Pre-Trained_Models

August 12, 2022

1 Grapevine leaves classification, pre-trained models parts

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1.1 Environment Initialization

[ ]:
```
#Loading General Tools and Libraries
import os
import random
import shutil
import sklearn
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
import tensorflow as tf
import tensorflow_datasets as tfds
from tensorflow import keras
from keras import layers
plt.style.use('ggplot')
```

1.2 Data Loading

1.2.1 Data Downloading

[ ]:
```
#Loading Dataset
!rm -rf Grapevine_Leaves_Image_Dataset*
!rm -rf Test_Data
!wget https://www.muratkoklu.com/datasets/Grapevine_Leaves_Image_Dataset.zip
!unzip -q Grapevine_Leaves_Image_Dataset.zip
!rm Grapevine_Leaves_Image_Dataset.zip
!ls -lh
```

```
--2022-08-06 06:26:31--
https://www.muratkoklu.com/datasets/Grapevine_Leaves_Image_Dataset.zip
Resolving www.muratkoklu.com (www.muratkoklu.com)… 185.179.25.150
Connecting to www.muratkoklu.com (www.muratkoklu.com)|185.179.25.150|:443…
```

```
connected.
HTTP request sent, awaiting response… 200 OK
Length: 113862245 (109M) [application/zip]
Saving to: ‘Grapevine_Leaves_Image_Dataset.zip’

Grapevine_Leaves_Im 100%[===================>] 108.59M  20.7MB/s    in 6.3s

2022-08-06 06:26:38 (17.4 MB/s) - ‘Grapevine_Leaves_Image_Dataset.zip’ saved
[113862245/113862245]

total 8.0K
drwxr-xr-x 7 root root 4.0K Feb 11 17:53 Grapevine_Leaves_Image_Dataset
drwxr-xr-x 1 root root 4.0K Aug  3 20:21 sample_data
```

1.2.2 Select and Move 20% of Data for OOS (Out Of Sample) Testing

[ ]:
```
Species = ["Ak", "Ala_Idris", "Buzgulu", "Dimnit", "Nazli"]
OriginalDataPath = "Grapevine_Leaves_Image_Dataset"
TestDataPath = "Test_Data"
os.mkdir(os.path.join(TestDataPath,""))

for folder_name in Species:
  Percentage = 20/100
  Test_location = os.path.join(TestDataPath,folder_name)
  os.mkdir(Test_location)
  Original_location = os.path.join(OriginalDataPath, folder_name)
  AllImages = os.listdir(Original_location)
  Count = int(Percentage * len(AllImages))
  Selecteds = random.sample(AllImages, Count)
  for file in Selecteds:
    shutil.move(os.path.join(Original_location,file), Test_location)
```

1.2.3 Datasets Loading (Train, Validation, and Test)

[ ]:
```
image_size = (256,256)
batch_size = 32
validation_split = 0.2
seed = 199

train_data = tf.keras.utils.image_dataset_from_directory(
    'Grapevine_Leaves_Image_Dataset',
    class_names = ["Ak", "Ala_Idris", "Buzgulu", "Dimnit", "Nazli"],
    batch_size=batch_size,
    image_size=image_size,
    seed=seed,
    validation_split=validation_split,
    subset="training"
```

```
)

validation_data = tf.keras.utils.image_dataset_from_directory(
    'Grapevine_Leaves_Image_Dataset',
    class_names = ["Ak", "Ala_Idris", "Buzgulu", "Dimnit", "Nazli"],
    batch_size=batch_size,
    image_size=image_size,
    seed=seed,
    validation_split=validation_split,
    subset="validation"
)

test_data = tf.keras.utils.image_dataset_from_directory(
    'Test_Data',
    class_names = ["Ak", "Ala_Idris", "Buzgulu", "Dimnit", "Nazli"],
    image_size=image_size,
    batch_size=100,
    shuffle=False)
```

```
Found 400 files belonging to 5 classes.
Using 320 files for training.
Found 400 files belonging to 5 classes.
Using 80 files for validation.
Found 100 files belonging to 5 classes.
```

1.3 Data Augmentation

1.3.1 Color Transformation

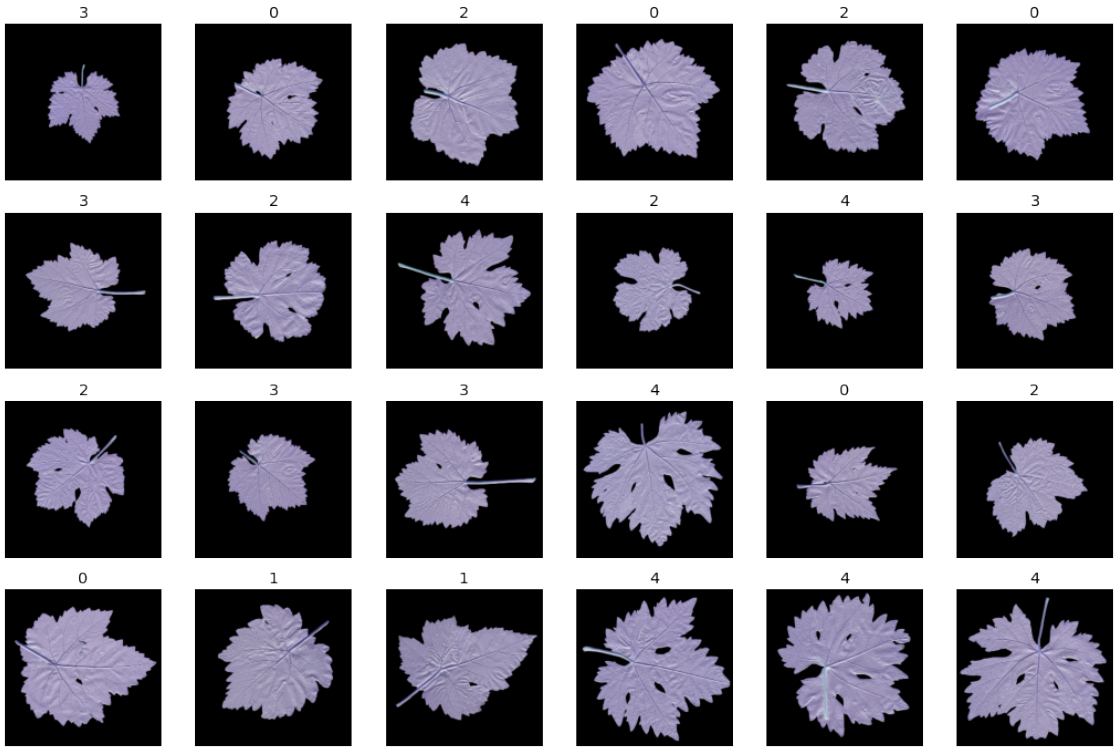
[ ]:
```
train_data2 = train_data.map(lambda x, y: (255-x, y))
validation_data2 = validation_data.map(lambda x, y: (255-x, y))
test_data2 = test_data.map(lambda x, y: (255-x, y))
```

1.3.2 Data Augmentation

[ ]:
```
data_augmentation = keras.Sequential([
    layers.RandomFlip("horizontal"),
    layers.RandomFlip("vertical"),
    layers.RandomZoom(height_factor=(-0.2,0.2), width_factor=(-0.2,0.
  ↪2),fill_mode='constant', fill_value=0),
    layers.RandomRotation(0.3, fill_mode='constant', fill_value=0)
])

augmented_train_data = train_data2
for i in range(4):
  augmented_train_data = augmented_train_data.concatenate(train_data2.
  ↪map(lambda x, y: (data_augmentation(x, training=True), y)))
```

1.3.3 Showing a random sample

[ ]:
```
plt.figure(figsize=(18, 12))
for images, labels in augmented_train_data.take(1):
    for i in range(24):
        ax = plt.subplot(4, 6, i + 1)
        plt.imshow(images[i].numpy().astype("uint8"))
        plt.title(int(labels[i]))
        plt.axis("off")
```



[ ]:
```

```

1.4 Pre-Trained Models

1.4.1 Training Parameters

[ ]:
```
pre_trained_data = train_data2
pre_trained_epochs = 30
pre_trained_validation_data = validation_data2
```

1.4.2 Xception

Model Architecture Define

[ ]:
```
pretrained_model = tf.keras.applications.Xception(
        weights='imagenet',
        include_top=False ,
        input_shape=image_size + (3,))
pretrained_model.trainable = False
Xception_Model = tf.keras.Sequential([
    layers.RandomRotation(0.3, fill_mode='constant', fill_value=0,␣
 ↪input_shape=image_size + (3,)),
    layers.RandomZoom(height_factor=(-0.2,0.2), width_factor=(-0.2,0.
 ↪2),fill_mode='constant', fill_value=0),
    layers.RandomFlip("horizontal"),
    layers.RandomFlip("vertical"),
    pretrained_model, layers.Flatten(),
    layers.Dense(512, activation='relu'),
    layers.Dense(256, activation='relu'),
    tf.keras.layers.Dense(5, activation='softmax')])
Xception_Model.summary()
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-
applications/xception/xception_weights_tf_dim_ordering_tf_kernels_notop.h5
83689472/83683744 [==============================] - 0s 0us/step
83697664/83683744 [==============================] - 0s 0us/step
Model: "sequential_2"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 random_rotation_2 (RandomRo  (None, 256, 256, 3)      0
 tation)

 random_zoom_1 (RandomZoom)  (None, 256, 256, 3)       0

 random_flip_4 (RandomFlip)  (None, 256, 256, 3)       0

 random_flip_5 (RandomFlip)  (None, 256, 256, 3)       0

 xception (Functional)       (None, 8, 8, 2048)        20861480

 flatten_1 (Flatten)         (None, 131072)            0

 dense_5 (Dense)             (None, 512)               67109376

 dense_6 (Dense)             (None, 256)               131328

 dense_7 (Dense)             (None, 5)                 1285

=================================================================
Total params: 88,103,469
Trainable params: 67,241,989
```

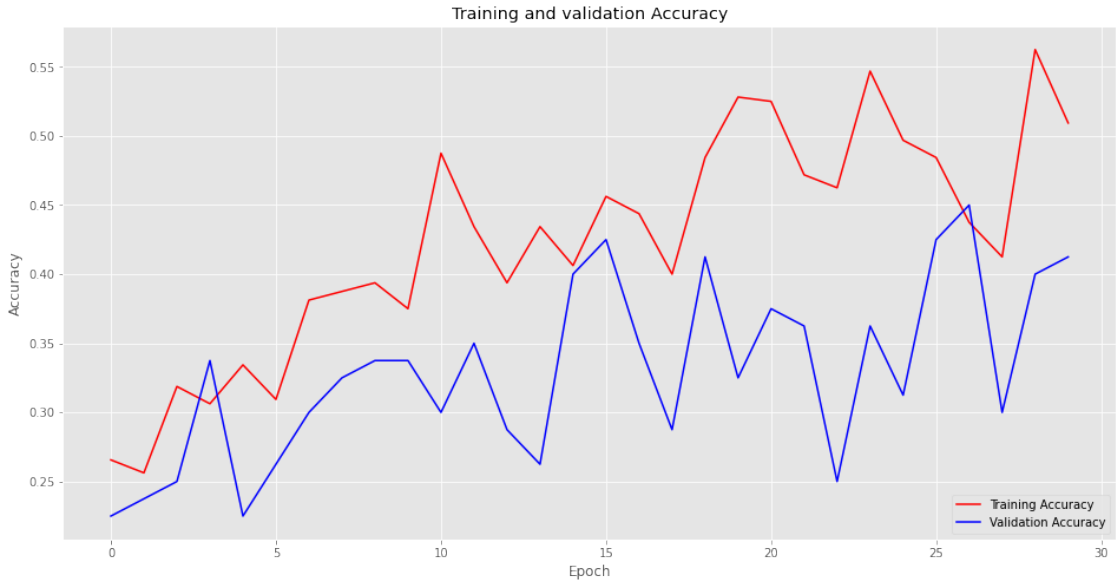
```
Non-trainable params: 20,861,480
_________________________________________________________________
```

Model Creation and Training

[ ]:
```
Xception_Model.compile(
    optimizer=keras.optimizers.Adam(1e-4),
    loss=tf.keras.losses.SparseCategoricalCrossentropy(),
    metrics=["accuracy"])
Xception_Model_History = Xception_Model.fit(
    pre_trained_data,
    epochs = pre_trained_epochs,
    validation_data = pre_trained_validation_data)
```

