
generate_graph(corn_model10, test_corn_generator)
```

2022-04-13 19:05:37.847021: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]

Plugin optimizer for device_type GPU is enabled.
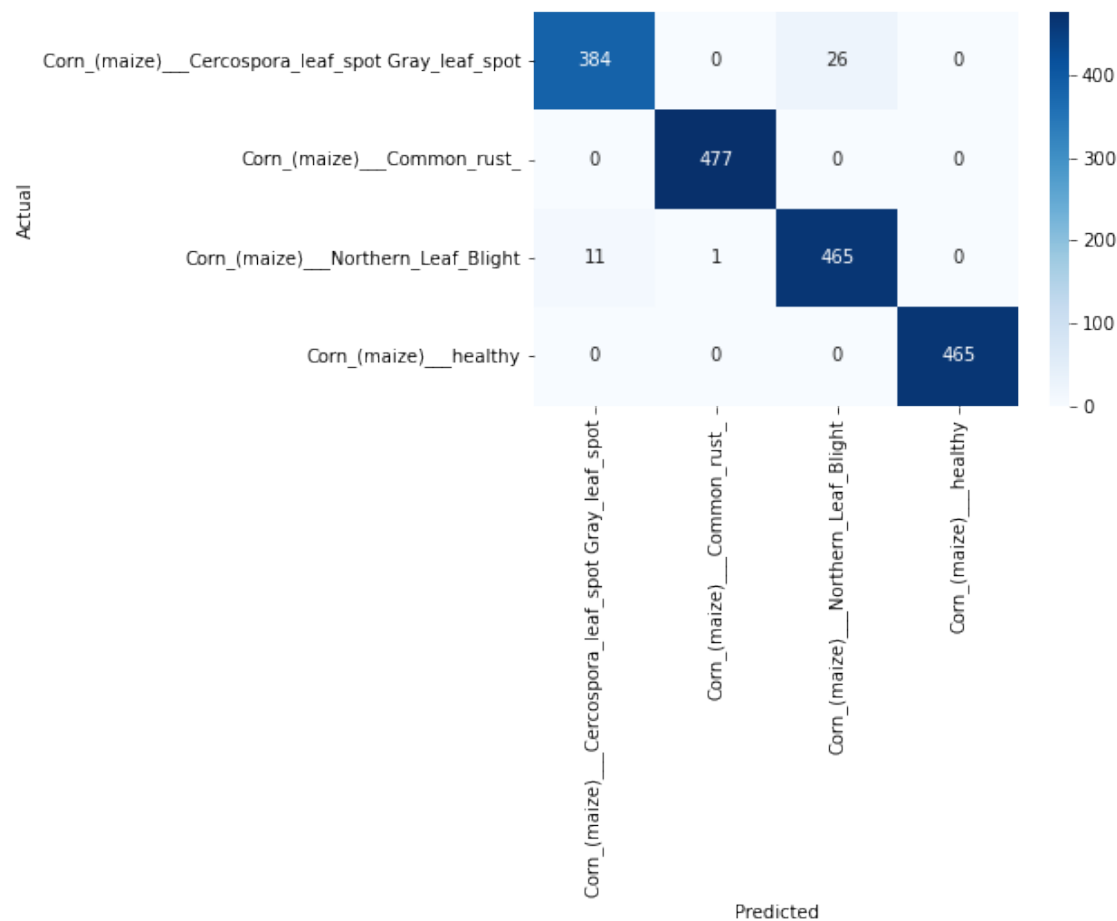
Test accuracy: 97.92236194641882

20 epochs result

