CSC462 Machine Learning Date Project

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Problem:

There are many date fruit types in Saudi Arabia such as Ajwa, Medjoo, Nabtat Ali, etc. Some of these dates are very similar so at times you can't tell which is which, Then we want to design and build a machine learning-based image classification system based on a images of a date to learn and classify any given date image which date is it.

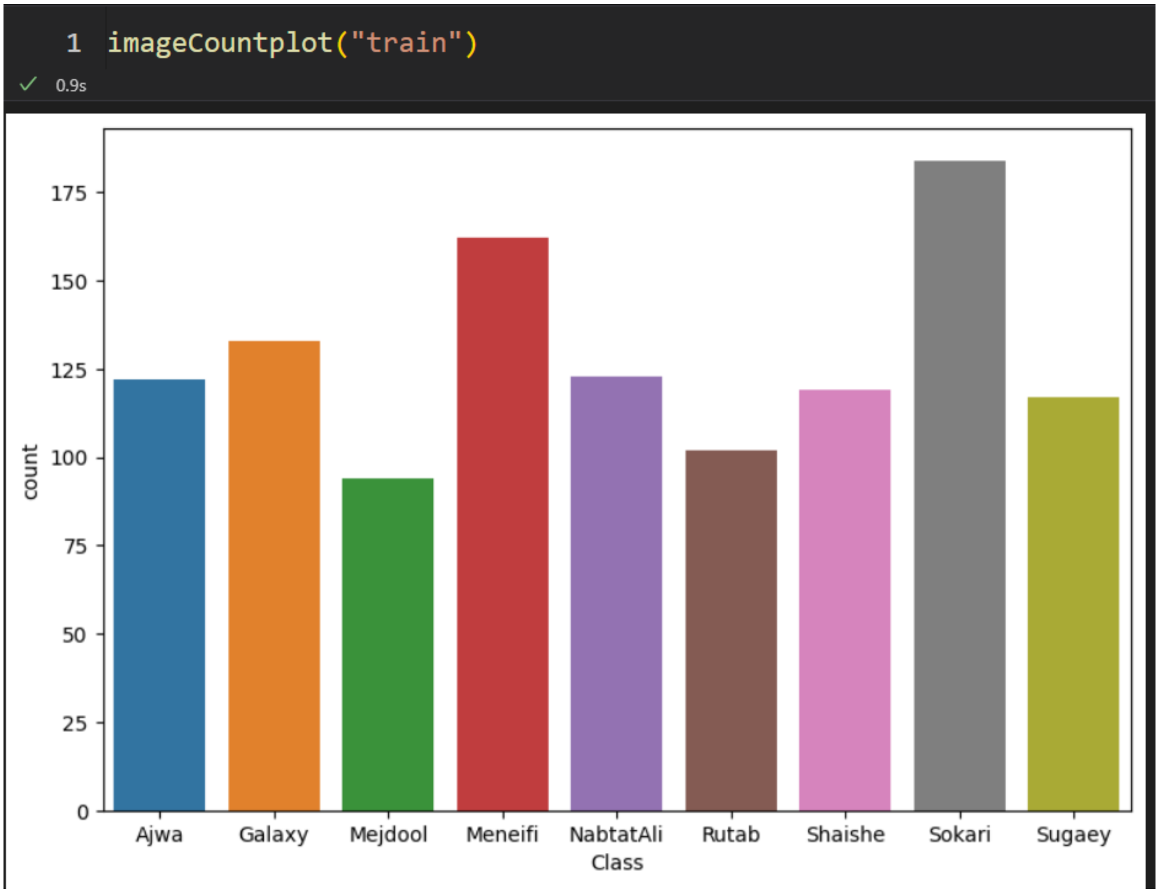
Roles:

Yasser : Data, Model, Training, Testing, tflite.

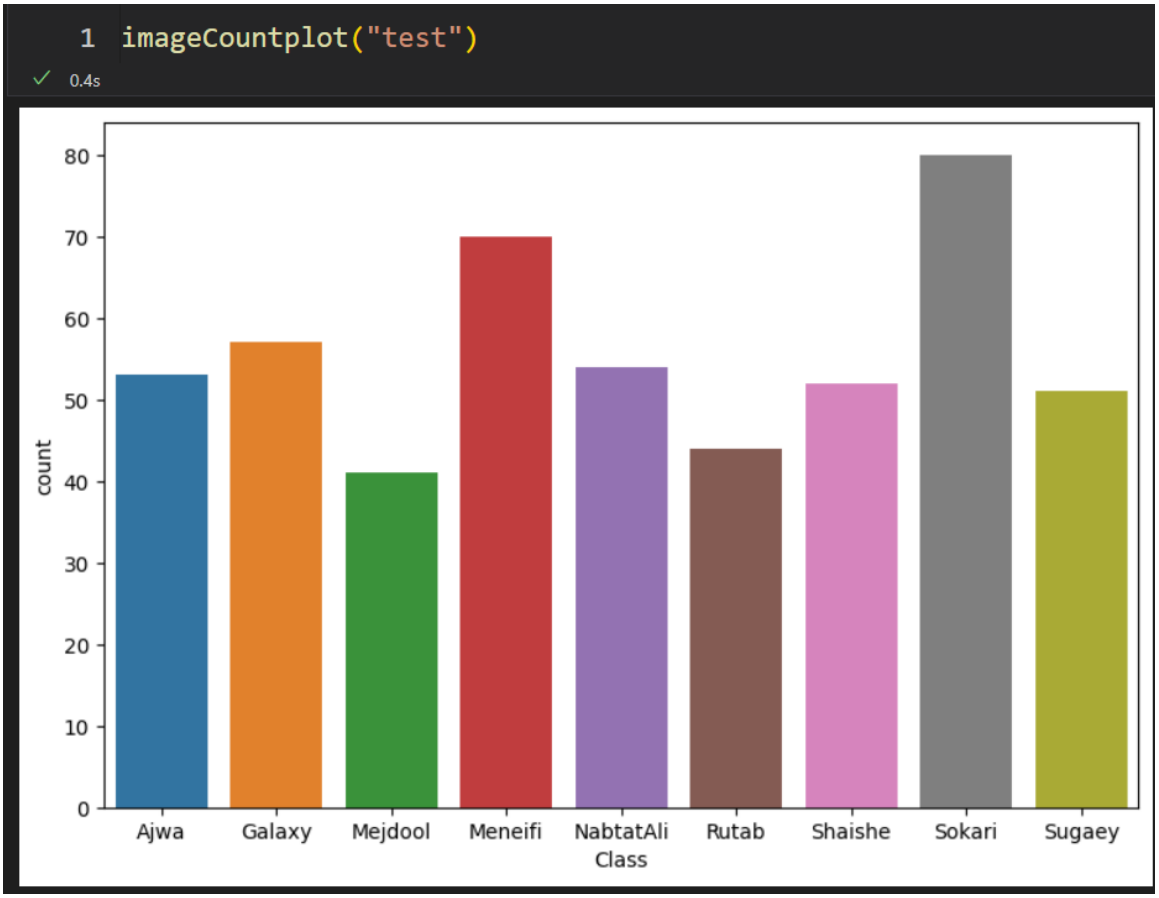
Rakan: Data, Visualizations, tflite, Mobile App.

Platform: Jupyter Notebook via Visual Studio.