Accuracy and Loss Curves

[ ]:
```
Xception_Model_acc = Xception_Model_History.history['accuracy']
Xception_Model_val_acc = Xception_Model_History.history['val_accuracy']
Xception_Model_loss = Xception_Model_History.history['loss']
Xception_Model_val_loss = Xception_Model_History.history['val_loss']
epochs = range(len(Xception_Model_acc))
fig = plt.figure(figsize=(16,8))
plt.plot(epochs, Xception_Model_acc, 'r', label="Training Accuracy")
plt.plot(epochs, Xception_Model_val_acc, 'b', label="Validation Accuracy")
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.title('Training and validation Accuracy')
plt.legend(loc='lower right')
fig2 = plt.figure(figsize=(16,8))
plt.plot(epochs, Xception_Model_loss, 'r', label="Training Loss")
plt.plot(epochs, Xception_Model_val_loss, 'b', label="Validation Loss")
plt.legend(loc='upper right')
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.title('Training and validation Loss')
plt.show()
```



Model Performance Evaluation on Test Data

[ ]:
```
from sklearn.metrics import␣
  ↪accuracy_score,classification_report,confusion_matrix

result = Xception_Model.predict(test_data2)
Xception_Model_y_predict = np.array([i.argmax() for i in result])

Xception_Model_cm = confusion_matrix(y_test, Xception_Model_y_predict)
```

```
Xception_Model_ac = accuracy_score(y_test,Xception_Model_y_predict)

print("confusion matrix on test data :\n",Xception_Model_cm)
print("accuracy score on test data:\n",Xception_Model_ac)

print(classification_report(y_test, Xception_Model_y_predict))
```

```
confusion matrix on test data :
 [[ 6  2  4  4  4]
 [ 1  7  1  4  7]
 [ 0  3 10  1  6]
 [ 0  1  4  8  7]
 [ 1  0  1  3 15]]
accuracy score on test data:
 0.46
              precision    recall  f1-score   support

           0       0.75      0.30      0.43        20
           1       0.54      0.35      0.42        20
           2       0.50      0.50      0.50        20
           3       0.40      0.40      0.40        20
           4       0.38      0.75      0.51        20

    accuracy                           0.46       100
   macro avg       0.51      0.46      0.45       100
weighted avg       0.51      0.46      0.45       100
```

1.4.3 VGG16

Model Architecture Define

[ ]:
```
pretrained_model = tf.keras.applications.VGG16(
    include_top=False,
    weights="imagenet",
    input_shape=image_size + (3,),
    classes=1000,
    classifier_activation="softmax",
)
pretrained_model.trainable = False
VGG16_Model = tf.keras.Sequential([
    layers.RandomRotation(0.3, fill_mode='constant', fill_value=0,␣
 ↪input_shape=image_size + (3,)),
    layers.RandomZoom(height_factor=(-0.2,0.2), width_factor=(-0.2,0.
 ↪2),fill_mode='constant', fill_value=0),
    layers.RandomFlip("horizontal"),
    layers.RandomFlip("vertical"),
    pretrained_model, layers.Flatten(),
    layers.Dense(512, activation='relu'),
```

```
    layers.Dense(256, activation='relu'),
    tf.keras.layers.Dense(5, activation='softmax')])
VGG16_Model.summary()
```

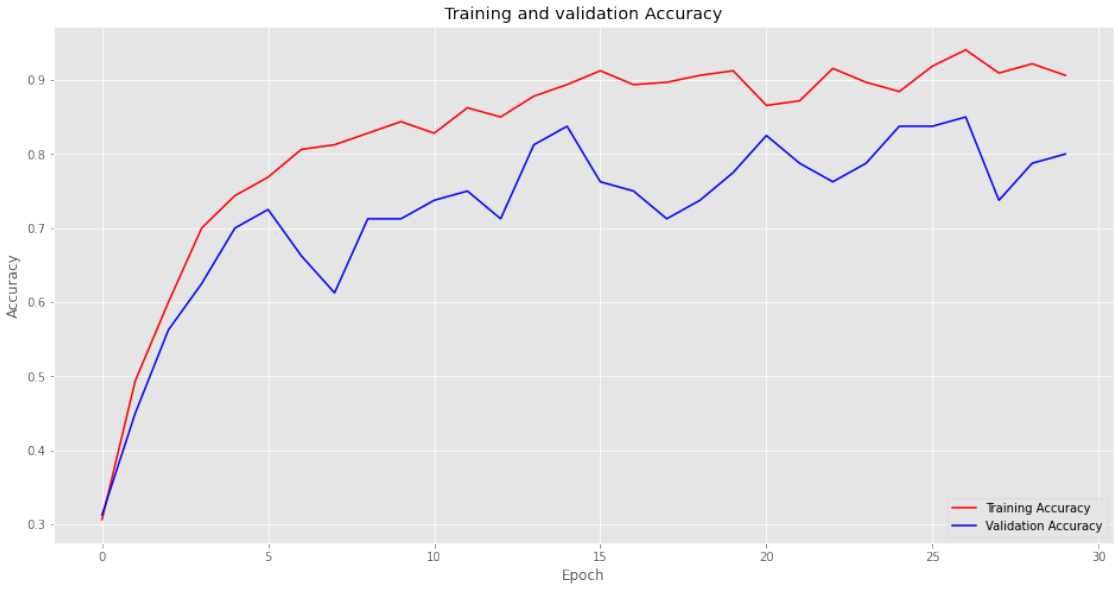
```
Downloading data from https://storage.googleapis.com/tensorflow/keras-
applications/vgg16/vgg16_weights_tf_dim_ordering_tf_kernels_notop.h5
58892288/58889256 [==============================] - 0s 0us/step
58900480/58889256 [==============================] - 0s 0us/step
Model: "sequential_3"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 random_rotation_3 (RandomRo  (None, 256, 256, 3)      0
 tation)

 random_zoom_2 (RandomZoom)  (None, 256, 256, 3)       0

 random_flip_6 (RandomFlip)  (None, 256, 256, 3)       0

 random_flip_7 (RandomFlip)  (None, 256, 256, 3)       0

 vgg16 (Functional)          (None, 8, 8, 512)         14714688

 flatten_2 (Flatten)         (None, 32768)             0

 dense_8 (Dense)             (None, 512)               16777728

 dense_9 (Dense)             (None, 256)               131328

 dense_10 (Dense)            (None, 5)                 1285

=================================================================
Total params: 31,625,029
Trainable params: 16,910,341
Non-trainable params: 14,714,688
_________________________________________________________________
```

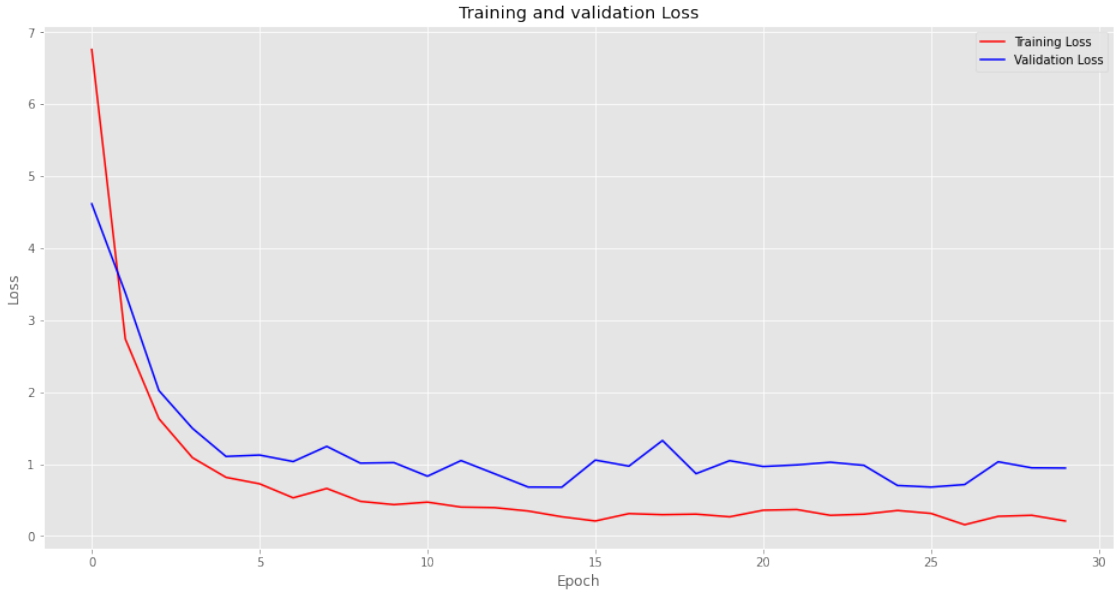
Model Creation and Training

[ ]:
```
VGG16_Model.compile(
    optimizer=keras.optimizers.Adam(1e-4),
    loss=tf.keras.losses.SparseCategoricalCrossentropy(),
    metrics=["accuracy"])
VGG16_Model_History = VGG16_Model.fit(
    pre_trained_data,
    epochs = pre_trained_epochs,
    validation_data = pre_trained_validation_data)
```

Accuracy and Loss Curves

```
[ ]: VGG16_Model_acc = VGG16_Model_History.history['accuracy']
VGG16_Model_val_acc = VGG16_Model_History.history['val_accuracy']
VGG16_Model_loss = VGG16_Model_History.history['loss']
VGG16_Model_val_loss = VGG16_Model_History.history['val_loss']
epochs = range(len(VGG16_Model_acc))
fig = plt.figure(figsize=(16,8))
plt.plot(epochs, VGG16_Model_acc, 'r', label="Training Accuracy")
plt.plot(epochs, VGG16_Model_val_acc, 'b', label="Validation Accuracy")
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.title('Training and validation Accuracy')
plt.legend(loc='lower right')
fig2 = plt.figure(figsize=(16,8))
plt.plot(epochs, VGG16_Model_loss, 'r', label="Training Loss")
plt.plot(epochs, VGG16_Model_val_loss, 'b', label="Validation Loss")
plt.legend(loc='upper right')
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.title('Training and validation Loss')
plt.show()
```





Model Performance Evaluation on Test Data

[ ]:
```
from sklearn.metrics import accuracy_score,classification_report,confusion_matrix

result = VGG16_Model.predict(test_data2)
VGG16_Model_y_predict = np.array([i.argmax() for i in result])

VGG16_Model_cm = confusion_matrix(y_test, VGG16_Model_y_predict)
VGG16_Model_ac = accuracy_score(y_test,VGG16_Model_y_predict)

print("confusion matrix on test data :\n",VGG16_Model_cm)
print("accuracy score on test data:\n",VGG16_Model_ac)

print(classification_report(y_test, VGG16_Model_y_predict))
```

```
confusion matrix on test data :
 [[15  5  0  0  0]
 [ 0 17  2  0  1]
 [ 0  2 17  1  0]
 [ 2  0  2 16  0]
 [ 1  0  0  0 19]]
accuracy score on test data:
 0.84
              precision    recall  f1-score   support

           0       0.83      0.75      0.79        20
           1       0.71      0.85      0.77        20
           2       0.81      0.85      0.83        20
```

```
           3       0.94      0.80      0.86        20
           4       0.95      0.95      0.95        20

    accuracy                           0.84       100
   macro avg       0.85      0.84      0.84       100
weighted avg       0.85      0.84      0.84       100
```

1.4.4 VGG19

Model Architecture Define

```
[ ]: pretrained_model = tf.keras.applications.VGG16(
         include_top=False,
         weights="imagenet",
         input_shape=image_size + (3,),
         classes=1000,
         classifier_activation="softmax",
     )
     pretrained_model.trainable = False
     VGG19_Model = tf.keras.Sequential([
         layers.RandomRotation(0.3, fill_mode='constant', fill_value=0,␣
      ↪input_shape=image_size + (3,)),
         layers.RandomZoom(height_factor=(-0.2,0.2), width_factor=(-0.2,0.
      ↪2),fill_mode='constant', fill_value=0),
         layers.RandomFlip("horizontal"),
         layers.RandomFlip("vertical"),
         pretrained_model, layers.Flatten(),
         layers.Dense(512, activation='relu'),
         layers.Dense(256, activation='relu'),
         tf.keras.layers.Dense(5, activation='softmax')])
     VGG19_Model.summary()
```

```
Model: "sequential_4"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 random_rotation_4 (RandomRo  (None, 256, 256, 3)      0
 tation)

 random_zoom_3 (RandomZoom)  (None, 256, 256, 3)       0

 random_flip_8 (RandomFlip)  (None, 256, 256, 3)       0

 random_flip_9 (RandomFlip)  (None, 256, 256, 3)       0

 vgg16 (Functional)          (None, 8, 8, 512)         14714688

 flatten_3 (Flatten)         (None, 32768)             0
```