```
[ ]: generate_graph(corn_model20, test_corn_generator)
```
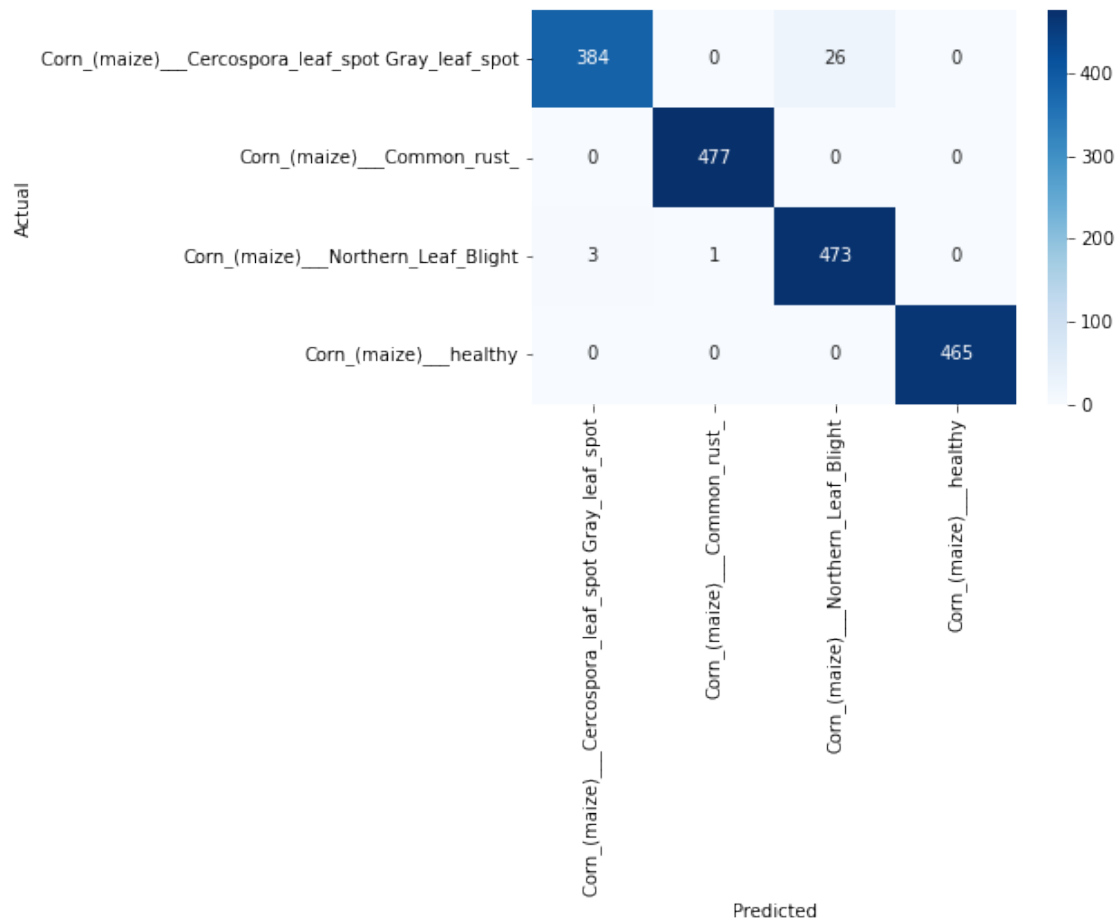
Test accuracy: 98.35975943138327

1.5.2 Potato graph

10 epochs results

```
[ ]: generate_graph(potato_model10, test_potato_generator)
```