Dataset Samples:



```
imageCountplot("train")
```



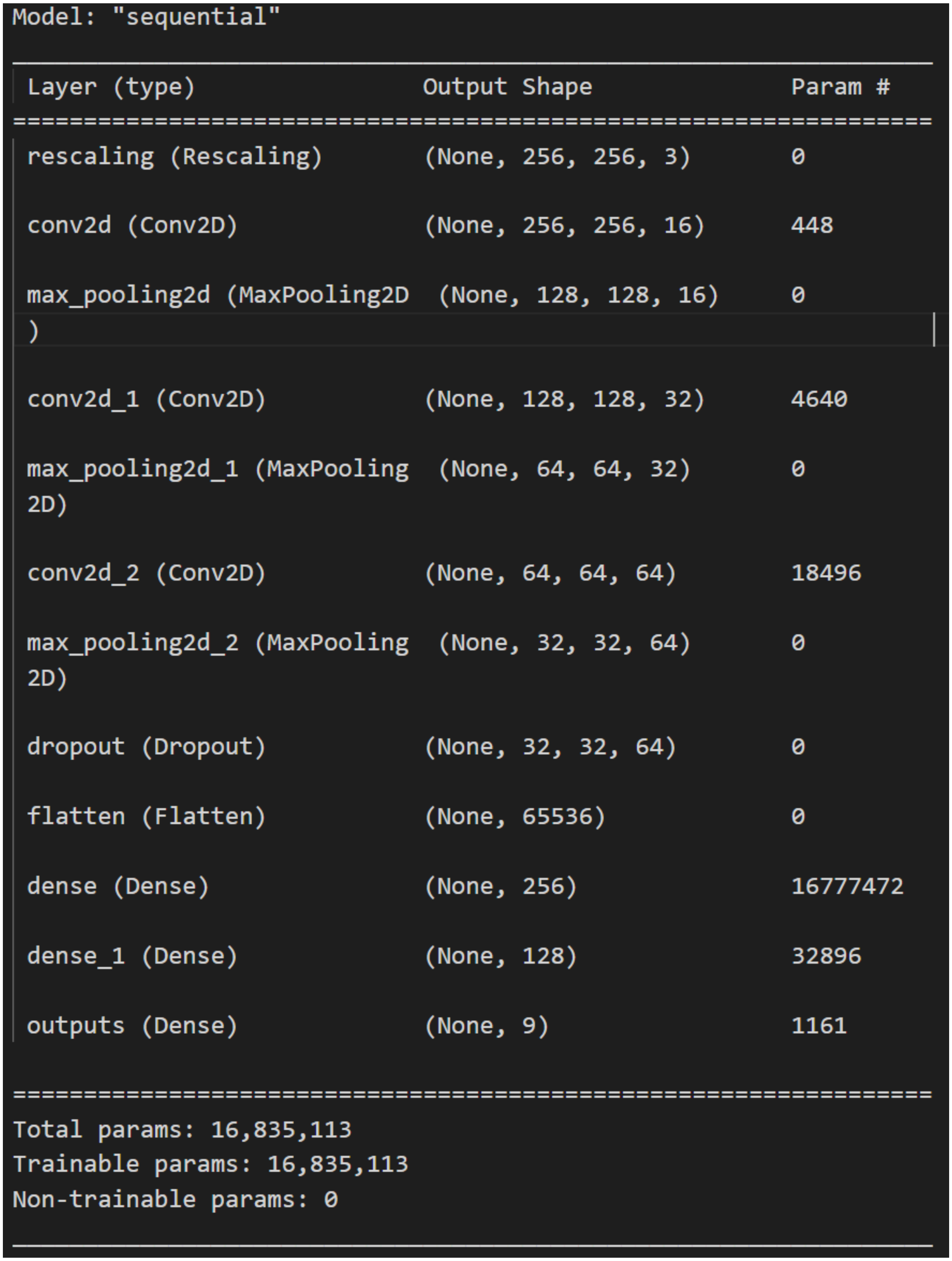
```
imageCountplot("test")
```

CNN Design:

The model is made of 12 layers.

1. Rescaling layer: to rescale normalize the image pixels.
2. convolutional layer with 16 nodes, and “relu” as an activation function.
3. MaxPooling layer after the convolutional layer
4. convolutional layer with 32 nodes, and “relu” as an activation function.
5. MaxPooling layer after the convolutional layer
6. convolutional layer with 64 nodes, and “relu” as an activation function.

7. MaxPooling layer after the convolutional layer
8. Dropout Layer with 30% chance of dropping a node.
9. Flatten Layer.
10. Dense Layer with 256 nodes, and “relu” as activation function.
11. Dense Layer with 128 nodes, and “relu” as activation function.
12. Dense Layer (Output) with number of classes (9) nodes.

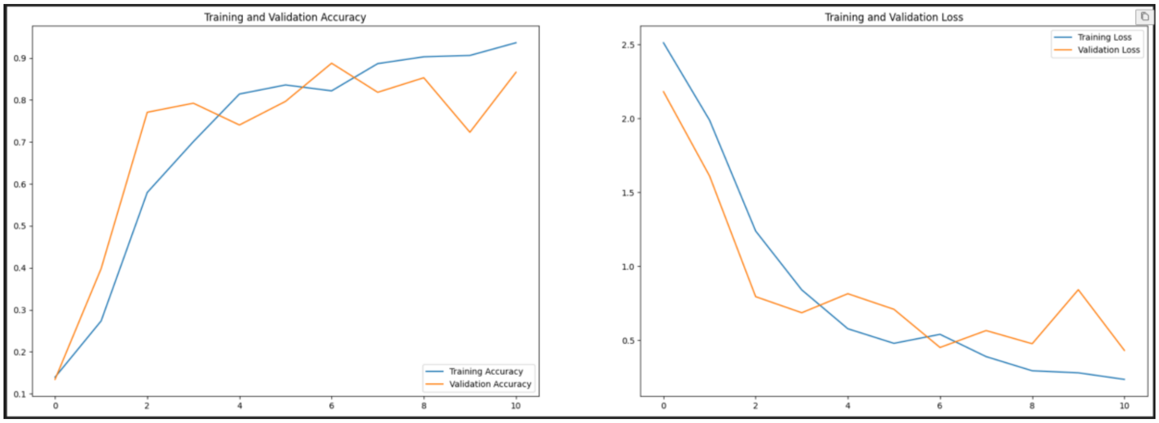


```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 rescaling (Rescaling)       (None, 256, 256, 3)       0

 conv2d (Conv2D)             (None, 256, 256, 16)      448

 max_pooling2d (MaxPooling2D  (None, 128, 128, 16)     0
 )

 conv2d_1 (Conv2D)           (None, 128, 128, 32)      4640

 max_pooling2d_1 (MaxPooling  (None, 64, 64, 32)       0
 2D)

 conv2d_2 (Conv2D)           (None, 64, 64, 64)        18496

 max_pooling2d_2 (MaxPooling  (None, 32, 32, 64)       0
 2D)

 dropout (Dropout)           (None, 32, 32, 64)        0

 flatten (Flatten)           (None, 65536)             0

 dense (Dense)               (None, 256)               16777472

 dense_1 (Dense)             (None, 128)               32896

 outputs (Dense)             (None, 9)                 1161

=================================================================
Total params: 16,835,113
Trainable params: 16,835,113
Non-trainable params: 0
_________________________________________________________________
```

Optimizer: Adam

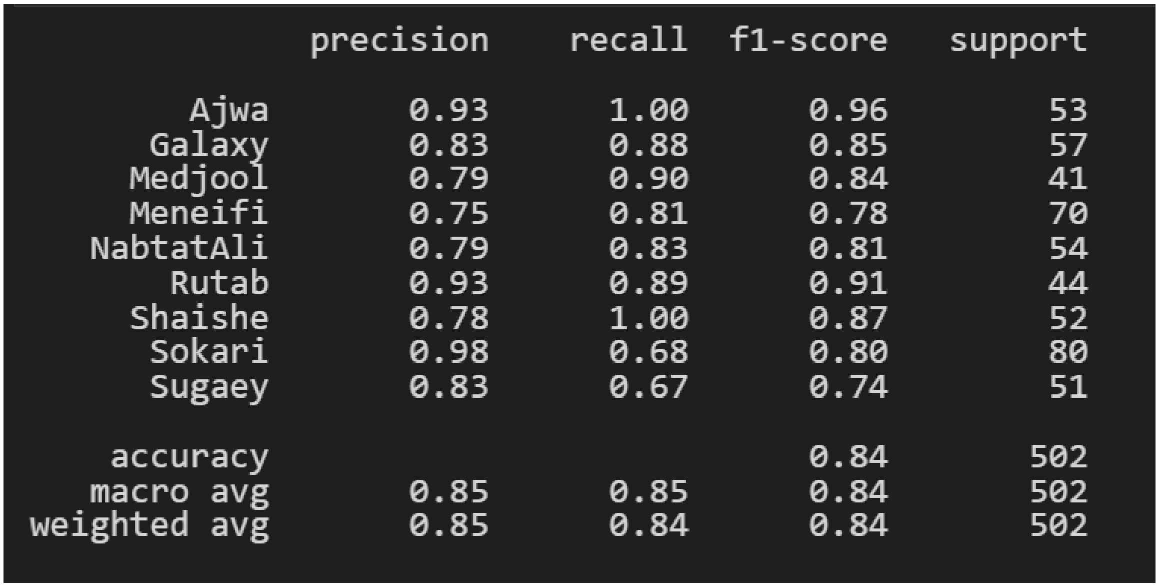
Number of Epochs: 11

Plots of Loss and Accuracy:



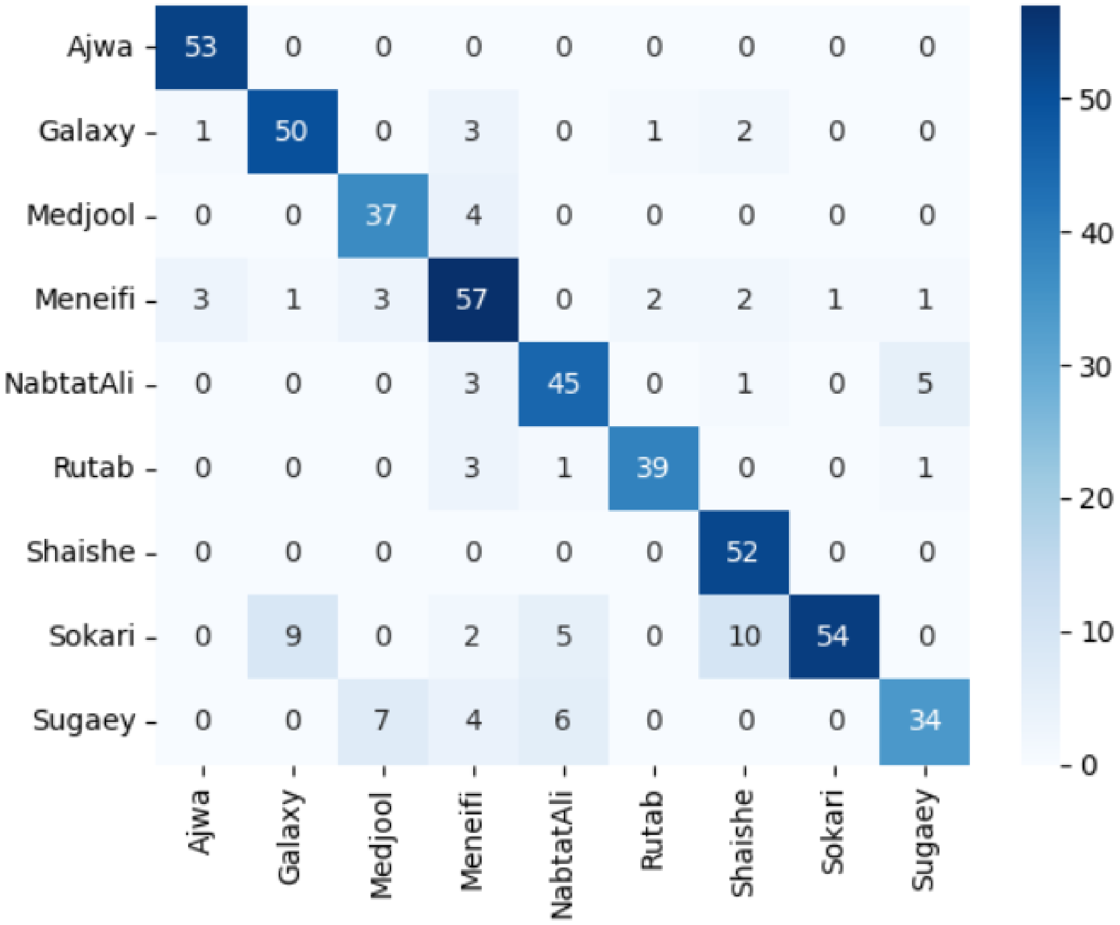
Evaluation Results:

1- **Classification Report:**



```
              precision    recall  f1-score   support

        Ajwa       0.93      1.00      0.96        53
      Galaxy       0.83      0.88      0.85        57
     Medjool       0.79      0.90      0.84        41
     Meneifi       0.75      0.81      0.78        70
   NabtatAli       0.79      0.83      0.81        54
       Rutab       0.93      0.89      0.91        44
     Shaishe       0.78      1.00      0.87        52
      Sokari       0.98      0.68      0.80        80
      Sugaey       0.83      0.67      0.74        51

    accuracy                           0.84       502
   macro avg       0.85      0.85      0.84       502
weighted avg       0.85      0.84      0.84       502
```

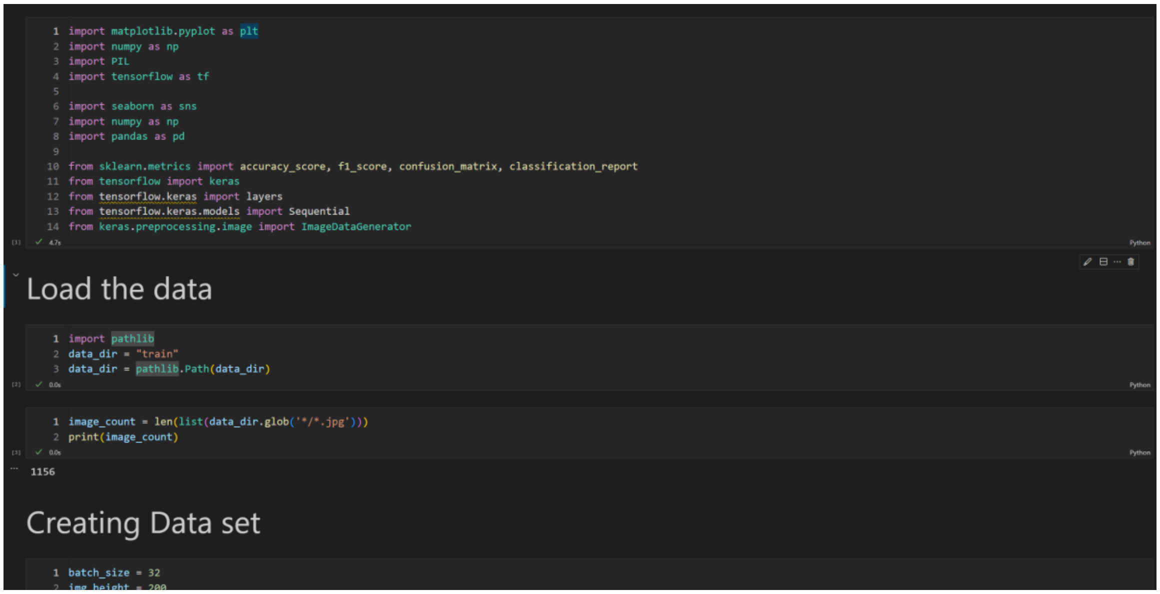
2- **Confusion Matrix:**



	Ajwa	Galaxy	Medjool	Meneifi	NabtatAli	Rutab	Shaishe	Sokari	Sugaey
Ajwa	53	0	0	0	0	0	0	0	0
Galaxy	1	50	0	3	0	1	2	0	0
Medjool	0	0	37	4	0	0	0	0	0
Meneifi	3	1	3	57	0	2	2	1	1
NabtatAli	0	0	0	3	45	0	1	0	5
Rutab	0	0	0	3	1	39	0	0	1
Shaishe	0	0	0	0	0	0	52	0	0
Sokari	0	9	0	2	5	0	10	54	0
Sugaey	0	0	7	4	6	0	0	0	34

Screenshots:

1- Source Code:



```
import matplotlib.pyplot as plt
import numpy as np
import PIL
import tensorflow as tf

import seaborn as sns
import numpy as np
import pandas as pd

from sklearn.metrics import accuracy_score, f1_score, confusion_matrix, classification_report
from tensorflow import keras
from tensorflow.keras import layers
from tensorflow.keras.models import Sequential
from keras.preprocessing.image import ImageDataGenerator
```

Load the data

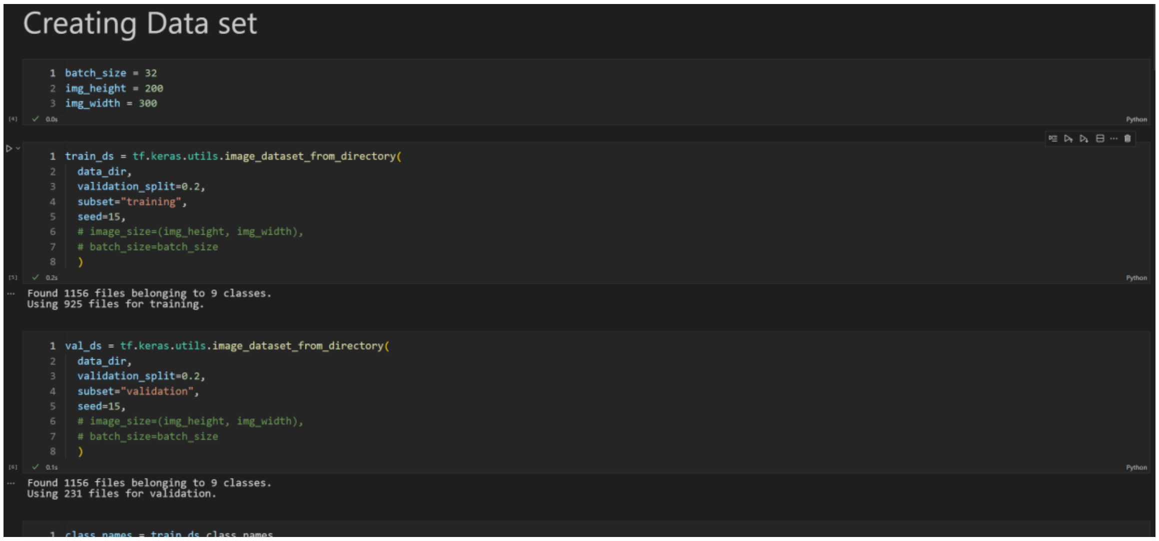
```
import pathlib
data_dir = "train"
data_dir = pathlib.Path(data_dir)
```

```
image_count = len(list(data_dir.glob('*/*.jpg')))
print(image_count)
```

```
1156
```