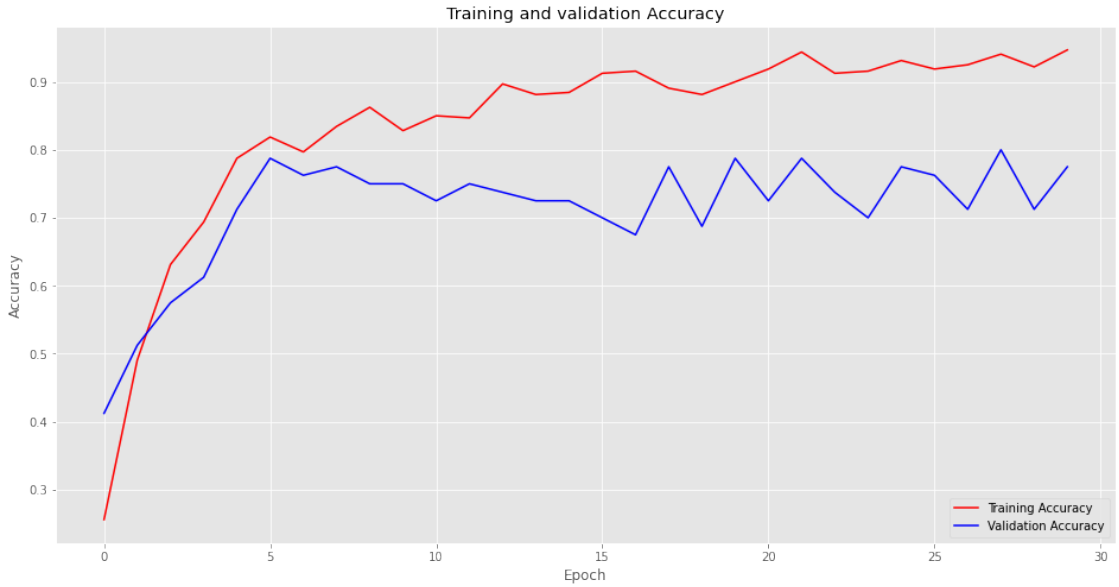
```
 dense_11 (Dense)            (None, 512)               16777728

 dense_12 (Dense)            (None, 256)               131328

 dense_13 (Dense)            (None, 5)                 1285

=================================================================
Total params: 31,625,029
Trainable params: 16,910,341
Non-trainable params: 14,714,688
_________________________________________________________________
```

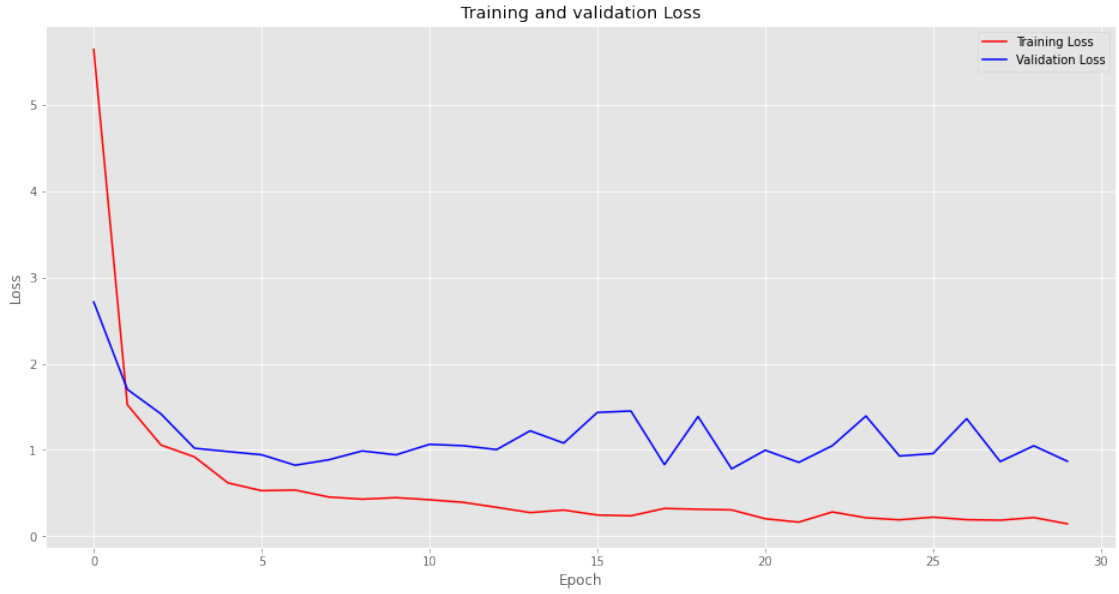
Model Creation and Training

[ ]:
```
VGG19_Model.compile(
    optimizer=keras.optimizers.Adam(1e-4),
    loss=tf.keras.losses.SparseCategoricalCrossentropy(),
    metrics=["accuracy"])
VGG19_Model_History = VGG19_Model.fit(
    pre_trained_data,
    epochs = pre_trained_epochs,
    validation_data = pre_trained_validation_data)
```

Accuracy and Loss Curves

[ ]:
```
VGG19_Model_acc = VGG19_Model_History.history['accuracy']
VGG19_Model_val_acc = VGG19_Model_History.history['val_accuracy']
VGG19_Model_loss = VGG19_Model_History.history['loss']
VGG19_Model_val_loss = VGG19_Model_History.history['val_loss']
epochs = range(len(VGG19_Model_acc))
fig = plt.figure(figsize=(16,8))
plt.plot(epochs, VGG19_Model_acc, 'r', label="Training Accuracy")
plt.plot(epochs, VGG19_Model_val_acc, 'b', label="Validation Accuracy")
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.title('Training and validation Accuracy')
plt.legend(loc='lower right')
fig2 = plt.figure(figsize=(16,8))
plt.plot(epochs, VGG19_Model_loss, 'r', label="Training Loss")
plt.plot(epochs, VGG19_Model_val_loss, 'b', label="Validation Loss")
plt.legend(loc='upper right')
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.title('Training and validation Loss')
plt.show()
```





Model Performance Evaluation on Test Data

[ ]:
```
from sklearn.metrics import
  ↪accuracy_score,classification_report,confusion_matrix

result = VGG19_Model.predict(test_data2)
VGG19_Model_y_predict = np.array([i.argmax() for i in result])
```

```
VGG19_Model_cm = confusion_matrix(y_test, VGG19_Model_y_predict)
VGG19_Model_ac = accuracy_score(y_test,VGG19_Model_y_predict)

print("confusion matrix on test data :\n",VGG19_Model_cm)
print("accuracy score on test data:\n",VGG19_Model_ac)

print(classification_report(y_test, VGG19_Model_y_predict))
```

```
confusion matrix on test data :
 [[17  3  0  0  0]
 [ 1 16  3  0  0]
 [ 0  2 18  0  0]
 [ 2  0  3 15  0]
 [ 2  1  2  0 15]]
accuracy score on test data:
 0.81
              precision    recall  f1-score   support

           0       0.77      0.85      0.81        20
           1       0.73      0.80      0.76        20
           2       0.69      0.90      0.78        20
           3       1.00      0.75      0.86        20
           4       1.00      0.75      0.86        20

    accuracy                           0.81       100
   macro avg       0.84      0.81      0.81       100
weighted avg       0.84      0.81      0.81       100
```

1.4.5 ResNet50

Model Architecture Define

[ ]:
```
pretrained_model = tf.keras.applications.ResNet50(
    include_top=False,
    weights="imagenet",
    input_shape=image_size + (3,),
    classes=1000,
)
pretrained_model.trainable = False
ResNet50_Model = tf.keras.Sequential([
    layers.RandomRotation(0.3, fill_mode='constant', fill_value=0,␣
 ↪input_shape=image_size + (3,)),
    layers.RandomZoom(height_factor=(-0.2,0.2), width_factor=(-0.2,0.
 ↪2),fill_mode='constant', fill_value=0),
    layers.RandomFlip("horizontal"),
    layers.RandomFlip("vertical"),
    pretrained_model, layers.Flatten(),
    layers.Dense(512, activation='relu'),
```

```
    layers.Dense(256, activation='relu'),
    tf.keras.layers.Dense(5, activation='softmax')])
ResNet50_Model.summary()
```

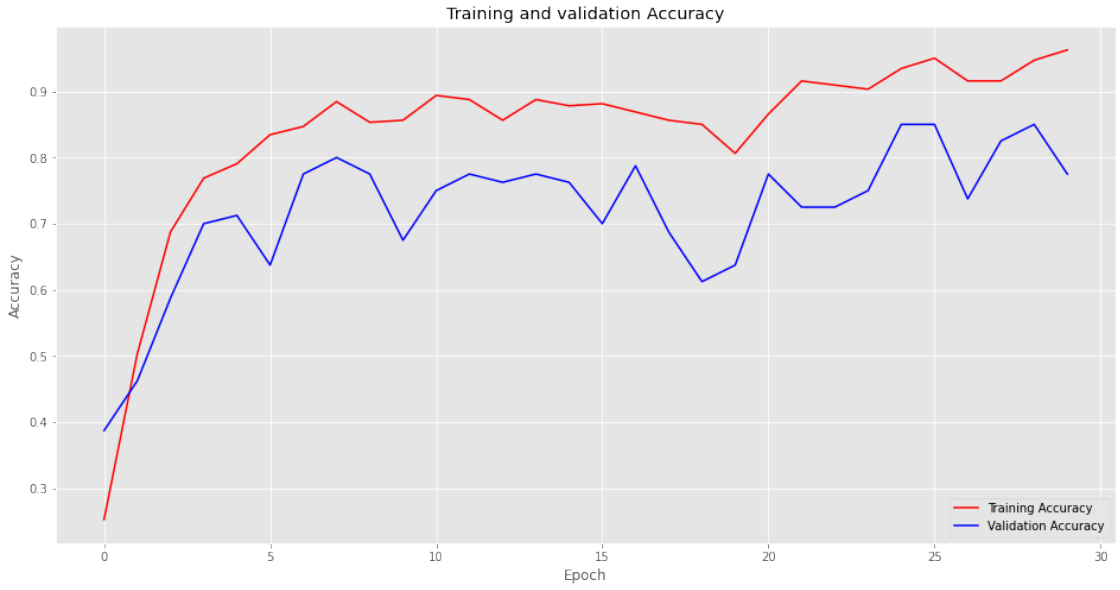
```
Downloading data from https://storage.googleapis.com/tensorflow/keras-
applications/resnet/resnet50_weights_tf_dim_ordering_tf_kernels_notop.h5
94773248/94765736 [==============================] - 0s 0us/step
94781440/94765736 [==============================] - 0s 0us/step
Model: "sequential_5"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 random_rotation_5 (RandomRo  (None, 256, 256, 3)      0
 tation)

 random_zoom_4 (RandomZoom)  (None, 256, 256, 3)       0

 random_flip_10 (RandomFlip)  (None, 256, 256, 3)      0

 random_flip_11 (RandomFlip)  (None, 256, 256, 3)      0

 resnet50 (Functional)       (None, 8, 8, 2048)        23587712

 flatten_4 (Flatten)         (None, 131072)            0

 dense_14 (Dense)            (None, 512)               67109376

 dense_15 (Dense)            (None, 256)               131328

 dense_16 (Dense)            (None, 5)                 1285

=================================================================
Total params: 90,829,701
Trainable params: 67,241,989
Non-trainable params: 23,587,712
_________________________________________________________________
```