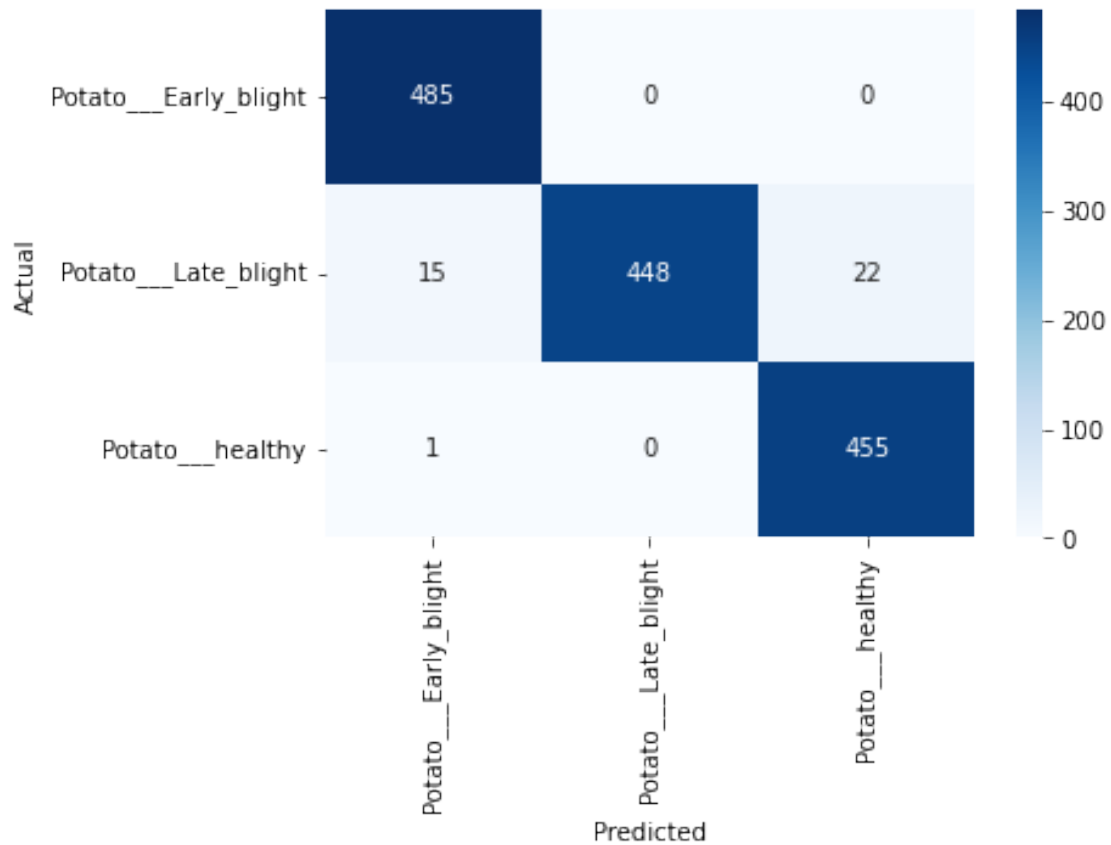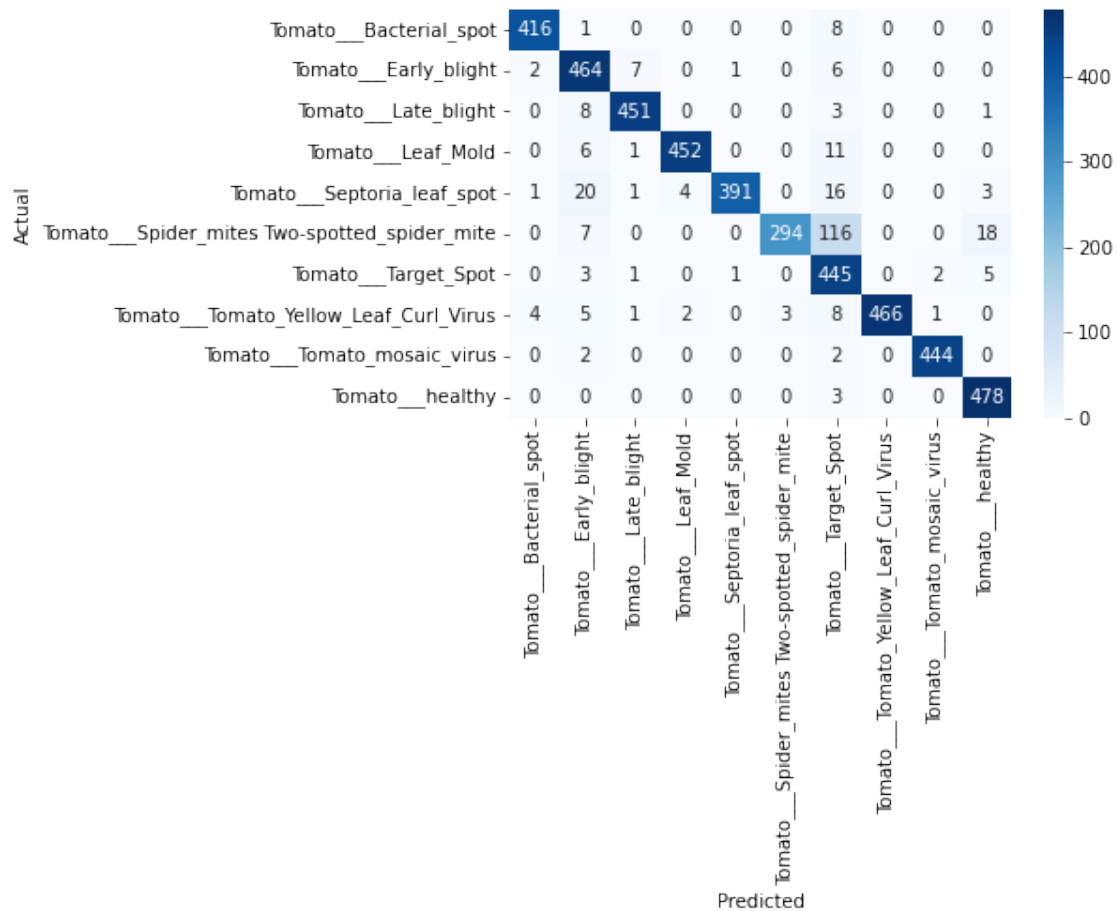
2022-04-13 19:06:36.648390: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
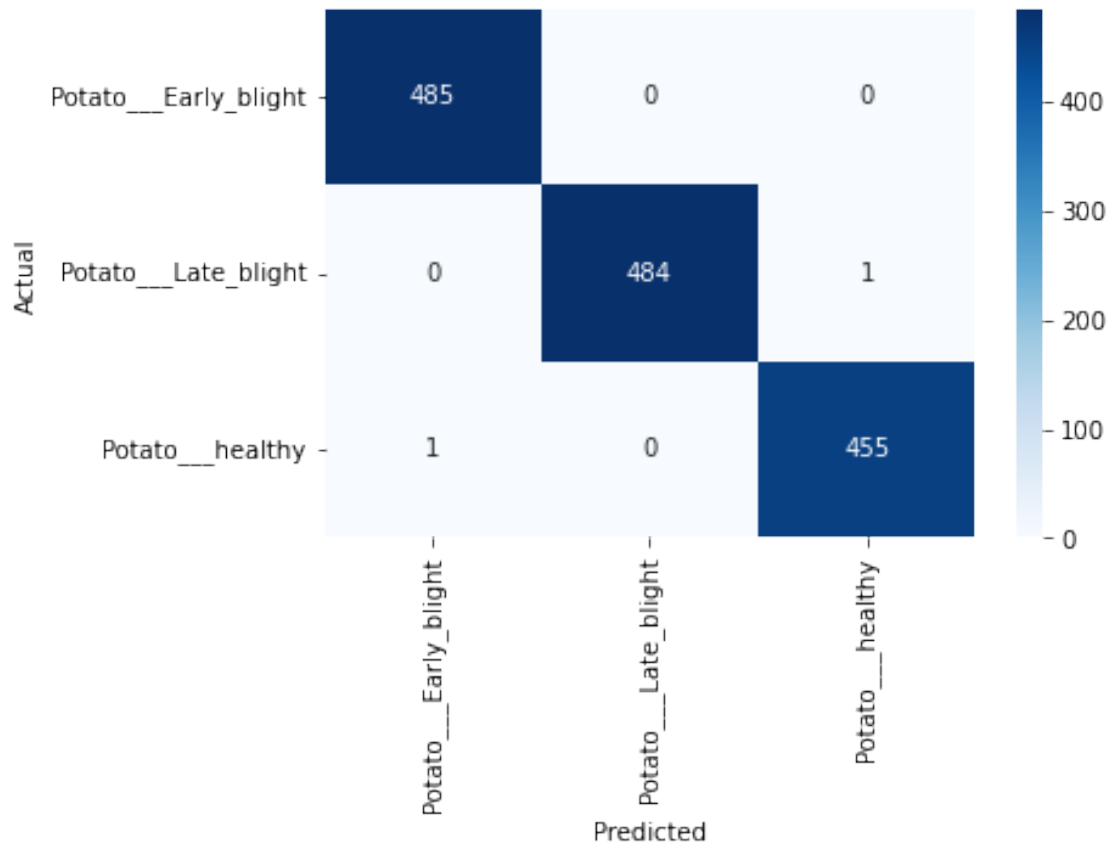
Test accuracy: 99.85974754558204

20 epochs result

```
generate_graph(potato_model20, test_potato_generator)
