Model2_FT - FineTuning using Densenet201

by Kaushik Srivatsan - CDS - kaushik.s-25@scds.saiuniversity.edu.in

```
from google.colab import drive
drive.mount('/content/drive')
```

```
Mounted at /content/drive
```

```
import tensorflow as tf
print(tf.__version__)

from tensorflow import keras
tf.random.set_seed(42)

import numpy as np
np.random.seed(42)

import matplotlib.pyplot as plt
%matplotlib inline

import glob
import PIL
from PIL import Image
```

```
2.15.0
```

Loading the preprocessed dataset

```
# load numpy array from npy file
from numpy import load

X_train_std = load('/content/drive/MyDrive/Models/X_train_std_model1.npy')
X_test_std = load('/content/drive/MyDrive/Models/X_test_std_model1.npy')

y_train = load('/content/drive/MyDrive/Models/y_train_model1.npy')
y_test = load('/content/drive/MyDrive/Models/y_test_model1.npy')
```

```
print("X_train_std_shape: {}".format(X_train_std.shape))
print("X_test_std_shape: {}".format(X_test_std.shape))
```

```
X_train_std_shape: (373, 299, 299, 3)
X_test_std_shape: (125, 299, 299, 3)
```

Loading the Transfer-learning Model

```
model2_FT = keras.models.load_model('/content/drive/MyDrive/Models/model2_TL.h5')
model2_FT.summary()
```

```
 conv5_block32_1_bn (BatchN  (None, 9, 9, 128)           512       ['conv5_block32_1_conv[0][0]']
 ormalization)

 conv5_block32_1_relu (Acti  (None, 9, 9, 128)           0         ['conv5_block32_1_bn[0][0]']
 vation)

 conv5_block32_2_conv (Conv  (None, 9, 9, 32)            36864     ['conv5_block32_1_relu[0][0]']
 2D)

 conv5_block32_concat (Conc  (None, 9, 9, 1920)          0         ['conv5_block31_concat[0][0]',
 atenate)                                                    'conv5_block32_2_conv[0][0]']

 bn (BatchNormalization)     (None, 9, 9, 1920)          7680      ['conv5_block32_concat[0][0]']

 relu (Activation)           (None, 9, 9, 1920)          0         ['bn[0][0]']

 global_average_pooling2d (  (None, 1920)                0         ['relu[0][0]']
 GlobalAveragePooling2D)

 batch_normalization (Batch  (None, 1920)                7680      ['global_average_pooling2d[0][
 Normalization)                                                  0]']

 dropout (Dropout)           (None, 1920)                0         ['batch_normalization[0][0]']

 dense (Dense)               (None, 4)                   7684      ['dropout[0][0]']

==================================================================================================
Total params: 18337348 (69.95 MB)
Trainable params: 11524 (45.02 KB)
Non-trainable params: 18325824 (69.91 MB)
__________________________________________________________________________________________________
```

Modifyng and Fine tuning the layers to be trained

```
total_layers = len(model2_FT.layers)
split_index = int(0.35 * total_layers)

for layer in model2_FT.layers[:split_index]:
    layer.trainable = False

for layer in model2_FT.layers[split_index:]:
    layer.trainable = True
```

Compiling and Training the Model

```
model2_FT.compile(loss='sparse_categorical_crossentropy',
                optimizer='adam',
                metrics=['accuracy'])

callbacks_FineTune = [
             keras.callbacks.ModelCheckpoint("bestFT2.h5",
                                          monitor='val_accuracy',
                                          save_weights_only=True,
                                          save_best_only=True)
]

history_FineTune = model2_FT.fit(x = X_train_std, y = y_train, epochs=10,
                                 validation_split=0.1, batch_size=16, callbacks=callbacks_FineTune)
```