Model Creation and Training

[ ]:
```
ResNet50_Model.compile(
    optimizer=keras.optimizers.Adam(1e-4),
    loss=tf.keras.losses.SparseCategoricalCrossentropy(),
    metrics=["accuracy"])
ResNet50_Model_History = ResNet50_Model.fit(
    pre_trained_data,
    epochs = pre_trained_epochs,
    validation_data = pre_trained_validation_data)
```

Accuracy and Loss Curves

```
[ ]: ResNet50_Model_acc = ResNet50_Model_History.history['accuracy']
ResNet50_Model_val_acc = ResNet50_Model_History.history['val_accuracy']
ResNet50_Model_loss = ResNet50_Model_History.history['loss']
ResNet50_Model_val_loss = ResNet50_Model_History.history['val_loss']
epochs = range(len(ResNet50_Model_acc))
fig = plt.figure(figsize=(16,8))
plt.plot(epochs, ResNet50_Model_acc, 'r', label="Training Accuracy")
plt.plot(epochs, ResNet50_Model_val_acc, 'b', label="Validation Accuracy")
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.title('Training and validation Accuracy')
plt.legend(loc='lower right')
fig2 = plt.figure(figsize=(16,8))
plt.plot(epochs, ResNet50_Model_loss, 'r', label="Training Loss")
plt.plot(epochs, ResNet50_Model_val_loss, 'b', label="Validation Loss")
plt.legend(loc='upper right')
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.title('Training and validation Loss')
plt.show()
```



Model Performance Evaluation on Test Data

[ ]:
```
from sklearn.metrics import␣
  ↪accuracy_score,classification_report,confusion_matrix

result = ResNet50_Model.predict(test_data2)
ResNet50_Model_y_predict = np.array([i.argmax() for i in result])

ResNet50_Model_cm = confusion_matrix(y_test, ResNet50_Model_y_predict)
ResNet50_Model_ac = accuracy_score(y_test,ResNet50_Model_y_predict)

print("confusion matrix on test data :\n",ResNet50_Model_cm)
print("accuracy score on test data:\n",ResNet50_Model_ac)

print(classification_report(y_test, ResNet50_Model_y_predict))
```

```
WARNING:tensorflow:5 out of the last 5 calls to <function
Model.make_predict_function.<locals>.predict_function at 0x7ff9b0116170>
triggered tf.function retracing. Tracing is expensive and the excessive number
of tracings could be due to (1) creating @tf.function repeatedly in a loop, (2)
passing tensors with different shapes, (3) passing Python objects instead of
tensors. For (1), please define your @tf.function outside of the loop. For (2),
@tf.function has experimental_relax_shapes=True option that relaxes argument
shapes that can avoid unnecessary retracing. For (3), please refer to
https://www.tensorflow.org/guide/function#controlling_retracing and
https://www.tensorflow.org/api_docs/python/tf/function for  more details.
confusion matrix on test data :
 [[18  0  1  0  1]
 [ 4 13  2  0  1]
```

```
 [ 2  0 17  1  0]
 [ 2  0  1 14  3]
 [ 1  0  0  0 19]]
accuracy score on test data:
 0.81
              precision    recall  f1-score   support

           0       0.67      0.90      0.77        20
           1       1.00      0.65      0.79        20
           2       0.81      0.85      0.83        20
           3       0.93      0.70      0.80        20
           4       0.79      0.95      0.86        20

    accuracy                           0.81       100
   macro avg       0.84      0.81      0.81       100
weighted avg       0.84      0.81      0.81       100
```

1.4.6 ResNet101

Model Architecture Define

[ ]:
```
pretrained_model = tf.keras.applications.ResNet101(
    include_top=False,
    weights="imagenet",
    input_shape=image_size + (3,),
    classes=1000,
)
pretrained_model.trainable = False
ResNet101_Model = tf.keras.Sequential([
    layers.RandomRotation(0.3, fill_mode='constant', fill_value=0,␣
 ↪input_shape=image_size + (3,)),
    layers.RandomZoom(height_factor=(-0.2,0.2), width_factor=(-0.2,0.
 ↪2),fill_mode='constant', fill_value=0),
    layers.RandomFlip("horizontal"),
    layers.RandomFlip("vertical"),
    pretrained_model, layers.Flatten(),
    layers.Dense(512, activation='relu'),
    layers.Dense(256, activation='relu'),
    tf.keras.layers.Dense(5, activation='softmax')])
ResNet101_Model.summary()
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-
applications/resnet/resnet101_weights_tf_dim_ordering_tf_kernels_notop.h5
171450368/171446536 [==============================] - 1s 0us/step
171458560/171446536 [==============================] - 1s 0us/step
Model: "sequential_6"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
```

```
=================================================================
 random_rotation_6 (RandomRo  (None, 256, 256, 3)      0
 tation)

 random_zoom_5 (RandomZoom)  (None, 256, 256, 3)       0

 random_flip_12 (RandomFlip)  (None, 256, 256, 3)      0

 random_flip_13 (RandomFlip)  (None, 256, 256, 3)      0

 resnet101 (Functional)      (None, 8, 8, 2048)        42658176

 flatten_5 (Flatten)         (None, 131072)            0

 dense_17 (Dense)            (None, 512)               67109376

 dense_18 (Dense)            (None, 256)               131328

 dense_19 (Dense)            (None, 5)                 1285

=================================================================
Total params: 109,900,165
Trainable params: 67,241,989
Non-trainable params: 42,658,176
_________________________________________________________________
```

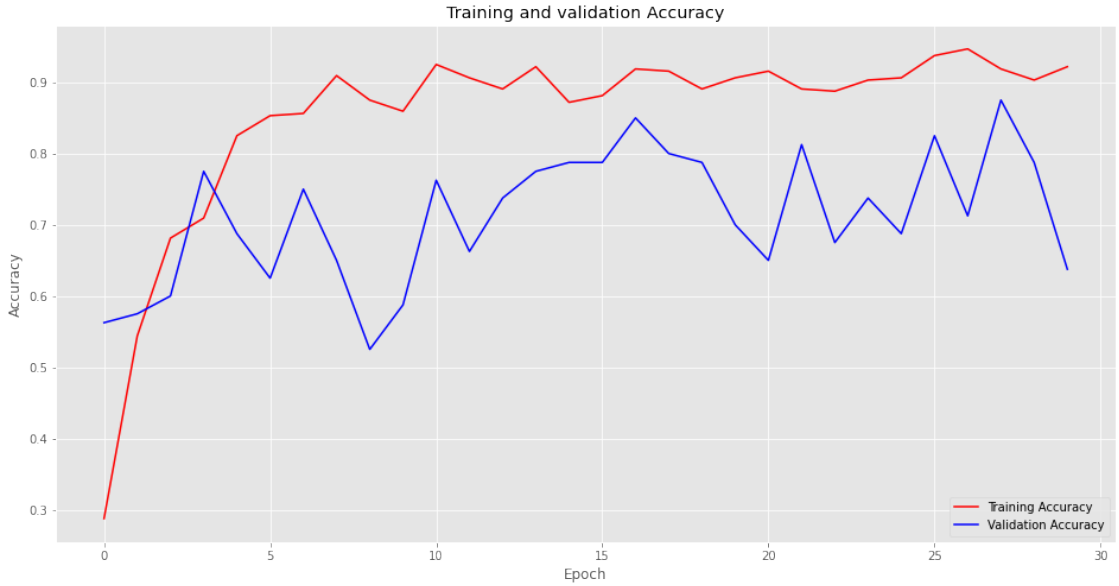
Model Creation and Training

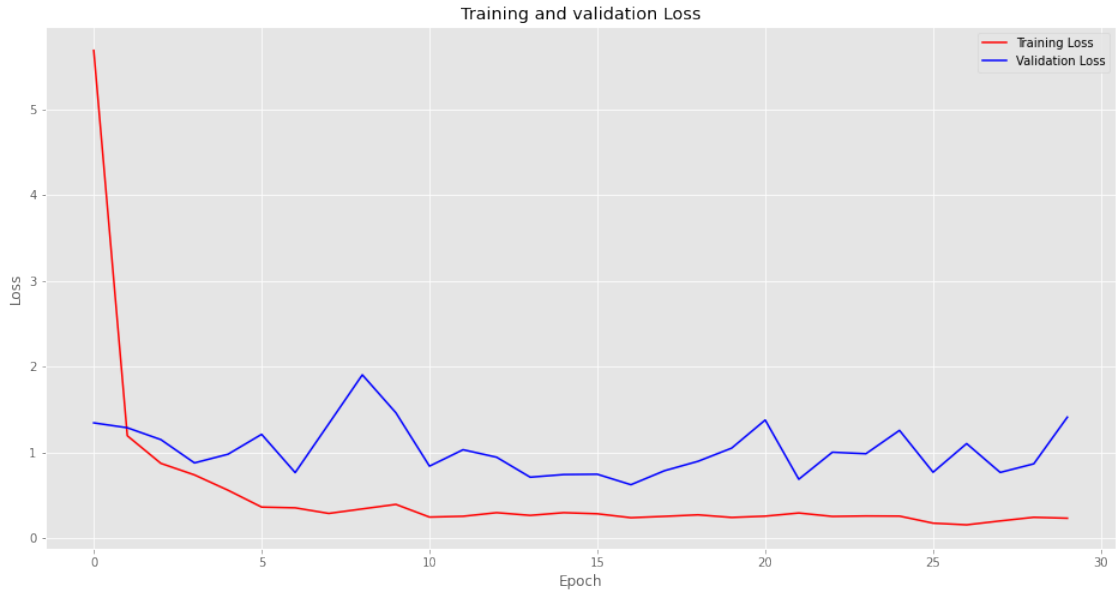
[ ]:
```
ResNet101_Model.compile(
    optimizer=keras.optimizers.Adam(1e-4),
    loss=tf.keras.losses.SparseCategoricalCrossentropy(),
    metrics=["accuracy"])
ResNet101_Model_History = ResNet101_Model.fit(
    pre_trained_data,
    epochs = pre_trained_epochs,
    validation_data = pre_trained_validation_data)
```

Accuracy and Loss Curves

[ ]:
```
ResNet101_Model_acc = ResNet101_Model_History.history['accuracy']
ResNet101_Model_val_acc = ResNet101_Model_History.history['val_accuracy']
ResNet101_Model_loss = ResNet101_Model_History.history['loss']
ResNet101_Model_val_loss = ResNet101_Model_History.history['val_loss']
epochs = range(len(ResNet101_Model_acc))
fig = plt.figure(figsize=(16,8))
plt.plot(epochs, ResNet101_Model_acc, 'r', label="Training Accuracy")
plt.plot(epochs, ResNet101_Model_val_acc, 'b', label="Validation Accuracy")
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
```

```
plt.title('Training and validation Accuracy')
plt.legend(loc='lower right')
fig2 = plt.figure(figsize=(16,8))
plt.plot(epochs, ResNet101_Model_loss, 'r', label="Training Loss")
plt.plot(epochs, ResNet101_Model_val_loss, 'b', label="Validation Loss")
plt.legend(loc='upper right')
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.title('Training and validation Loss')
plt.show()
```





Model Performance Evaluation on Test Data

```
[ ]: from sklearn.metrics import␣
      ↪accuracy_score,classification_report,confusion_matrix

     result = ResNet101_Model.predict(test_data2)
     ResNet101_Model_y_predict = np.array([i.argmax() for i in result])

     ResNet101_Model_cm = confusion_matrix(y_test, ResNet101_Model_y_predict)
     ResNet101_Model_ac = accuracy_score(y_test,ResNet101_Model_y_predict)

     print("confusion matrix on test data :\n",ResNet101_Model_cm)
     print("accuracy score on test data:\n",ResNet101_Model_ac)

     print(classification_report(y_test, ResNet101_Model_y_predict))
```

```
WARNING:tensorflow:6 out of the last 6 calls to <function
Model.make_predict_function.<locals>.predict_function at 0x7ff82cf69d40>
triggered tf.function retracing. Tracing is expensive and the excessive number
of tracings could be due to (1) creating @tf.function repeatedly in a loop, (2)
passing tensors with different shapes, (3) passing Python objects instead of
tensors. For (1), please define your @tf.function outside of the loop. For (2),
@tf.function has experimental_relax_shapes=True option that relaxes argument
shapes that can avoid unnecessary retracing. For (3), please refer to
https://www.tensorflow.org/guide/function#controlling_retracing and
https://www.tensorflow.org/api_docs/python/tf/function for  more details.
confusion matrix on test data :
 [[18  0  0  0  2]
 [ 1 11  3  0  5]
 [ 3  1 14  0  2]
 [ 5  0  0  8  7]
 [ 0  0  0  0 20]]
accuracy score on test data:
 0.71
              precision    recall  f1-score   support

           0       0.67      0.90      0.77        20
           1       0.92      0.55      0.69        20
           2       0.82      0.70      0.76        20
           3       1.00      0.40      0.57        20
           4       0.56      1.00      0.71        20

    accuracy                           0.71       100
   macro avg       0.79      0.71      0.70       100
weighted avg       0.79      0.71      0.70       100
```