```

Test accuracy: 97.3352033660589

1.5.3 Tomato graph

10 epochs result

```
generate_graph(tomato_model10, test_tomato_generator)
```

2022-04-13 19:07:23.529094: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
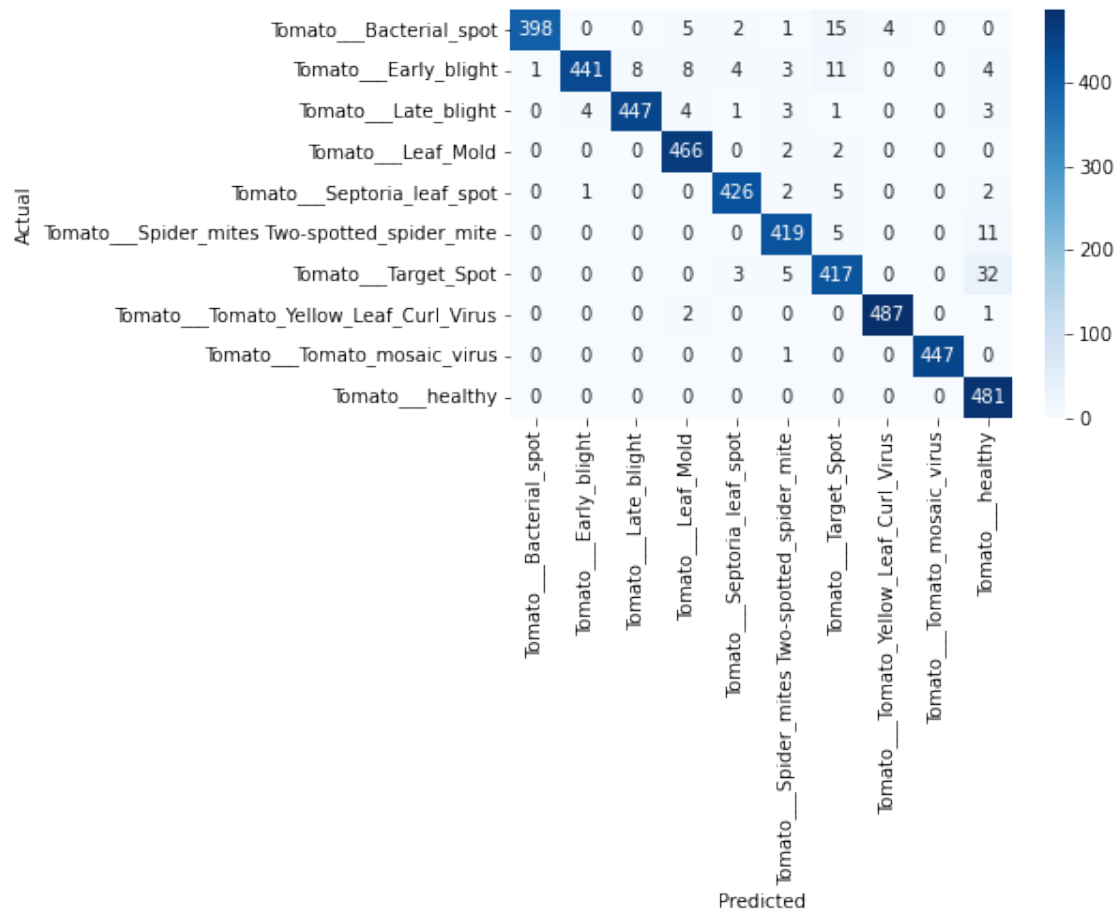Plugin optimizer for device_type GPU is enabled.

Test accuracy: 93.80588876772083

20 epochs result

```
[ ]: generate_graph(tomato_model20, test_tomato_generator)

2022-04-13 19:20:31.606501: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
```

Test accuracy: 96.59760087241003