Creating Data set

```
batch_size = 32
img_height = 200
```



Creating Data set

```
batch_size = 32
img_height = 200
img_width = 300
```

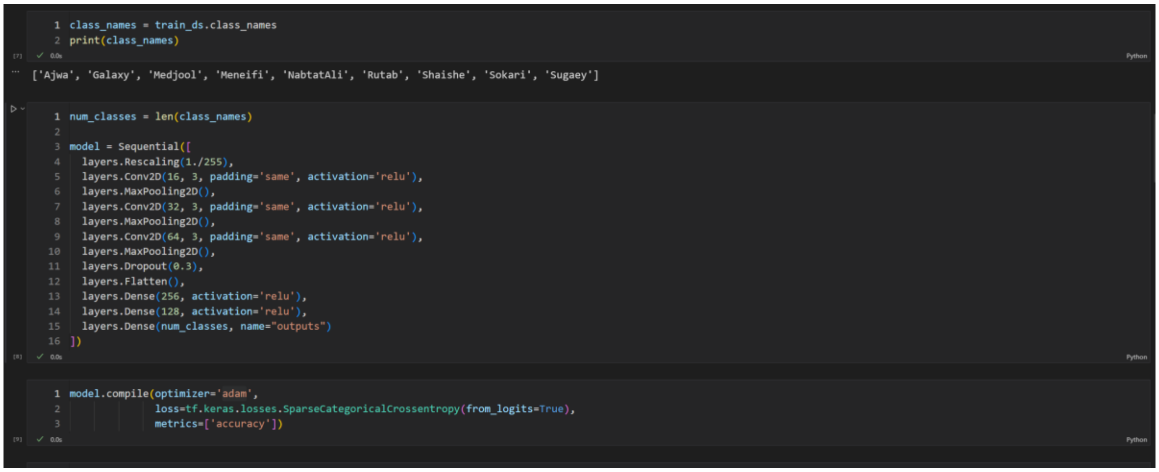
```
train_ds = tf.keras.utils.image_dataset_from_directory(
  data_dir,
  validation_split=0.2,
  subset="training",
  seed=15,
  # image_size=(img_height, img_width),
  # batch_size=batch_size
  )
```

```
Found 1156 files belonging to 9 classes.
Using 925 files for training.
```

```
val_ds = tf.keras.utils.image_dataset_from_directory(
  data_dir,
  validation_split=0.2,
  subset="validation",
  seed=15,
  # image_size=(img_height, img_width),
  # batch_size=batch_size
  )
```

```
Found 1156 files belonging to 9 classes.
Using 231 files for validation.
```

```
class_names = train_ds.class_names
```

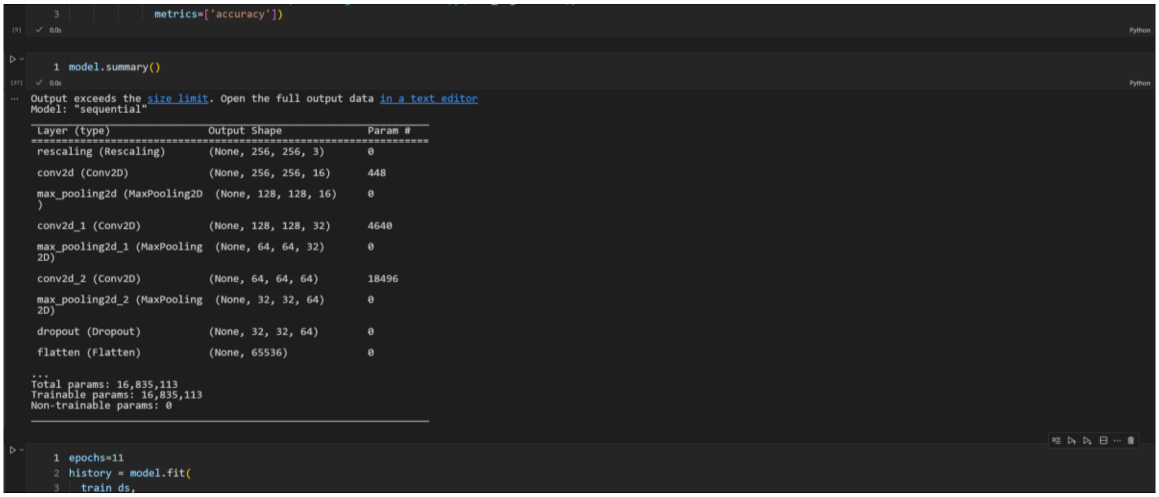


```python
class_names = train_ds.class_names
print(class_names)
```

```
['Ajwa', 'Galaxy', 'Medjool', 'Meneifi', 'NabtatAli', 'Rutab', 'Shaishe', 'Sokari', 'Sugaey']
```

```python
num_classes = len(class_names)

model = Sequential([
  layers.Rescaling(1./255),
  layers.Conv2D(16, 3, padding='same', activation='relu'),
  layers.MaxPooling2D(),
  layers.Conv2D(32, 3, padding='same', activation='relu'),
  layers.MaxPooling2D(),
  layers.Conv2D(64, 3, padding='same', activation='relu'),
  layers.MaxPooling2D(),
  layers.Dropout(0.3),
  layers.Flatten(),
  layers.Dense(256, activation='relu'),
  layers.Dense(128, activation='relu'),
  layers.Dense(num_classes, name="outputs")
])
```

```python
model.compile(optimizer='adam',
              loss=tf.keras.losses.SparseCategoricalCrossentropy(from_logits=True),
              metrics=['accuracy'])
```



```python
              metrics=['accuracy'])
```

```python
model.summary()
```

```
Output exceeds the size limit. Open the full output data in a text editor
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 rescaling (Rescaling)       (None, 256, 256, 3)       0

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 2D)

 dropout (Dropout)           (None, 32, 32, 64)        0

 flatten (Flatten)           (None, 65536)             0

...
Total params: 16,835,113
Trainable params: 16,835,113
Non-trainable params: 0
_________________________________________________________________
```
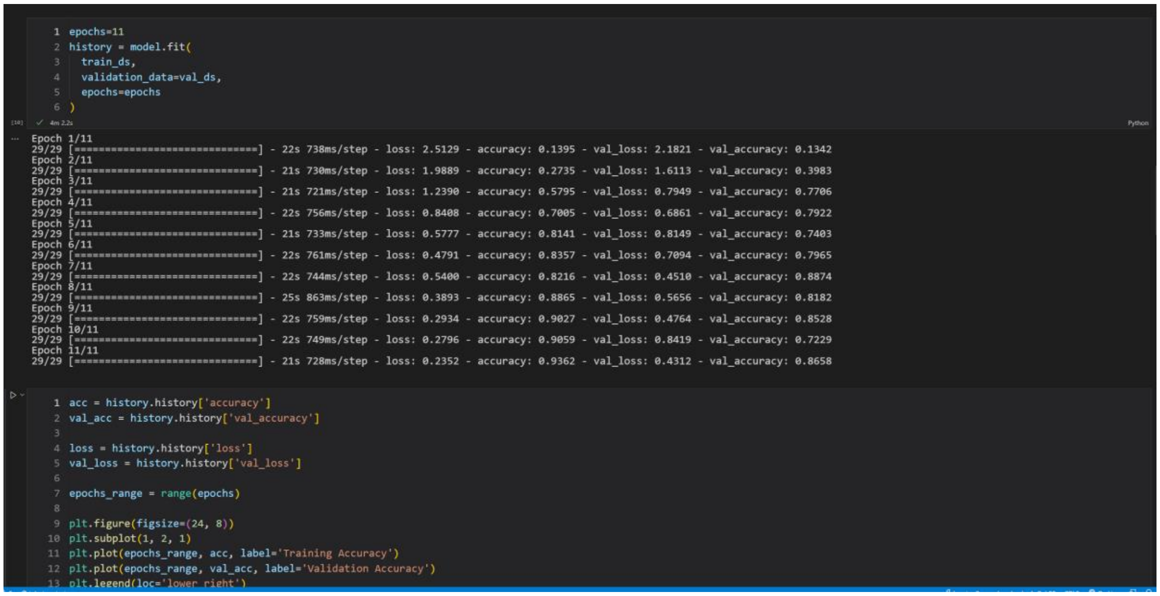
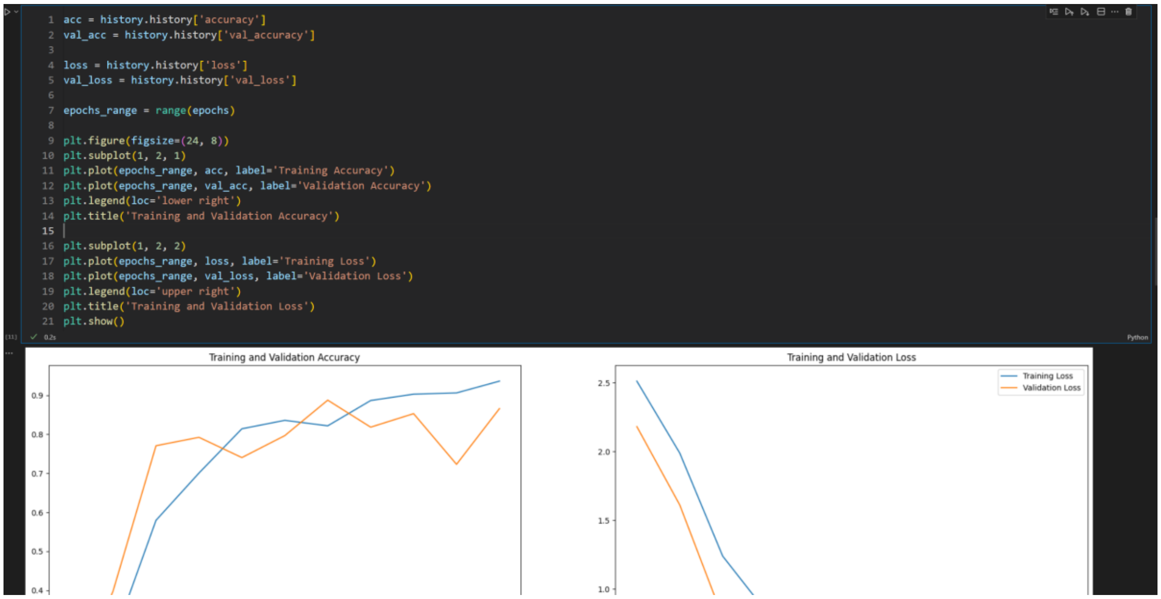

```python
epochs=11
history = model.fit(
  train_ds,
```