1.4.7 ResNet152

Model Architecture Define

```
[ ]: pretrained_model = tf.keras.applications.ResNet152(
        include_top=False,
        weights="imagenet",
        input_shape=image_size + (3,),
        classes=1000,
    )
    pretrained_model.trainable = False
    ResNet152_Model = tf.keras.Sequential([
        layers.RandomRotation(0.3, fill_mode='constant', fill_value=0,␣
      ↪input_shape=image_size + (3,)),
        layers.RandomZoom(height_factor=(-0.2,0.2), width_factor=(-0.2,0.
      ↪2),fill_mode='constant', fill_value=0),
        layers.RandomFlip("horizontal"),
        layers.RandomFlip("vertical"),
        pretrained_model, layers.Flatten(),
        layers.Dense(512, activation='relu'),
        layers.Dense(256, activation='relu'),
        tf.keras.layers.Dense(5, activation='softmax')])
    ResNet152_Model.summary()
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-
applications/resnet/resnet152_weights_tf_dim_ordering_tf_kernels_notop.h5
234700800/234698864 [==============================] - 1s 0us/step
234708992/234698864 [==============================] - 1s 0us/step
Model: "sequential_7"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 random_rotation_7 (RandomRo  (None, 256, 256, 3)      0
 tation)

 random_zoom_6 (RandomZoom)  (None, 256, 256, 3)       0

 random_flip_14 (RandomFlip)  (None, 256, 256, 3)      0

 random_flip_15 (RandomFlip)  (None, 256, 256, 3)      0

 resnet152 (Functional)      (None, 8, 8, 2048)        58370944

 flatten_6 (Flatten)         (None, 131072)            0

 dense_20 (Dense)            (None, 512)               67109376

 dense_21 (Dense)            (None, 256)               131328
```

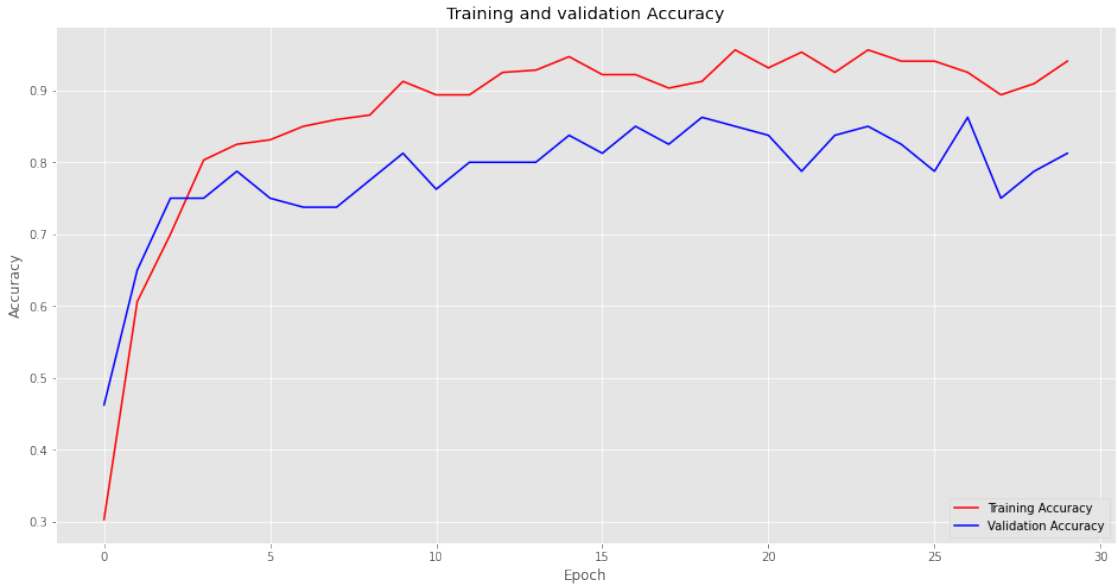
```
 dense_22 (Dense)             (None, 5)                 1285

=================================================================
Total params: 125,612,933
Trainable params: 67,241,989
Non-trainable params: 58,370,944
_________________________________________________________________
```

Model Creation and Training

[ ]:
```
ResNet152_Model.compile(
    optimizer=keras.optimizers.Adam(1e-4),
    loss=tf.keras.losses.SparseCategoricalCrossentropy(),
    metrics=["accuracy"])
ResNet152_Model_History = ResNet152_Model.fit(
    pre_trained_data,
    epochs = pre_trained_epochs,
    validation_data = pre_trained_validation_data)
```

Accuracy and Loss Curves

[ ]:
```
ResNet152_Model_acc = ResNet152_Model_History.history['accuracy']
ResNet152_Model_val_acc = ResNet152_Model_History.history['val_accuracy']
ResNet152_Model_loss = ResNet152_Model_History.history['loss']
ResNet152_Model_val_loss = ResNet152_Model_History.history['val_loss']
epochs = range(len(ResNet152_Model_acc))
fig = plt.figure(figsize=(16,8))
plt.plot(epochs, ResNet152_Model_acc, 'r', label="Training Accuracy")
plt.plot(epochs, ResNet152_Model_val_acc, 'b', label="Validation Accuracy")
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.title('Training and validation Accuracy')
plt.legend(loc='lower right')
fig2 = plt.figure(figsize=(16,8))
plt.plot(epochs, ResNet152_Model_loss, 'r', label="Training Loss")
plt.plot(epochs, ResNet152_Model_val_loss, 'b', label="Validation Loss")
plt.legend(loc='upper right')
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.title('Training and validation Loss')
plt.show()
```



Model Performance Evaluation on Test Data

[ ]:
```
from sklearn.metrics import
  ↪accuracy_score,classification_report,confusion_matrix

result = ResNet152_Model.predict(test_data2)
ResNet152_Model_y_predict = np.array([i.argmax() for i in result])
```

```
ResNet152_Model_cm = confusion_matrix(y_test, ResNet152_Model_y_predict)
ResNet152_Model_ac = accuracy_score(y_test,ResNet152_Model_y_predict)

print("confusion matrix on test data :\n",ResNet152_Model_cm)
print("accuracy score on test data:\n",ResNet152_Model_ac)

print(classification_report(y_test, ResNet152_Model_y_predict))
```

```
confusion matrix on test data :
 [[17  1  1  1  0]
 [ 2 16  0  0  2]
 [ 1  2 15  0  2]
 [ 0  0  1 17  2]
 [ 0  0  1  0 19]]
accuracy score on test data:
 0.84
              precision    recall  f1-score   support

           0       0.85      0.85      0.85        20
           1       0.84      0.80      0.82        20
           2       0.83      0.75      0.79        20
           3       0.94      0.85      0.89        20
           4       0.76      0.95      0.84        20

    accuracy                           0.84       100
   macro avg       0.85      0.84      0.84       100
weighted avg       0.85      0.84      0.84       100
```

1.4.8 InceptionV3

Model Architecture Define

[ ]:
```
pretrained_model = tf.keras.applications.InceptionV3(
    include_top=False,
    weights="imagenet",
    input_shape=image_size + (3,),
    classes=1000,
    classifier_activation="softmax",
)
pretrained_model.trainable = False
InceptionV3_Model = tf.keras.Sequential([
    layers.RandomRotation(0.3, fill_mode='constant', fill_value=0,␣
 ↪input_shape=image_size + (3,)),
    layers.RandomZoom(height_factor=(-0.2,0.2), width_factor=(-0.2,0.
 ↪2),fill_mode='constant', fill_value=0),
    layers.RandomFlip("horizontal"),
    layers.RandomFlip("vertical"),
    pretrained_model, layers.Flatten(),
```

```
    layers.Dense(512, activation='relu'),
    layers.Dense(256, activation='relu'),
    tf.keras.layers.Dense(5, activation='softmax')])
InceptionV3_Model.summary()
```

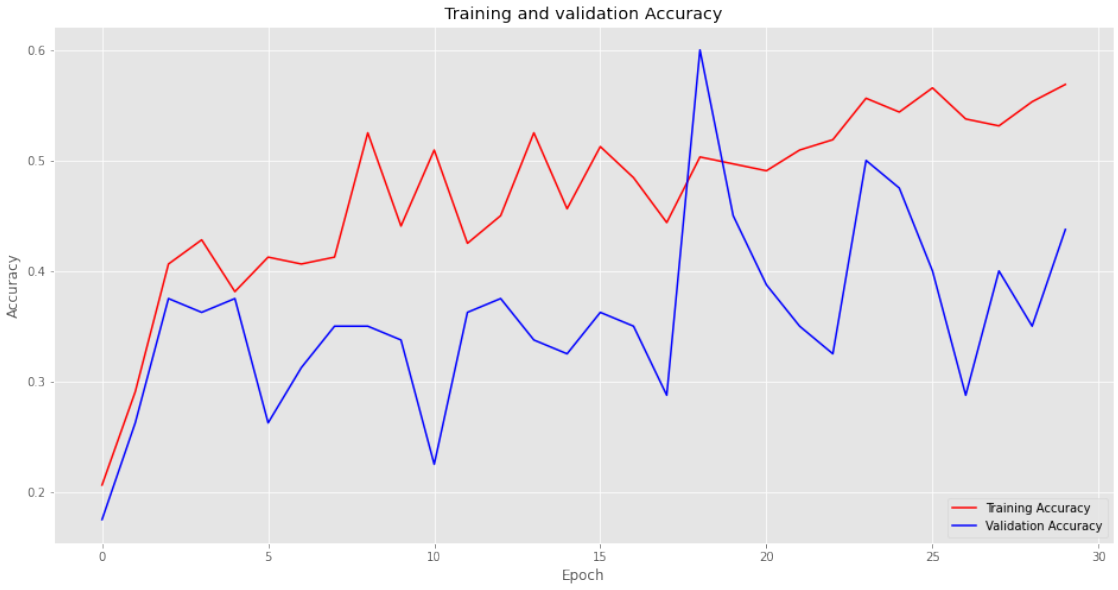
```
Downloading data from https://storage.googleapis.com/tensorflow/keras-applicatio
ns/inception_v3/inception_v3_weights_tf_dim_ordering_tf_kernels_notop.h5
87916544/87910968 [==============================] - 0s 0us/step
87924736/87910968 [==============================] - 0s 0us/step
Model: "sequential_8"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 random_rotation_8 (RandomRo  (None, 256, 256, 3)      0
 tation)

 random_zoom_7 (RandomZoom)  (None, 256, 256, 3)       0

 random_flip_16 (RandomFlip)  (None, 256, 256, 3)      0

 random_flip_17 (RandomFlip)  (None, 256, 256, 3)      0

 inception_v3 (Functional)   (None, 6, 6, 2048)        21802784

 flatten_7 (Flatten)         (None, 73728)             0

 dense_23 (Dense)            (None, 512)               37749248

 dense_24 (Dense)            (None, 256)               131328

 dense_25 (Dense)            (None, 5)                 1285

=================================================================
Total params: 59,684,645
Trainable params: 37,881,861
Non-trainable params: 21,802,784
_________________________________________________________________
```

