Fine Tuning using Xception

Gayanthika Shankar

School of Computing and Data Science

gayanthika.s-26@scds.saiuniversity.edu.in

```
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
```

```
2.17.1
```

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

```
Mounted at /content/gdrive
```

```
#Load the pre-processed dataset form drive

from numpy import load

X_train_std = load('/content/gdrive/MyDrive/DL/X_train_std.npy')
X_test_std = load('/content/gdrive/MyDrive/DL/X_test_std.npy')

y_train = load('/content/gdrive/MyDrive/DL/y_train.npy')
y_test = load('/content/gdrive/MyDrive/DL/y_test.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: (1245, 299, 299, 3)
X_test_std_shape: (416, 299, 299, 3)
```

Load the TL model

```
#Best saved

model1_FT = keras.models.load_model('/content/gdrive/MyDrive/DL/Xception_Best_Mod
```

```
WARNING:absl:Compiled the loaded model, but the compiled metrics have yet to
```

```
model1_FT.summary()
```

Model: "functional"

Layer (type)	Output Shape	Param #	Conne
input_layer_2 (InputLayer)	(None, 299, 299, 3)	0	-
block1_conv1 (Conv2D)	(None, 149, 149, 32)	864	input_
block1_conv1_bn (BatchNormalization)	(None, 149, 149, 32)	128	block
block1_conv1_act (Activation)	(None, 149, 149, 32)	0	block
block1_conv2 (Conv2D)	(None, 147, 147, 64)	18,432	block

block1_conv2_bn (BatchNormalization)	(None, 147, 147, 64)	256	block1
block1_conv2_act (Activation)	(None, 147, 147, 64)	0	block1
block2_sepconv1 (SeparableConv2D)	(None, 147, 147, 128)	8,768	block1
block2_sepconv1_bn (BatchNormalization)	(None, 147, 147, 128)	512	block2
block2_sepconv2_act (Activation)	(None, 147, 147, 128)	0	block2
block2_sepconv2 (SeparableConv2D)	(None, 147, 147, 128)	17,536	block2
block2_sepconv2_bn (BatchNormalization)	(None, 147, 147, 128)	512	block2
conv2d_8 (Conv2D)	(None, 74, 74, 128)	8,192	block1
block2_pool (MaxPooling2D)	(None, 74, 74, 128)	0	block2
batch_normalization_8 (BatchNormalization)	(None, 74, 74, 128)	512	conv2d
add_24 (Add)	(None, 74, 74, 128)	0	block2 batch_
block3_sepconv1_act (Activation)	(None, 74, 74, 128)	0	add_24
block3_sepconv1 (SeparableConv2D)	(None, 74, 74, 256)	33,920	block3
block3_sepconv1_bn (BatchNormalization)	(None, 74, 74, 256)	1,024	block3
block3_sepconv2_act (Activation)	(None, 74, 74, 256)	0	block3
block3_sepconv2 (SeparableConv2D)	(None, 74, 74, 256)	67,840	block3
block3_sepconv2_bn (BatchNormalization)	(None, 74, 74, 256)	1,024	block3
conv2d_9 (Conv2D)	(None, 37, 37, 256)	32,768	add_24
block3_pool (MaxPooling2D)	(None, 37, 37, 256)	0	block3

```
 (MaxPooling2D)          │                      │               │
─────────────────────────┼──────────────────────┼───────────────┼──────
 batch_normalization_9   │ (None, 37, 37, 256)  │         1,024 │ conv2d
 (BatchNormalization)    │                      │               │
─────────────────────────┼──────────────────────┼───────────────┼──────
 add_25 (Add)            │ (None, 37, 37, 256)  │             0 │ block3
                         │                      │               │ batch_
─────────────────────────┼──────────────────────┼───────────────┼──────
 block4_sepconv1_act     │ (None, 37, 37, 256)  │             0 │ add_25
 (Activation)            │                      │               │
─────────────────────────┼──────────────────────┼───────────────┼──────
 block4_sepconv1         │ (None, 37, 37, 728)  │       188,672 │ block4
 (SeparableConv2D)       │                      │               │
─────────────────────────┼──────────────────────┼───────────────┼──────
 block4_sepconv1_bn      │ (None, 37, 37, 728)  │         2,912 │ block4
 (BatchNormalization)    │                      │               │
─────────────────────────┼──────────────────────┼───────────────┼──────
 block4_sepconv2_act     │ (None, 37, 37, 728)  │             0 │ block4
 (Activation)            │                      │               │
─────────────────────────┼──────────────────────┼───────────────┼──────
 block4_sepconv2         │ (None, 37, 37, 728)  │       536,536 │ block4
 (SeparableConv2D)       │                      │               │
─────────────────────────┼──────────────────────┼───────────────┼──────
 block4_sepconv2_bn      │ (None, 37, 37, 728)  │         2,912 │ block4
 (BatchNormalization)    │                      │               │
─────────────────────────┼──────────────────────┼───────────────┼──────
 conv2d_10 (Conv2D)      │ (None, 19, 19, 728)  │       186,368 │ add_25
─────────────────────────┼──────────────────────┼───────────────┼──────
 block4_pool             │ (None, 19, 19, 728)  │             0 │ block4
 (MaxPooling2D)          │                      │               │
─────────────────────────┼──────────────────────┼───────────────┼──────
 batch_normalization_10  │ (None, 19, 19, 728)  │         2,912 │ conv2d
 (BatchNormalization)    │                      │               │
─────────────────────────┼──────────────────────┼───────────────┼──────
 add_26 (Add)            │ (None, 19, 19, 728)  │             0 │ block4
                         │                      │               │ batch_
─────────────────────────┼──────────────────────┼───────────────┼──────
 block5_sepconv1_act     │ (None, 19, 19, 728)  │             0 │ add_26
 (Activation)            │                      │               │
─────────────────────────┼──────────────────────┼───────────────┼──────
 block5_sepconv1         │ (None, 19, 19, 728)  │       536,536 │ block5
 (SeparableConv2D)       │                      │               │
─────────────────────────┼──────────────────────┼───────────────┼──────
 block5_sepconv1_bn      │ (None, 19, 19, 728)  │         2,912 │ block5
 (BatchNormalization)    │                      │               │
─────────────────────────┼──────────────────────┼───────────────┼──────
 block5_sepconv2_act     │ (None, 19, 19, 728)  │             0 │ block5
 (Activation)            │                      │               │
─────────────────────────┼──────────────────────┼───────────────┼──────
 block5_sepconv2         │ (None, 19, 19, 728)  │       536,536 │ block5
 (SeparableConv2D)       │                      │               │
─────────────────────────┼──────────────────────┼───────────────┼──────
 block5_sepconv2_bn      │ (None, 19, 19, 728)  │         2,912 │ block5
 (BatchNormalization)    │                      │               │
```