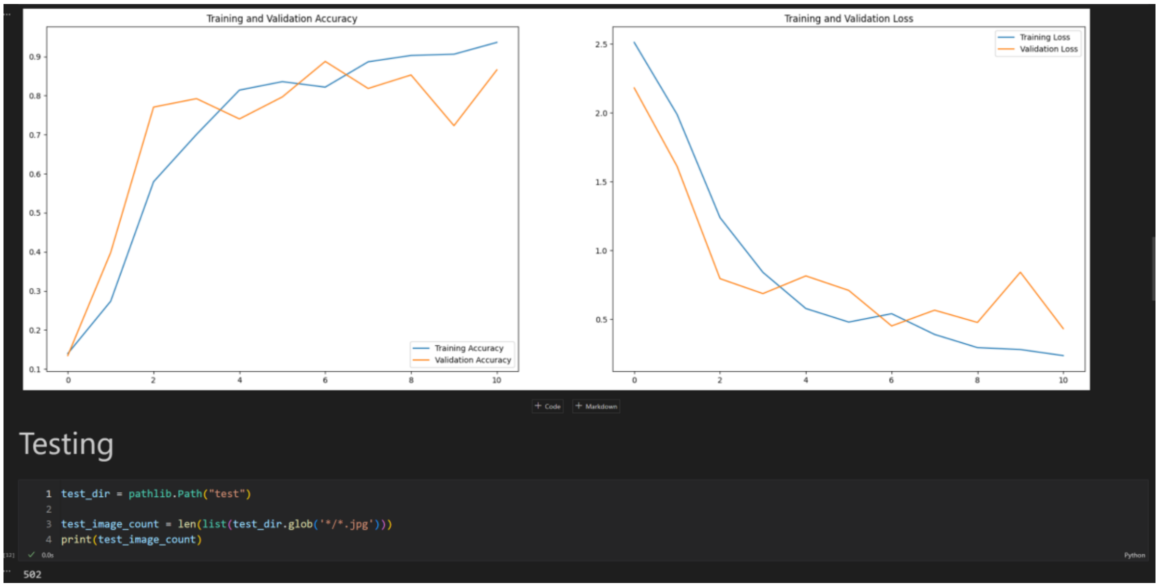
```python
epochs=11
history = model.fit(
  train_ds,
  validation_data=val_ds,
  epochs=epochs
)
```

```
Epoch 1/11
29/29 [==============================] - 22s 738ms/step - loss: 2.5129 - accuracy: 0.1395 - val_loss: 2.1821 - val_accuracy: 0.1342
Epoch 2/11
29/29 [==============================] - 21s 730ms/step - loss: 1.9889 - accuracy: 0.2735 - val_loss: 1.6113 - val_accuracy: 0.3983
Epoch 3/11
29/29 [==============================] - 21s 721ms/step - loss: 1.2390 - accuracy: 0.5795 - val_loss: 0.7949 - val_accuracy: 0.7706
Epoch 4/11
29/29 [==============================] - 22s 756ms/step - loss: 0.8408 - accuracy: 0.7005 - val_loss: 0.6861 - val_accuracy: 0.7922
Epoch 5/11
29/29 [==============================] - 21s 733ms/step - loss: 0.5777 - accuracy: 0.8141 - val_loss: 0.8149 - val_accuracy: 0.7403
Epoch 6/11
29/29 [==============================] - 22s 761ms/step - loss: 0.4791 - accuracy: 0.8357 - val_loss: 0.7094 - val_accuracy: 0.7965
Epoch 7/11
29/29 [==============================] - 22s 744ms/step - loss: 0.5400 - accuracy: 0.8216 - val_loss: 0.4510 - val_accuracy: 0.8874
Epoch 8/11
29/29 [==============================] - 25s 863ms/step - loss: 0.3893 - accuracy: 0.8865 - val_loss: 0.5656 - val_accuracy: 0.8182
Epoch 9/11
29/29 [==============================] - 22s 759ms/step - loss: 0.2934 - accuracy: 0.9027 - val_loss: 0.4764 - val_accuracy: 0.8528
Epoch 10/11
29/29 [==============================] - 22s 749ms/step - loss: 0.2796 - accuracy: 0.9059 - val_loss: 0.8419 - val_accuracy: 0.7229
Epoch 11/11
29/29 [==============================] - 21s 728ms/step - loss: 0.2352 - accuracy: 0.9362 - val_loss: 0.4312 - val_accuracy: 0.8658
```

```python
acc = history.history['accuracy']
val_acc = history.history['val_accuracy']

loss = history.history['loss']
val_loss = history.history['val_loss']

epochs_range = range(epochs)

plt.figure(figsize=(24, 8))
plt.subplot(1, 2, 1)
plt.plot(epochs_range, acc, label='Training Accuracy')
plt.plot(epochs_range, val_acc, label='Validation Accuracy')
plt.legend(loc='lower right')
```



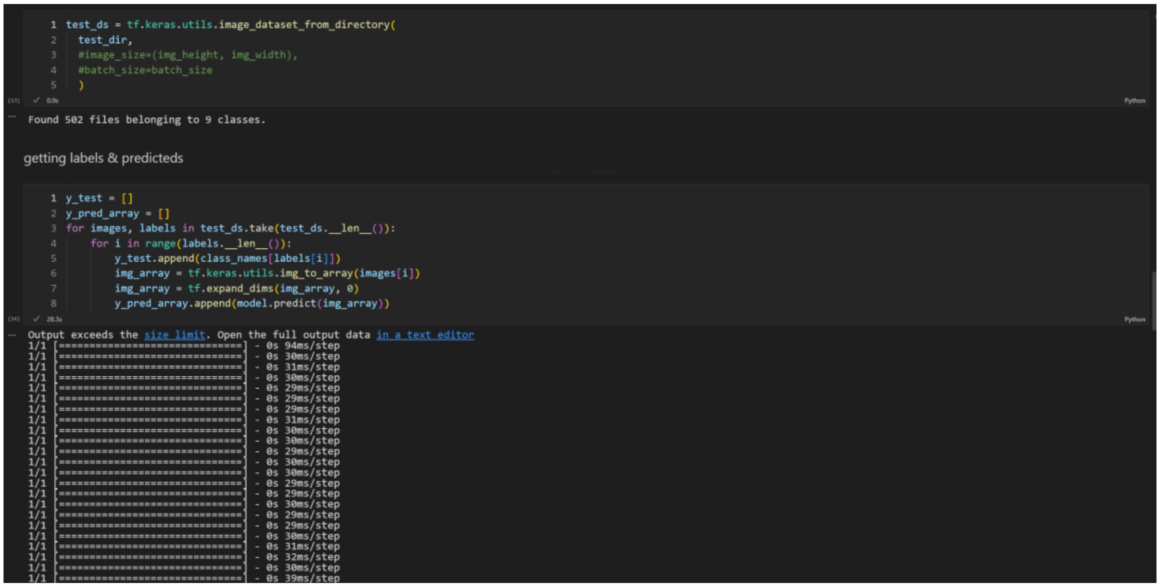
```python
acc = history.history['accuracy']
val_acc = history.history['val_accuracy']

loss = history.history['loss']
val_loss = history.history['val_loss']

epochs_range = range(epochs)

plt.figure(figsize=(24, 8))
plt.subplot(1, 2, 1)
plt.plot(epochs_range, acc, label='Training Accuracy')
plt.plot(epochs_range, val_acc, label='Validation Accuracy')
plt.legend(loc='lower right')
plt.title('Training and Validation Accuracy')

plt.subplot(1, 2, 2)
plt.plot(epochs_range, loss, label='Training Loss')
plt.plot(epochs_range, val_loss, label='Validation Loss')
plt.legend(loc='upper right')
plt.title('Training and Validation Loss')
plt.show()
```