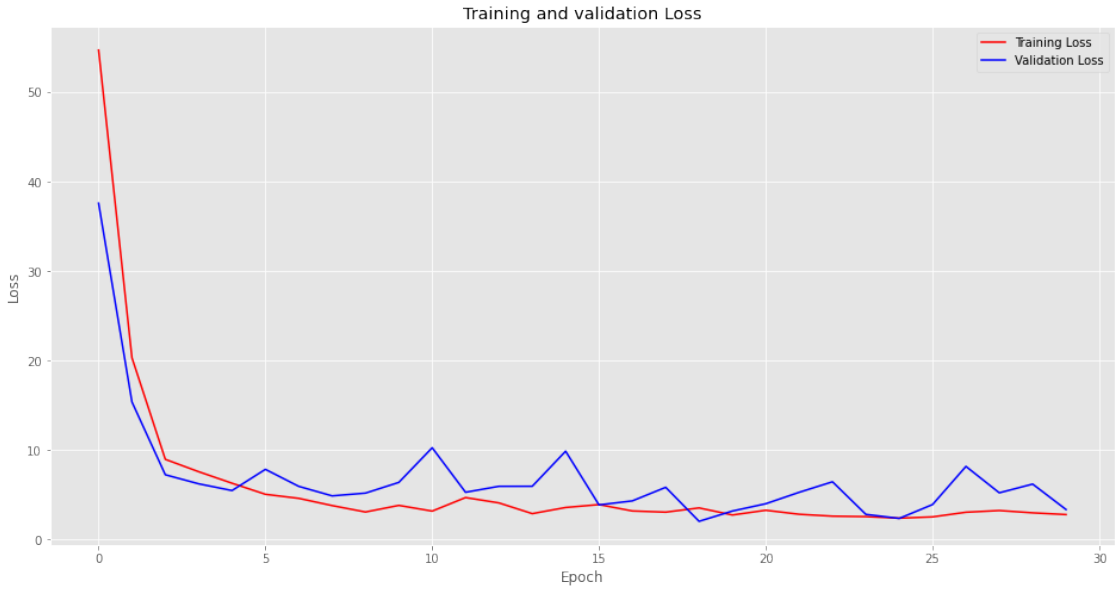
Model Creation and Training

[ ]:
```
InceptionV3_Model.compile(
    optimizer=keras.optimizers.Adam(1e-4),
    loss=tf.keras.losses.SparseCategoricalCrossentropy(),
    metrics=["accuracy"])
InceptionV3_Model_History = InceptionV3_Model.fit(
    pre_trained_data,
    epochs = pre_trained_epochs,
    validation_data = pre_trained_validation_data)
```

Accuracy and Loss Curves

```
[ ]: InceptionV3_Model_acc = InceptionV3_Model_History.history['accuracy']
InceptionV3_Model_val_acc = InceptionV3_Model_History.history['val_accuracy']
InceptionV3_Model_loss = InceptionV3_Model_History.history['loss']
InceptionV3_Model_val_loss = InceptionV3_Model_History.history['val_loss']
epochs = range(len(InceptionV3_Model_acc))
fig = plt.figure(figsize=(16,8))
plt.plot(epochs, InceptionV3_Model_acc, 'r', label="Training Accuracy")
plt.plot(epochs, InceptionV3_Model_val_acc, 'b', label="Validation Accuracy")
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.title('Training and validation Accuracy')
plt.legend(loc='lower right')
fig2 = plt.figure(figsize=(16,8))
plt.plot(epochs, InceptionV3_Model_loss, 'r', label="Training Loss")
plt.plot(epochs, InceptionV3_Model_val_loss, 'b', label="Validation Loss")
plt.legend(loc='upper right')
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.title('Training and validation Loss')
plt.show()
```





Model Performance Evaluation on Test Data

[ ]:
```
from sklearn.metrics import␣
  ↪accuracy_score,classification_report,confusion_matrix

result = InceptionV3_Model.predict(test_data2)
InceptionV3_Model_y_predict = np.array([i.argmax() for i in result])

InceptionV3_Model_cm = confusion_matrix(y_test, InceptionV3_Model_y_predict)
InceptionV3_Model_ac = accuracy_score(y_test,InceptionV3_Model_y_predict)

print("confusion matrix on test data :\n",InceptionV3_Model_cm)
print("accuracy score on test data:\n",InceptionV3_Model_ac)

print(classification_report(y_test, InceptionV3_Model_y_predict))
```

```
confusion matrix on test data :
 [[ 0  5  3 11  1]
 [ 0  6  2  8  4]
 [ 0  1  6  9  4]
 [ 0  2  0 14  4]
 [ 0  1  0  6 13]]
accuracy score on test data:
 0.39
              precision    recall  f1-score   support

           0       0.00      0.00      0.00        20
           1       0.40      0.30      0.34        20
           2       0.55      0.30      0.39        20
```

```
           3       0.29      0.70      0.41        20
           4       0.50      0.65      0.57        20

    accuracy                           0.39       100
   macro avg       0.35      0.39      0.34       100
weighted avg       0.35      0.39      0.34       100

/usr/local/lib/python3.7/dist-packages/sklearn/metrics/_classification.py:1318:
UndefinedMetricWarning: Precision and F-score are ill-defined and being set to
0.0 in labels with no predicted samples. Use `zero_division` parameter to
control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
/usr/local/lib/python3.7/dist-packages/sklearn/metrics/_classification.py:1318:
UndefinedMetricWarning: Precision and F-score are ill-defined and being set to
0.0 in labels with no predicted samples. Use `zero_division` parameter to
control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
/usr/local/lib/python3.7/dist-packages/sklearn/metrics/_classification.py:1318:
UndefinedMetricWarning: Precision and F-score are ill-defined and being set to
0.0 in labels with no predicted samples. Use `zero_division` parameter to
control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

1.4.9 InceptionResNetV2

Model Architecture Define

[ ]:
```
pretrained_model = tf.keras.applications.InceptionResNetV2(
    include_top=False,
    weights="imagenet",
    input_shape=image_size + (3,),
    classes=1000,
    classifier_activation="softmax",
)
pretrained_model.trainable = False
InceptionResNetV2_Model = tf.keras.Sequential([
    layers.RandomRotation(0.3, fill_mode='constant', fill_value=0,␣
 ↪input_shape=image_size + (3,)),
    layers.RandomZoom(height_factor=(-0.2,0.2), width_factor=(-0.2,0.
 ↪2),fill_mode='constant', fill_value=0),
    layers.RandomFlip("horizontal"),
    layers.RandomFlip("vertical"),
    pretrained_model, layers.Flatten(),
    layers.Dense(512, activation='relu'),
    layers.Dense(256, activation='relu'),
    tf.keras.layers.Dense(5, activation='softmax')])
InceptionResNetV2_Model.summary()
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-applicatio
```

```
ns/inception_resnet_v2/inception_resnet_v2_weights_tf_dim_ordering_tf_kernels_no
top.h5
219062272/219055592 [==============================] - 1s 0us/step
219070464/219055592 [==============================] - 1s 0us/step
Model: "sequential_9"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 random_rotation_9 (RandomRo  (None, 256, 256, 3)      0
 tation)

 random_zoom_8 (RandomZoom)  (None, 256, 256, 3)       0

 random_flip_18 (RandomFlip)  (None, 256, 256, 3)      0

 random_flip_19 (RandomFlip)  (None, 256, 256, 3)      0

 inception_resnet_v2 (Functi  (None, 6, 6, 1536)       54336736
 onal)

 flatten_8 (Flatten)         (None, 55296)             0

 dense_26 (Dense)            (None, 512)               28312064

 dense_27 (Dense)            (None, 256)               131328

 dense_28 (Dense)            (None, 5)                 1285

=================================================================
Total params: 82,781,413
Trainable params: 28,444,677
Non-trainable params: 54,336,736
_________________________________________________________________
```

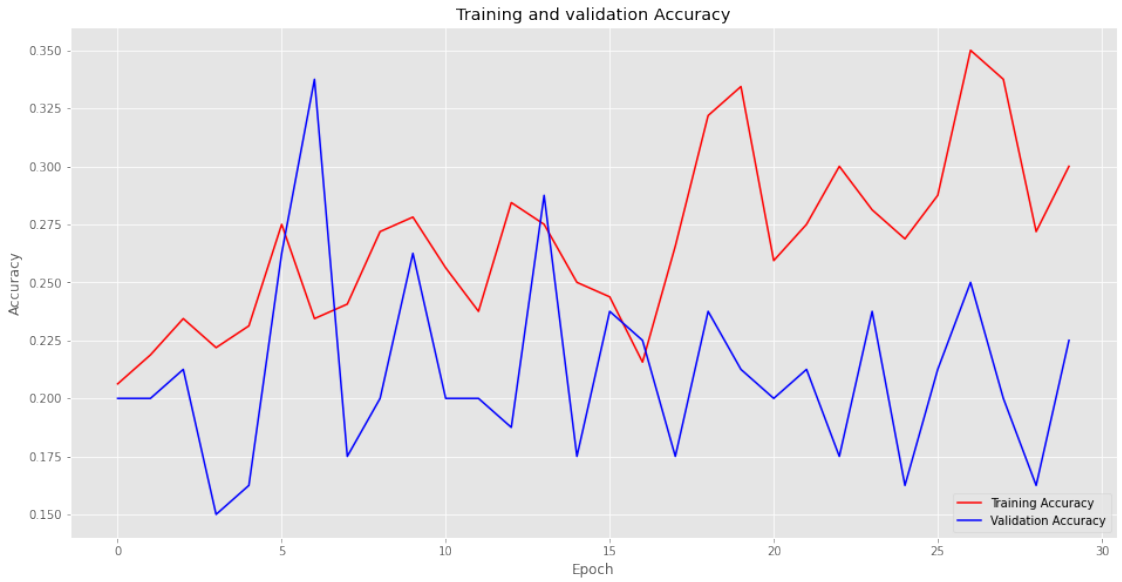
Model Creation and Training

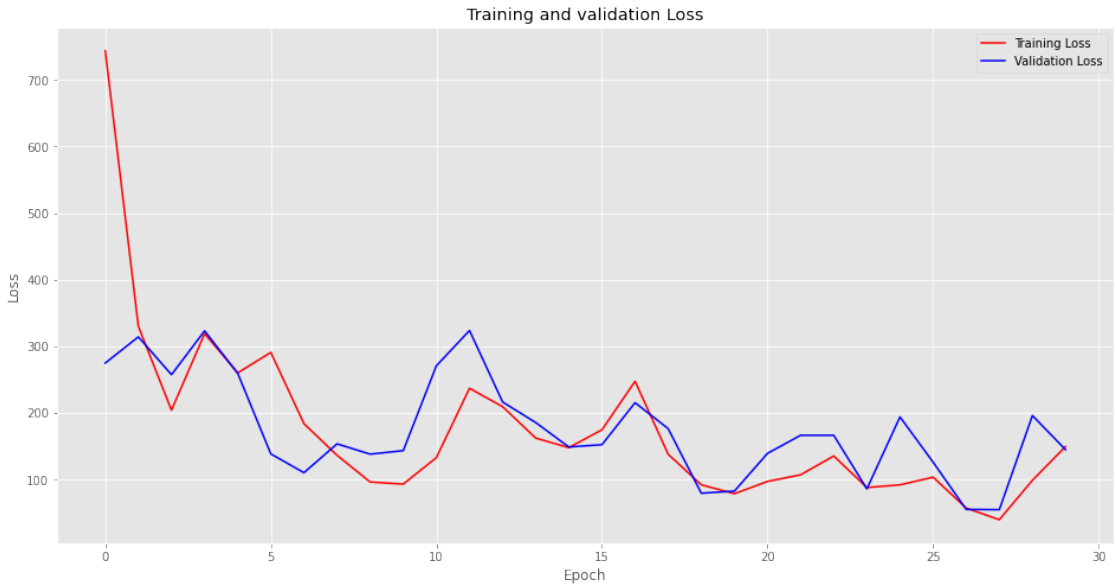
[ ]:
```
InceptionResNetV2_Model.compile(
    optimizer=keras.optimizers.Adam(1e-4),
    loss=tf.keras.losses.SparseCategoricalCrossentropy(),
    metrics=["accuracy"])
InceptionResNetV2_Model_History = InceptionResNetV2_Model.fit(
    pre_trained_data,
    epochs = pre_trained_epochs,
    validation_data = pre_trained_validation_data)
```

Accuracy and Loss Curves

[ ]:
```
InceptionResNetV2_Model_acc = InceptionResNetV2_Model_History.
 ↪history['accuracy']
```