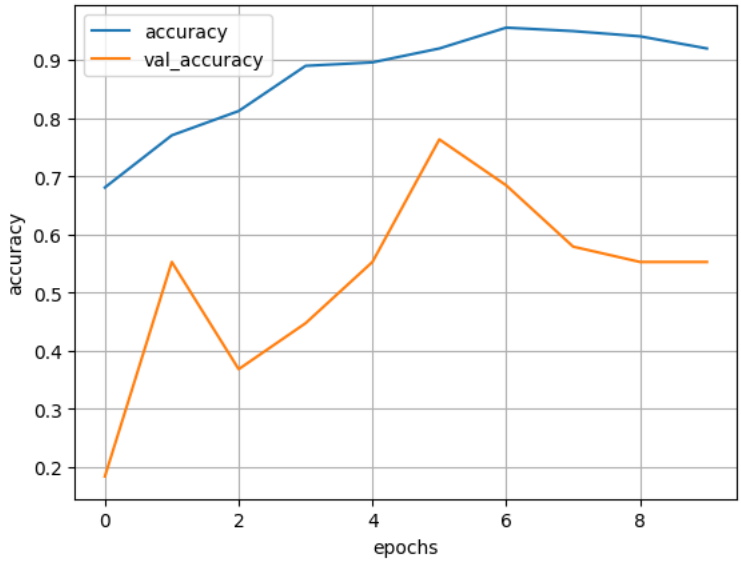
```
Epoch 1/10
21/21 [==============================] - 124s 1s/step - loss: 1.1181 - accuracy: 0.6806 - val_loss: 33.8642 - val_accuracy: 0.1842
Epoch 2/10
21/21 [==============================] - 7s 352ms/step - loss: 0.6563 - accuracy: 0.7701 - val_loss: 18.8863 - val_accuracy: 0.5526
Epoch 3/10
21/21 [==============================] - 6s 304ms/step - loss: 0.7855 - accuracy: 0.8119 - val_loss: 42.8772 - val_accuracy: 0.3684
Epoch 4/10
21/21 [==============================] - 6s 308ms/step - loss: 0.3230 - accuracy: 0.8896 - val_loss: 6.5055 - val_accuracy: 0.4474
Epoch 5/10
21/21 [==============================] - 6s 304ms/step - loss: 0.2884 - accuracy: 0.8955 - val_loss: 9.6068 - val_accuracy: 0.5526
Epoch 6/10
21/21 [==============================] - 8s 375ms/step - loss: 0.2293 - accuracy: 0.9194 - val_loss: 1.2646 - val_accuracy: 0.7632
Epoch 7/10
21/21 [==============================] - 7s 323ms/step - loss: 0.1288 - accuracy: 0.9552 - val_loss: 2.0049 - val_accuracy: 0.6842
Epoch 8/10
21/21 [==============================] - 7s 318ms/step - loss: 0.1363 - accuracy: 0.9493 - val_loss: 10.4870 - val_accuracy: 0.5789
Epoch 9/10
21/21 [==============================] - 7s 327ms/step - loss: 0.1881 - accuracy: 0.9403 - val_loss: 2.3366 - val_accuracy: 0.5526
Epoch 10/10
21/21 [==============================] - 7s 325ms/step - loss: 0.1977 - accuracy: 0.9194 - val_loss: 1.8203 - val_accuracy: 0.5526
```

```
keys = ['accuracy', 'val_accuracy']
progress = {k:v for k,v in history_FineTune.history.items() if k in keys}

import pandas as pd
pd.DataFrame(progress).plot()

plt.xlabel("epochs")
plt.ylabel("accuracy")

plt.grid(True)
plt.show()
```



Evaluating the Model with Best weights

```
model2_FT.load_weights("bestFT2.h5")

testLoss_FineTune, testAccuracy_FineTune = model2_FT.evaluate(x = X_test_std, y = y_test)

print("Test-loss: %f, Test-accuracy: %f" % (testLoss_FineTune, testAccuracy_FineTune))
```

```
4/4 [==============================] - 24s 4s/step - loss: 1.2774 - accuracy: 0.7600
Test-loss: 1.277431, Test-accuracy: 0.760000
```

Checking its Performance

```
y_proba = model2_FT.predict(X_test_std)
y_predict = np.argmax(y_proba, axis=-1)
print(y_predict)
```

```
4/4 [==============================] - 5s 289ms/step
[1 2 1 1 0 3 3 1 1 0 3 2 3 1 1 3 1 3 1 1 1 1 3 2 1 3 3 2 3 3 3 3 1 0 1 0 2
 3 2 2 3 3 2 0 1 2 1 3 2 3 1 1 3 3 0 0 2 1 2 2 0 3 1 3 3 3 2 1 1 1 2 3 2 3
 3 1 3 1 0 3 1 1 3 2 2 0 3 3 1 0 0 1 2 3 3 2 2 0 1 1 1 1 3 1 0 1 3 1 3 3 3
 1 3 2 3 3 0 3 1 1 3 1 3 3 0]
```