Testing

```python
test_dir = pathlib.Path("test")

test_image_count = len(list(test_dir.glob('*/*.jpg')))
print(test_image_count)
```

```
502
```



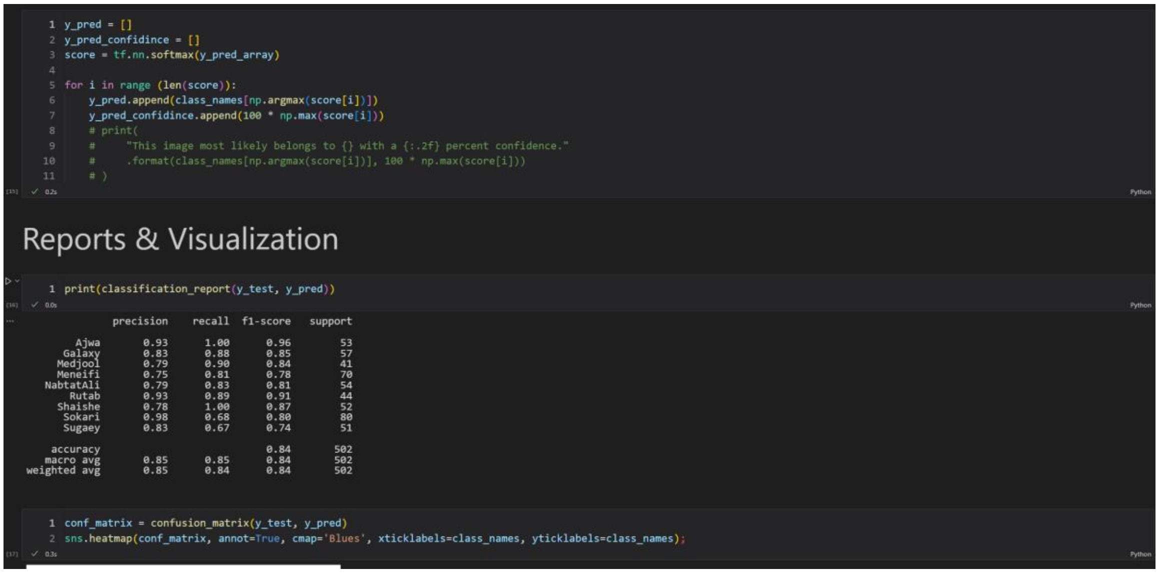
```
test_ds = tf.keras.utils.image_dataset_from_directory(
  test_dir,
  #image_size=(img_height, img_width),
  #batch_size=batch_size
  )
```

```
Found 502 files belonging to 9 classes.
```

getting labels & predicteds

```
y_test = []
y_pred_array = []
for images, labels in test_ds.take(test_ds.__len__()):
    for i in range(labels.__len__()):
        y_test.append(class_names[labels[i]])
        img_array = tf.keras.utils.img_to_array(images[i])
        img_array = tf.expand_dims(img_array, 0)
        y_pred_array.append(model.predict(img_array))
```

```
Output exceeds the size limit. Open the full output data in a text editor
1/1 [==============================] - 0s 94ms/step
1/1 [==============================] - 0s 30ms/step
1/1 [==============================] - 0s 31ms/step
1/1 [==============================] - 0s 30ms/step
1/1 [==============================] - 0s 29ms/step
1/1 [==============================] - 0s 29ms/step
1/1 [==============================] - 0s 29ms/step
1/1 [==============================] - 0s 31ms/step
1/1 [==============================] - 0s 30ms/step
1/1 [==============================] - 0s 30ms/step
1/1 [==============================] - 0s 29ms/step
1/1 [==============================] - 0s 30ms/step
1/1 [==============================] - 0s 30ms/step
1/1 [==============================] - 0s 29ms/step
1/1 [==============================] - 0s 29ms/step
1/1 [==============================] - 0s 30ms/step
1/1 [==============================] - 0s 29ms/step
1/1 [==============================] - 0s 29ms/step
1/1 [==============================] - 0s 30ms/step
1/1 [==============================] - 0s 31ms/step
1/1 [==============================] - 0s 32ms/step
1/1 [==============================] - 0s 30ms/step
1/1 [==============================] - 0s 39ms/step
```



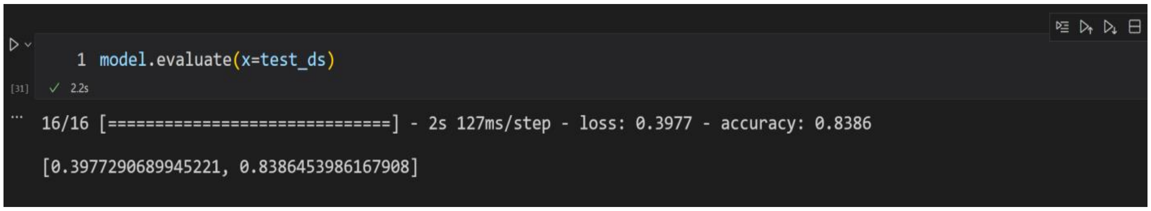
```
y_pred = []
y_pred_confidince = []
score = tf.nn.softmax(y_pred_array)

for i in range (len(score)):
    y_pred.append(class_names[np.argmax(score[i])])
    y_pred_confidince.append(100 * np.max(score[i]))
    # print(
    #     "This image most likely belongs to {} with a {:.2f} percent confidence."
    #     .format(class_names[np.argmax(score[i])], 100 * np.max(score[i]))
    # )
```

Reports & Visualization

```
print(classification_report(y_test, y_pred))
```

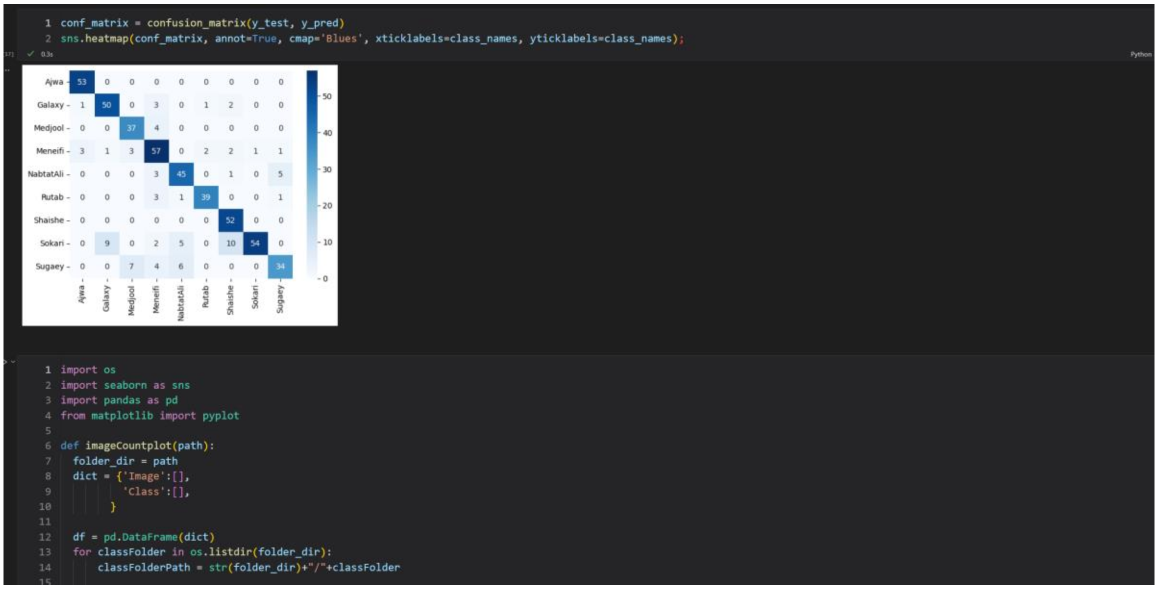
```
              precision    recall  f1-score   support

        Ajwa       0.93      1.00      0.96        53
      Galaxy       0.83      0.88      0.85        57
     Medjool       0.79      0.90      0.84        41
     Meneifi       0.75      0.81      0.78        70
   NabtatAli       0.79      0.83      0.81        54
       Rutab       0.93      0.89      0.91        44
     Shaishe       0.78      1.00      0.87        52
      Sokari       0.98      0.68      0.80        80
      Sugaey       0.83      0.67      0.74        51

    accuracy                           0.84       502
   macro avg       0.85      0.85      0.84       502
weighted avg       0.85      0.84      0.84       502
```

```
conf_matrix = confusion_matrix(y_test, y_pred)
sns.heatmap(conf_matrix, annot=True, cmap='Blues', xticklabels=class_names, yticklabels=class_names);
```



```
model.evaluate(x=test_ds)
```

```
16/16 [==============================] - 2s 127ms/step - loss: 0.3977 - accuracy: 0.8386

[0.3977290689945221, 0.8386453986167908]
```