```
InceptionResNetV2_Model_val_acc = InceptionResNetV2_Model_History.
 ↪history['val_accuracy']
InceptionResNetV2_Model_loss = InceptionResNetV2_Model_History.history['loss']
InceptionResNetV2_Model_val_loss = InceptionResNetV2_Model_History.
 ↪history['val_loss']
epochs = range(len(InceptionResNetV2_Model_acc))
fig = plt.figure(figsize=(16,8))
plt.plot(epochs, InceptionResNetV2_Model_acc, 'r', label="Training Accuracy")
plt.plot(epochs, InceptionResNetV2_Model_val_acc, 'b', label="Validation␣
 ↪Accuracy")
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.title('Training and validation Accuracy')
plt.legend(loc='lower right')
fig2 = plt.figure(figsize=(16,8))
plt.plot(epochs, InceptionResNetV2_Model_loss, 'r', label="Training Loss")
plt.plot(epochs, InceptionResNetV2_Model_val_loss, 'b', label="Validation Loss")
plt.legend(loc='upper right')
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.title('Training and validation Loss')
plt.show()
```





Model Performance Evaluation on Test Data

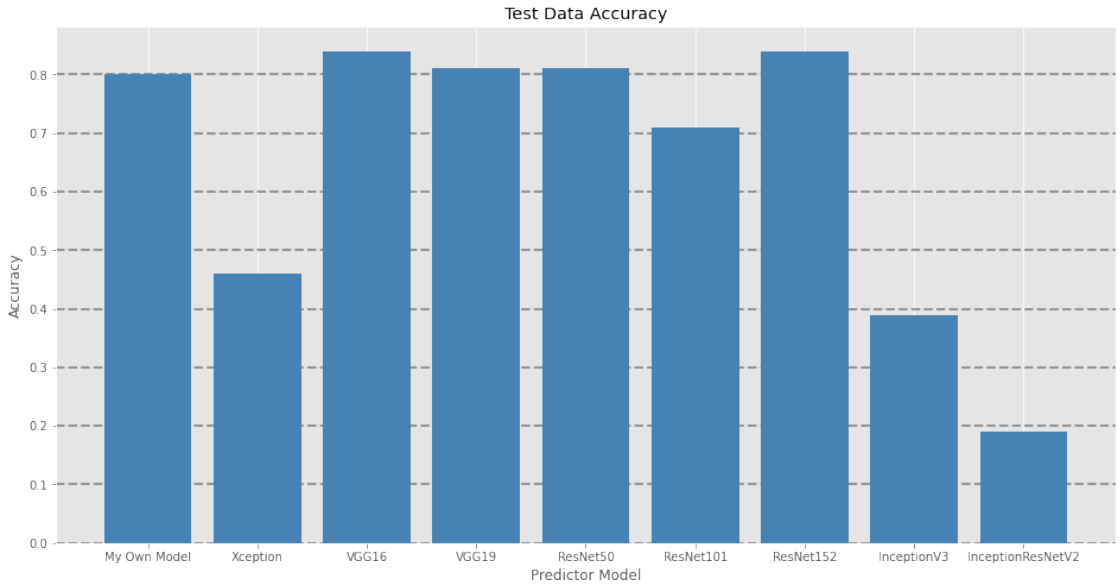
[ ]:
```
from sklearn.metrics import␣
 ↪accuracy_score,classification_report,confusion_matrix

result = InceptionResNetV2_Model.predict(test_data2)
InceptionResNetV2_Model_y_predict = np.array([i.argmax() for i in result])

InceptionResNetV2_Model_cm = confusion_matrix(y_test,␣
 ↪InceptionResNetV2_Model_y_predict)
InceptionResNetV2_Model_ac =␣
 ↪accuracy_score(y_test,InceptionResNetV2_Model_y_predict)

print("confusion matrix on test data :\n",InceptionResNetV2_Model_cm)
print("accuracy score on test data:\n",InceptionResNetV2_Model_ac)

print(classification_report(y_test, InceptionResNetV2_Model_y_predict))
```

```
confusion matrix on test data :
 [[ 0  1 16  3  0]
 [ 0  0 17  3  0]
 [ 0  1 18  1  0]
 [ 0  0 19  1  0]
 [ 0  3 14  3  0]]
accuracy score on test data:
 0.19
              precision    recall  f1-score   support

           0       0.00      0.00      0.00        20
```

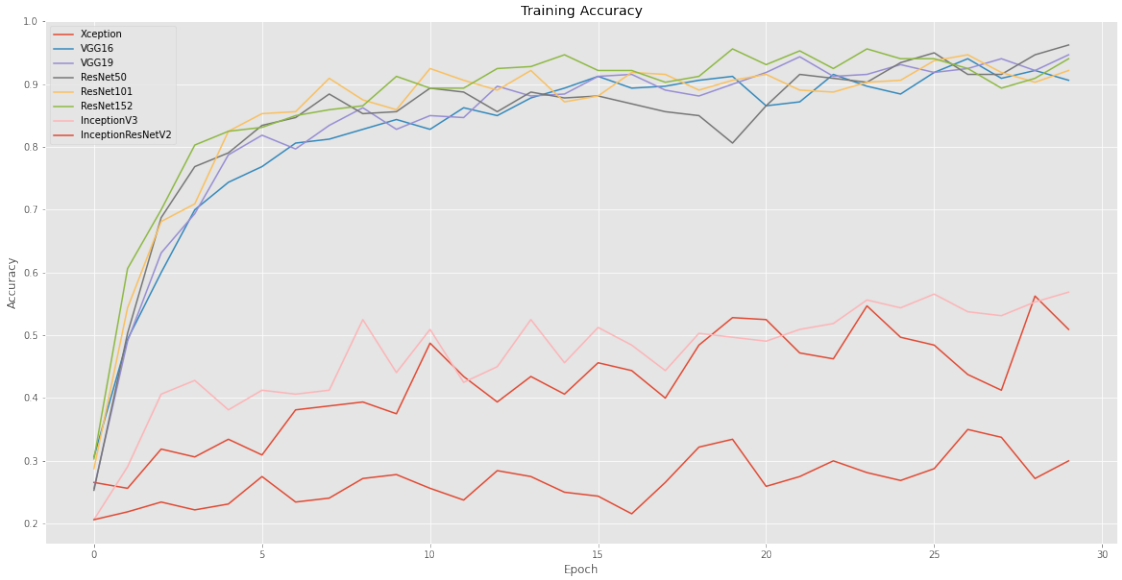
```
           1       0.00      0.00      0.00        20
           2       0.21      0.90      0.35        20
           3       0.09      0.05      0.06        20
           4       0.00      0.00      0.00        20

    accuracy                           0.19       100
   macro avg       0.06      0.19      0.08       100
weighted avg       0.06      0.19      0.08       100

/usr/local/lib/python3.7/dist-packages/sklearn/metrics/_classification.py:1318:
UndefinedMetricWarning: Precision and F-score are ill-defined and being set to
0.0 in labels with no predicted samples. Use `zero_division` parameter to
control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
/usr/local/lib/python3.7/dist-packages/sklearn/metrics/_classification.py:1318:
UndefinedMetricWarning: Precision and F-score are ill-defined and being set to
0.0 in labels with no predicted samples. Use `zero_division` parameter to
control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
/usr/local/lib/python3.7/dist-packages/sklearn/metrics/_classification.py:1318:
UndefinedMetricWarning: Precision and F-score are ill-defined and being set to
0.0 in labels with no predicted samples. Use `zero_division` parameter to
control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

1.4.10 Comparing Pre-Trained Models

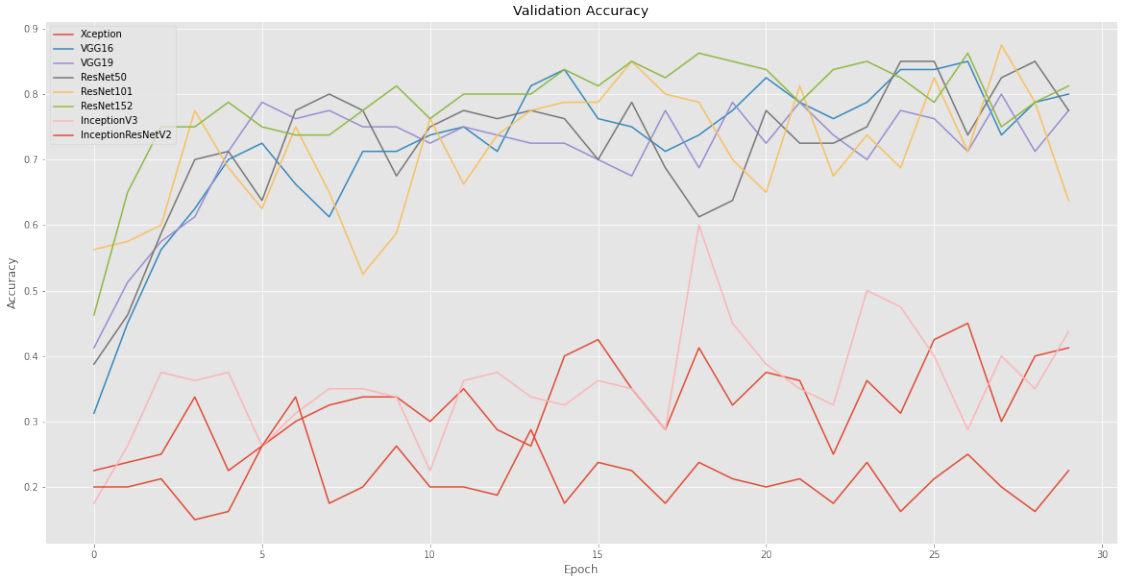
[ ]:
```python
Models_Names = ["My Own Model", "Xception", "VGG16", "VGG19",
                "ResNet50", "ResNet101", "ResNet152",
                "InceptionV3", "InceptionResNetV2"]
Models_test_acc = [MyOwnModel_ac, Xception_Model_ac, VGG16_Model_ac,␣
 ↪VGG19_Model_ac,
                   ResNet50_Model_ac, ResNet101_Model_ac, ResNet152_Model_ac,
                   InceptionV3_Model_ac, InceptionResNetV2_Model_ac]

fig = plt.figure(figsize=(16,8))
plt.bar(Models_Names, Models_test_acc, color='steelblue')
plt.grid(color='gray', linestyle='--', linewidth=2, axis='y', alpha=0.8)
plt.xlabel('Predictor Model')
plt.ylabel('Accuracy')
plt.title('Test Data Accuracy')
plt.show()
```



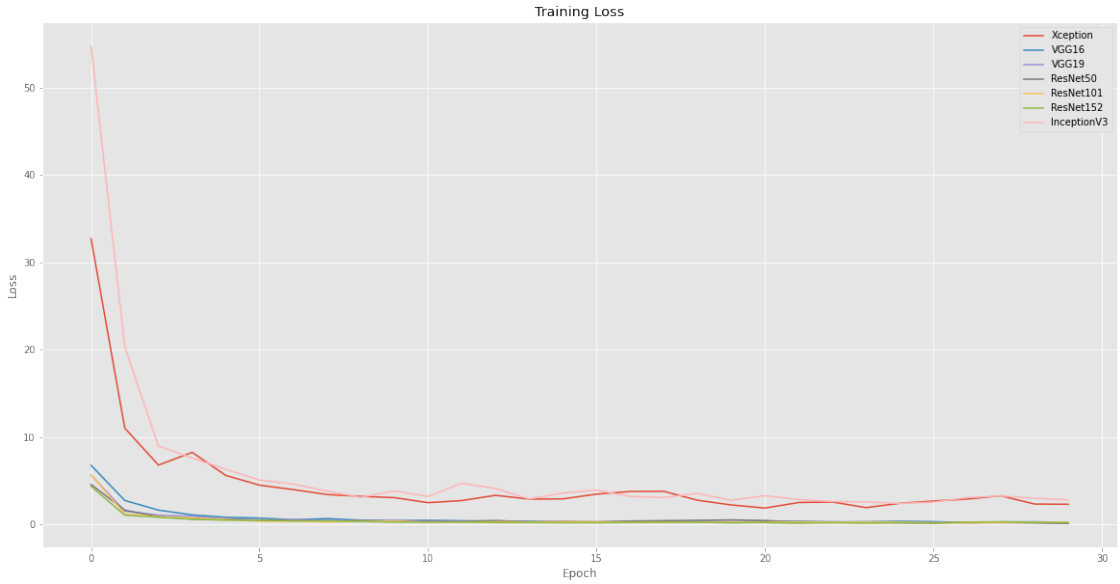
[ ]:
```
fig = plt.figure(figsize=(20,10))
plt.plot(epochs, Xception_Model_acc, label="Xception")
plt.plot(epochs, VGG16_Model_acc, label="VGG16")
plt.plot(epochs, VGG19_Model_acc, label="VGG19")
plt.plot(epochs, ResNet50_Model_acc, label="ResNet50")
plt.plot(epochs, ResNet101_Model_acc, label="ResNet101")
plt.plot(epochs, ResNet152_Model_acc, label="ResNet152")
plt.plot(epochs, InceptionV3_Model_acc, label="InceptionV3")
plt.plot(epochs, InceptionResNetV2_Model_acc, label="InceptionResNetV2")
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.title('Training Accuracy')
plt.legend(loc='upper left')
plt.show()
```