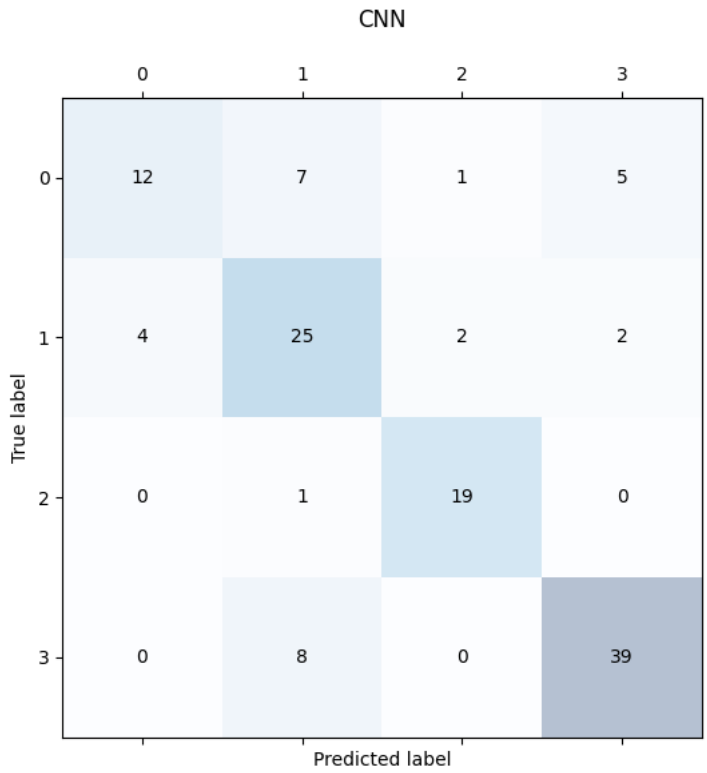
```
from sklearn.metrics import confusion_matrix
cm = confusion_matrix(y_true = y_test, y_pred = y_predict)

fig, ax = plt.subplots(figsize=(6, 6))
ax.matshow(cm, cmap=plt.cm.Blues, alpha=0.3)

for i in range(cm.shape[0]):
    for j in range(cm.shape[1]):
        ax.text(x=j, y=i, s=cm[i, j], va='center', ha='center')

ax.title.set_text('CNN\n')
plt.xlabel('Predicted label')
plt.ylabel('True label')

plt.tight_layout()
plt.savefig("ConfusionMatrix.png", dpi=300, format='png', pad_inches=0.3)
plt.show()
```




```
from sklearn.metrics import precision_score, recall_score, f1_score

pScore = precision_score(y_true= y_test, y_pred = y_predict, average = 'weighted')
print("Precision: ", pScore)

pScore = precision_score(y_true= y_test, y_pred = y_predict, average = 'weighted')
print("Precision: ", pScore)

rScore = recall_score(y_true= y_test, y_pred = y_predict, average = 'weighted')
print("Recall: ", rScore)

fScore = f1_score(y_true= y_test, y_pred = y_predict, average = 'weighted')
print("F1-score: ", fScore)

print("\n\n\n")

rScore = recall_score(y_true= y_test, y_pred = y_predict, average = 'weighted')
print("Recall: ", rScore)

fScore = f1_score(y_true= y_test, y_pred = y_predict, average = 'weighted')
print("F1-score: ", fScore)

print("\n\n\n")
```

```
Precision:  0.7679400366335679
Precision:  0.7679400366335679
Recall:  0.76
F1-score:  0.7555682925816679



Recall:  0.76
F1-score:  0.7555682925816679
```

Saving the Fine-Tuned Model

```
model2_FT.save('/content/drive/MyDrive/Models/model2_FT.h5')
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/engine/training.py:3103: UserWarning: You are saving your model as an HDF5 file vi
  saving_api.save_model(
```