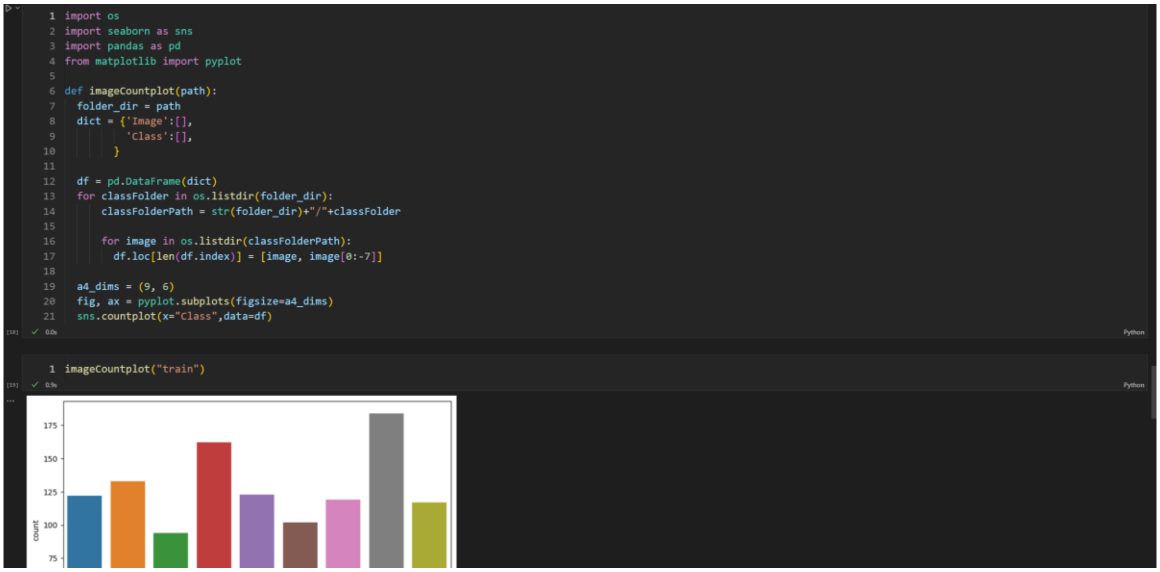


```python
conf_matrix = confusion_matrix(y_test, y_pred)
sns.heatmap(conf_matrix, annot=True, cmap='Blues', xticklabels=class_names, yticklabels=class_names);
```

```
[17]  ✓ 0.3s                                                                Python
```

	Ajwa	Galaxy	Medjool	Meneifi	NabtatAli	Rutab	Shaishe	Sokari	Sugaey
Ajwa	53	0	0	0	0	0	0	0	0
Galaxy	1	50	0	3	0	1	2	0	0
Medjool	0	0	37	4	0	0	0	0	0
Meneifi	3	1	3	57	0	2	2	1	1
NabtatAli	0	0	0	3	45	0	1	0	5
Rutab	0	0	0	3	1	39	0	0	1
Shaishe	0	0	0	0	0	0	52	0	0
Sokari	0	9	0	2	5	0	10	54	0
Sugaey	0	0	7	4	6	0	0	0	34

```python
import os
import seaborn as sns
import pandas as pd
from matplotlib import pyplot

def imageCountplot(path):
  folder_dir = path
  dict = {'Image':[],
          'Class':[],
        }

  df = pd.DataFrame(dict)
  for classFolder in os.listdir(folder_dir):
      classFolderPath = str(folder_dir)+"/"+classFolder
```

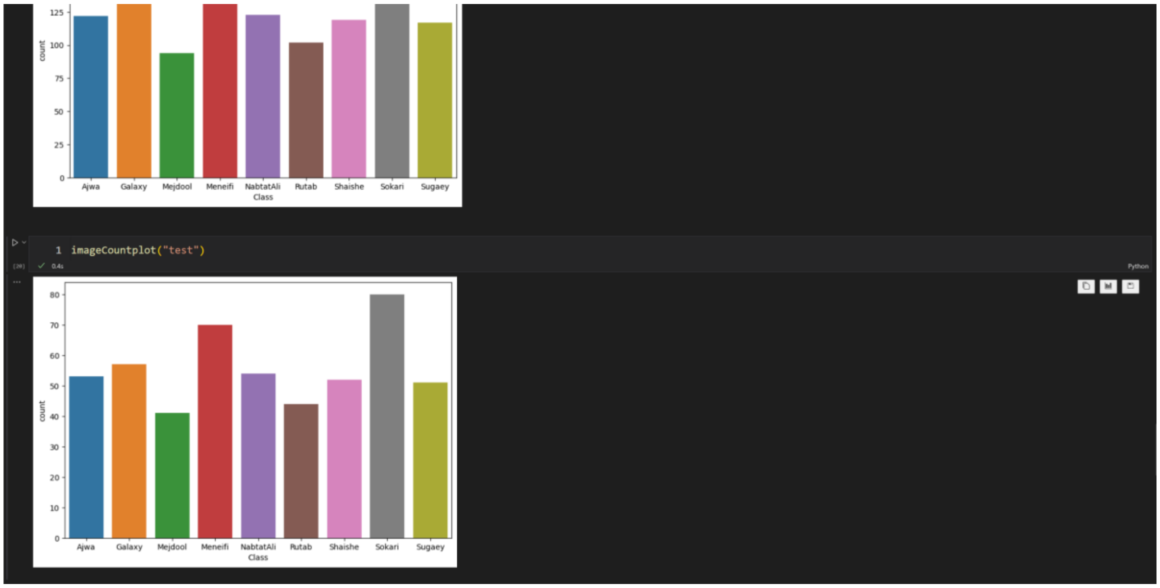


```python
import os
import seaborn as sns
import pandas as pd
from matplotlib import pyplot

def imageCountplot(path):
  folder_dir = path
  dict = {'Image':[],
          'Class':[],
        }

  df = pd.DataFrame(dict)
  for classFolder in os.listdir(folder_dir):
      classFolderPath = str(folder_dir)+"/"+classFolder

      for image in os.listdir(classFolderPath):
        df.loc[len(df.index)] = [image, image[0:-7]]

  a4_dims = (9, 6)
  fig, ax = pyplot.subplots(figsize=a4_dims)
  sns.countplot(x="Class",data=df)
```

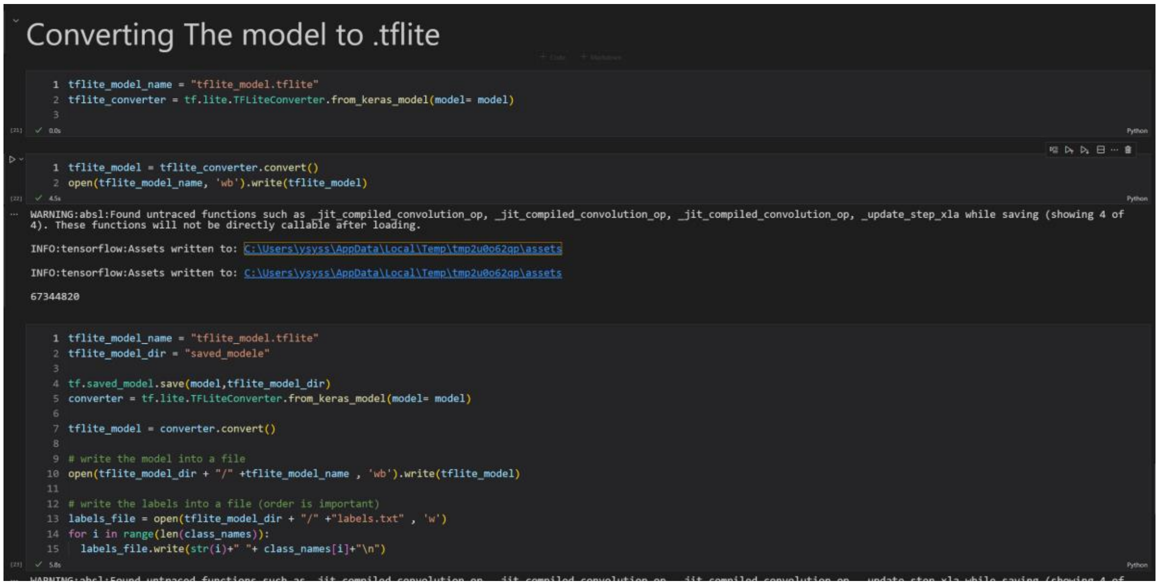
```
[18]  ✓ 0.0s                                                                Python
```

```python
imageCountplot("train")
```

```
[19]  ✓ 0.9s                                                                Python
```



```
imageCountplot("test")
```



Converting The model to .tflite

```
tflite_model_name = "tflite_model.tflite"
tflite_converter = tf.lite.TFLiteConverter.from_keras_model(model= model)

```

```
tflite_model = tflite_converter.convert()
open(tflite_model_name, 'wb').write(tflite_model)
```