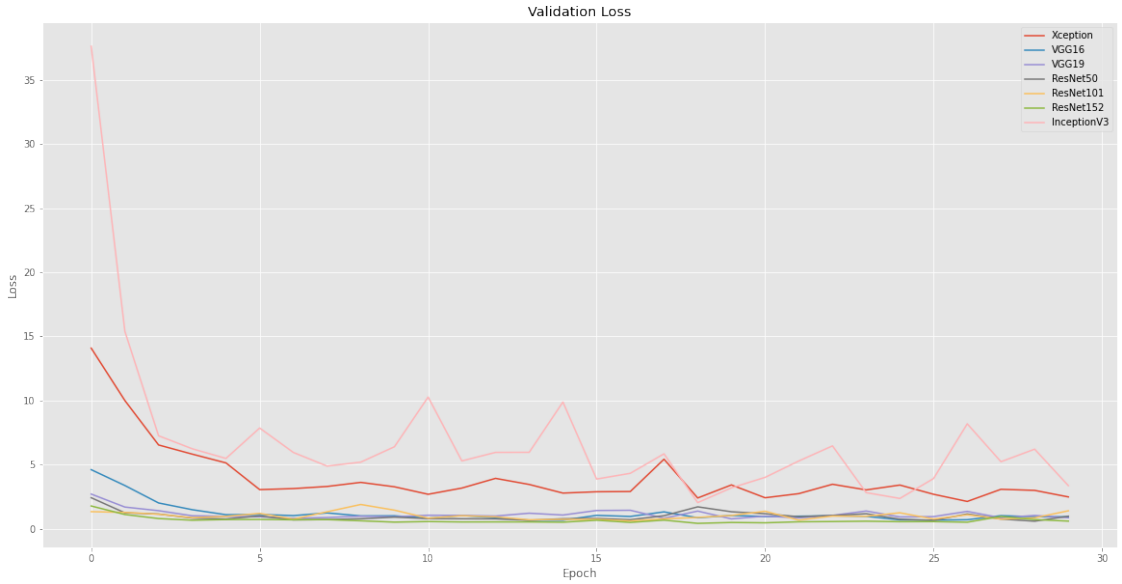
[ ]:
```
fig = plt.figure(figsize=(20,10))
plt.plot(epochs, Xception_Model_val_acc, label="Xception")
plt.plot(epochs, VGG16_Model_val_acc, label="VGG16")
plt.plot(epochs, VGG19_Model_val_acc, label="VGG19")
plt.plot(epochs, ResNet50_Model_val_acc, label="ResNet50")
plt.plot(epochs, ResNet101_Model_val_acc, label="ResNet101")
plt.plot(epochs, ResNet152_Model_val_acc, label="ResNet152")
plt.plot(epochs, InceptionV3_Model_val_acc, label="InceptionV3")
plt.plot(epochs, InceptionResNetV2_Model_val_acc, label="InceptionResNetV2")
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.title('Validation Accuracy')
plt.legend(loc='upper left')
plt.show()
```



[ ]:
```
fig = plt.figure(figsize=(20,10))
plt.plot(epochs, Xception_Model_loss, label="Xception")
plt.plot(epochs, VGG16_Model_loss, label="VGG16")
plt.plot(epochs, VGG19_Model_loss, label="VGG19")
plt.plot(epochs, ResNet50_Model_loss, label="ResNet50")
plt.plot(epochs, ResNet101_Model_loss, label="ResNet101")
plt.plot(epochs, ResNet152_Model_loss, label="ResNet152")
plt.plot(epochs, InceptionV3_Model_loss, label="InceptionV3")
#plt.plot(epochs, InceptionResNetV2_Model_loss, label="InceptionResNetV2")
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.title('Training Loss')
plt.legend(loc='upper right')
plt.show()
```



[ ]:
```
fig = plt.figure(figsize=(20,10))
plt.plot(epochs, Xception_Model_val_loss, label="Xception")
plt.plot(epochs, VGG16_Model_val_loss, label="VGG16")
plt.plot(epochs, VGG19_Model_val_loss, label="VGG19")
plt.plot(epochs, ResNet50_Model_val_loss, label="ResNet50")
plt.plot(epochs, ResNet101_Model_val_loss, label="ResNet101")
plt.plot(epochs, ResNet152_Model_val_loss, label="ResNet152")
plt.plot(epochs, InceptionV3_Model_val_loss, label="InceptionV3")
#plt.plot(epochs, InceptionResNetV2_Model_val_loss, label="InceptionResNetV2")
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.title('Validation Loss')
plt.legend(loc='upper right')
plt.show()
```



1.5 10 Different Seeds

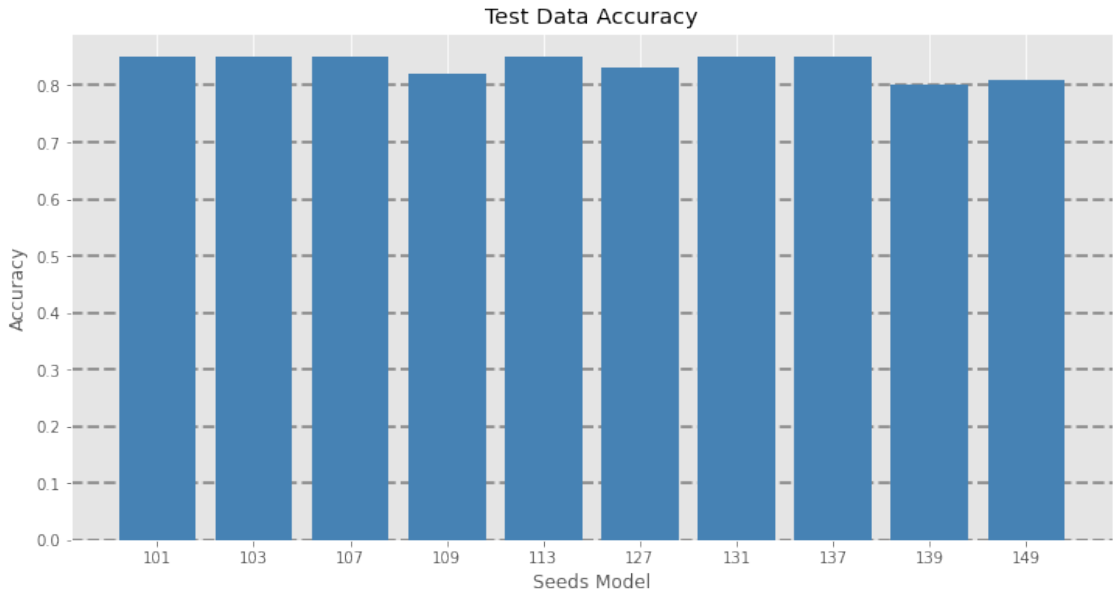
[ ]:
```
def load_by_conf(seed = 199, image_size = (256,256), batch_size = 32,␣
↪validation_split = 0.2):
    train_data = tf.keras.utils.image_dataset_from_directory(
        'Grapevine_Leaves_Image_Dataset',
        class_names = ["Ak", "Ala_Idris", "Buzgulu", "Dimnit", "Nazli"],
        batch_size=batch_size,
        image_size=image_size,
        seed=seed,
        validation_split=validation_split,
        subset="training"
    )
    validation_data = tf.keras.utils.image_dataset_from_directory(
        'Grapevine_Leaves_Image_Dataset',
        class_names = ["Ak", "Ala_Idris", "Buzgulu", "Dimnit", "Nazli"],
        batch_size=batch_size,
        image_size=image_size,
        seed=seed,
        validation_split=validation_split,
        subset="validation"
    )
    test_data = tf.keras.utils.image_dataset_from_directory(
        'Test_Data',
        class_names = ["Ak", "Ala_Idris", "Buzgulu", "Dimnit", "Nazli"],
        image_size=image_size,
        batch_size=100,
```

```
        shuffle=False,
    )
    train_data_transposed = train_data.map(lambda x, y: (255-x, y))
    validation_data_transposed = validation_data.map(lambda x, y: (255-x, y))
    test_data_transposed = test_data.map(lambda x, y: (255-x, y))
    return([train_data_transposed, validation_data_transposed,␣
↪test_data_transposed])
```

[ ]:
```
def best_model_train(data, epochs = 2):
    pretrained_model = tf.keras.applications.ResNet152(
        include_top=False,
        weights="imagenet",
        input_shape=image_size + (3,),
        classes=1000)
    pretrained_model.trainable = False

    Best_Model = tf.keras.Sequential([
        layers.RandomRotation(0.3, fill_mode='constant', fill_value=0,␣
↪input_shape=image_size + (3,)),
        layers.RandomZoom(height_factor=(-0.2,0.2), width_factor=(-0.2,0.
↪2),fill_mode='constant', fill_value=0),
        layers.RandomFlip("horizontal"),
        layers.RandomFlip("vertical"),
        pretrained_model, layers.Flatten(),
        layers.Dense(512, activation='relu'),
        layers.Dense(256, activation='relu'),
        tf.keras.layers.Dense(5, activation='softmax')])
    Best_Model.compile(
        optimizer=keras.optimizers.Adam(1e-4),
        loss=tf.keras.losses.SparseCategoricalCrossentropy(),
        metrics=["accuracy"])
    Best_Model_History = Best_Model.fit(
        data[0],
        epochs = epochs,
        validation_data = data[1],
        verbose=2)

    result = Best_Model.predict(data[2])
    Best_Model_y_predict = np.array([i.argmax() for i in result])
    y_test = np.concatenate([y for x, y in data[2]], axis=0)
    Best_Model_cm = confusion_matrix(y_test, Best_Model_y_predict)
    Best_Model_ac = accuracy_score(y_test,Best_Model_y_predict)
    res = [Best_Model_ac, Best_Model_cm, classification_report(y_test,␣
↪Best_Model_y_predict)]
    return(res)
```

[ ]:
```
seeds = [101, 103, 107, 109, 113, 127, 131, 137, 139, 149]
results = []
for s in seeds:
    print("*"*40)
    print("For Seed = ", s)
    print("*"*40)
    new_data = load_by_conf(seed = s)
    new_res = best_model_train(new_data, epochs = 30)
    results.append(new_res)
    print("*"*40)
    print("\n"*2)
accs = []
cfmxs = []
clfrep = []
for i in results:
    accs.append(i[0])
    cfmxs.append(i[1])
    clfrep.append(i[2])
```

[ ]:
```
fig = plt.figure(figsize=(12,6))
plt.bar([str(i) for i in seeds], accs, color='steelblue')
plt.grid(color='gray', linestyle='--', linewidth=2, axis='y', alpha=0.8)
plt.xlabel('Seeds Model')
plt.ylabel('Accuracy')
plt.title('Test Data Accuracy')
plt.show()
print("*"*100)
print("accuracies : ", accs)
print("Mean accuracy : ",np.array(accs).mean())
print("Best Model Classification Report :")
print(clfrep[np.array(accs).argmax()])
```




```
**********************************************************************************
********************
accuracies :  [0.85, 0.85, 0.85, 0.82, 0.85, 0.83, 0.85, 0.85, 0.8, 0.81]
Mean accuracy :  0.836
Best Model Classification Report :
              precision    recall  f1-score   support

           0       0.67      0.90      0.77        20
           1       1.00      0.80      0.89        20
           2       0.90      0.95      0.93        20
           3       1.00      0.70      0.82        20
           4       0.82      0.90      0.86        20

    accuracy                           0.85       100
   macro avg       0.88      0.85      0.85       100
weighted avg       0.88      0.85      0.85       100
```