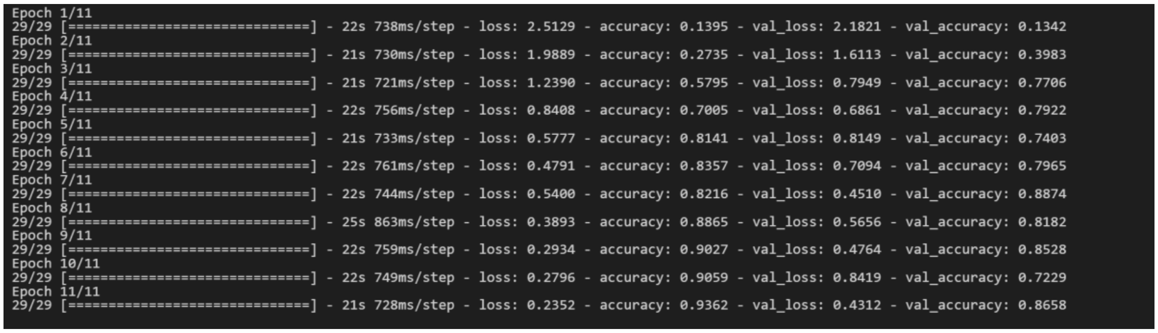
```
WARNING:absl:Found untraced functions such as _jit_compiled_convolution_op, _jit_compiled_convolution_op, _jit_compiled_convolution_op, _update_step_xla while saving (showing 4 of
4). These functions will not be directly callable after loading.

INFO:tensorflow:Assets written to: C:\Users\ysyss\AppData\Local\Temp\tmp2u0o62qp\assets

INFO:tensorflow:Assets written to: C:\Users\ysyss\AppData\Local\Temp\tmp2u0o62qp\assets

67344820
```

```
tflite_model_name = "tflite_model.tflite"
tflite_model_dir = "saved_modele"

tf.saved_model.save(model,tflite_model_dir)
converter = tf.lite.TFLiteConverter.from_keras_model(model= model)

tflite_model = converter.convert()

# write the model into a file
open(tflite_model_dir + "/" +tflite_model_name , 'wb').write(tflite_model)

# write the labels into a file (order is important)
labels_file = open(tflite_model_dir + "/" +"labels.txt" , 'w')
for i in range(len(class_names)):
  labels_file.write(str(i)+" "+ class_names[i]+"\n")
```

```
WARNING:absl:Found untraced functions such as _jit_compiled_convolution_op, _jit_compiled_convolution_op, _jit_compiled_convolution_op, _update_step_xla while saving (showing 4 of
```

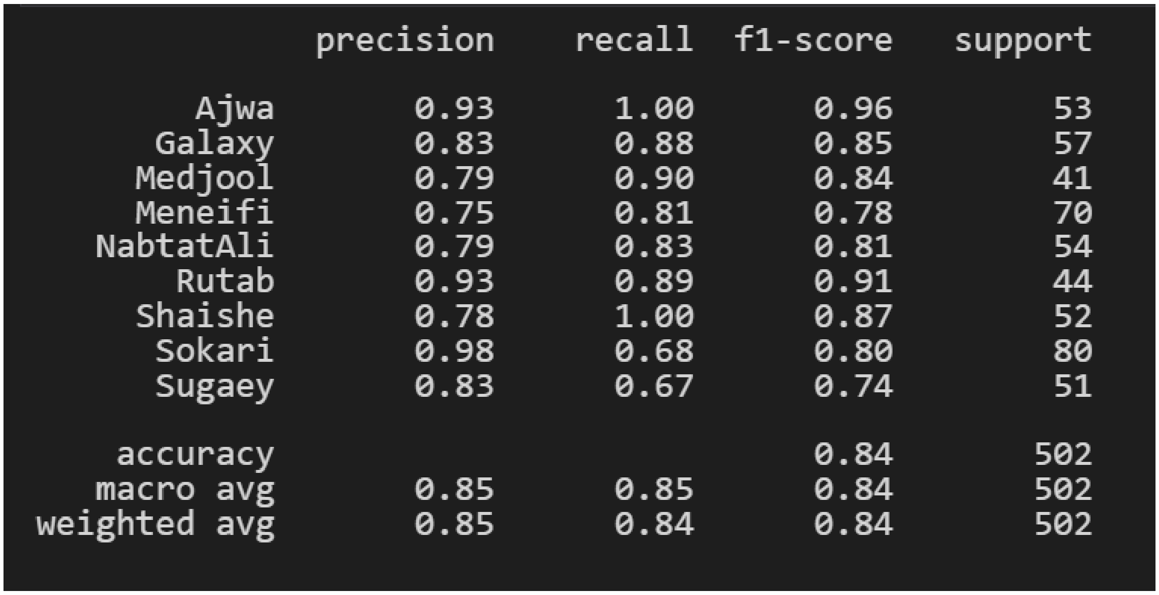
2-Evaluation Resutls

Training and valadation accuracy:

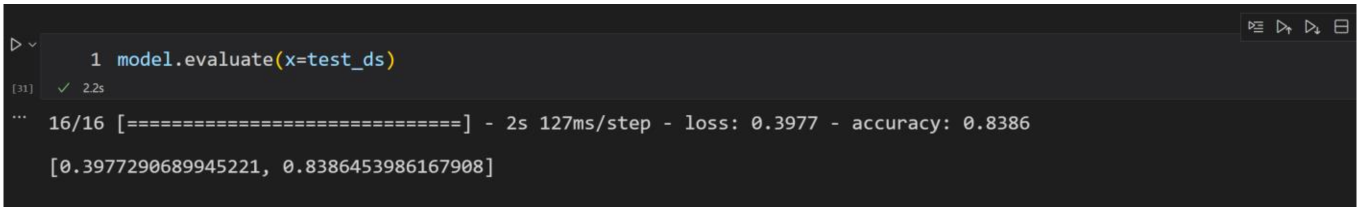


```
Epoch 1/11
29/29 [==============================] - 22s 738ms/step - loss: 2.5129 - accuracy: 0.1395 - val_loss: 2.1821 - val_accuracy: 0.1342
Epoch 2/11
29/29 [==============================] - 21s 730ms/step - loss: 1.9889 - accuracy: 0.2735 - val_loss: 1.6113 - val_accuracy: 0.3983
Epoch 3/11
29/29 [==============================] - 21s 721ms/step - loss: 1.2390 - accuracy: 0.5795 - val_loss: 0.7949 - val_accuracy: 0.7706
Epoch 4/11
29/29 [==============================] - 22s 756ms/step - loss: 0.8408 - accuracy: 0.7005 - val_loss: 0.6861 - val_accuracy: 0.7922
Epoch 5/11
29/29 [==============================] - 21s 733ms/step - loss: 0.5777 - accuracy: 0.8141 - val_loss: 0.8149 - val_accuracy: 0.7403
Epoch 6/11
29/29 [==============================] - 22s 761ms/step - loss: 0.4791 - accuracy: 0.8357 - val_loss: 0.7094 - val_accuracy: 0.7965
Epoch 7/11
29/29 [==============================] - 22s 744ms/step - loss: 0.5400 - accuracy: 0.8216 - val_loss: 0.4510 - val_accuracy: 0.8874
Epoch 8/11
29/29 [==============================] - 25s 863ms/step - loss: 0.3893 - accuracy: 0.8865 - val_loss: 0.5656 - val_accuracy: 0.8182
Epoch 9/11
29/29 [==============================] - 22s 759ms/step - loss: 0.2934 - accuracy: 0.9027 - val_loss: 0.4764 - val_accuracy: 0.8528
Epoch 10/11
29/29 [==============================] - 22s 749ms/step - loss: 0.2796 - accuracy: 0.9059 - val_loss: 0.8419 - val_accuracy: 0.7229
Epoch 11/11
29/29 [==============================] - 21s 728ms/step - loss: 0.2352 - accuracy: 0.9362 - val_loss: 0.4312 - val_accuracy: 0.8658
```

Testing Evalutaion:



```
              precision    recall  f1-score   support

        Ajwa       0.93      1.00      0.96        53
      Galaxy       0.83      0.88      0.85        57
     Medjool       0.79      0.90      0.84        41
     Meneifi       0.75      0.81      0.78        70
   NabtatAli       0.79      0.83      0.81        54
       Rutab       0.93      0.89      0.91        44
     Shaishe       0.78      1.00      0.87        52
      Sokari       0.98      0.68      0.80        80
      Sugaey       0.83      0.67      0.74        51

    accuracy                           0.84       502
   macro avg       0.85      0.85      0.84       502
weighted avg       0.85      0.84      0.84       502
```



```
model.evaluate(x=test_ds)
```

```
16/16 [==============================] - 2s 127ms/step - loss: 0.3977 - accuracy: 0.8386

[0.3977290689945221, 0.8386453986167908]
```

Extra work: (for fun)

We designed and implemented a Flutter mobile app that can use the AI model and provide the needed information for each date fruit type.

Link: https://youtu.be/W873jTv_kNA