(BatchNormalization)			
block5_sepconv3_act (Activation)	(None, 19, 19, 728)	0	block5
block5_sepconv3 (SeparableConv2D)	(None, 19, 19, 728)	536,536	block5
block5_sepconv3_bn (BatchNormalization)	(None, 19, 19, 728)	2,912	block5
add_27 (Add)	(None, 19, 19, 728)	0	block5 add_26
block6_sepconv1_act (Activation)	(None, 19, 19, 728)	0	add_27
block6_sepconv1 (SeparableConv2D)	(None, 19, 19, 728)	536,536	block6
block6_sepconv1_bn (BatchNormalization)	(None, 19, 19, 728)	2,912	block6
block6_sepconv2_act (Activation)	(None, 19, 19, 728)	0	block6
block6_sepconv2 (SeparableConv2D)	(None, 19, 19, 728)	536,536	block6
block6_sepconv2_bn (BatchNormalization)	(None, 19, 19, 728)	2,912	block6
block6_sepconv3_act (Activation)	(None, 19, 19, 728)	0	block6
block6_sepconv3 (SeparableConv2D)	(None, 19, 19, 728)	536,536	block6
block6_sepconv3_bn (BatchNormalization)	(None, 19, 19, 728)	2,912	block6
add_28 (Add)	(None, 19, 19, 728)	0	block6 add_27
block7_sepconv1_act (Activation)	(None, 19, 19, 728)	0	add_28
block7_sepconv1 (SeparableConv2D)	(None, 19, 19, 728)	536,536	block7
block7_sepconv1_bn (BatchNormalization)	(None, 19, 19, 728)	2,912	block7
block7_sepconv2_act (Activation)	(None, 19, 19, 728)	0	block7

(Activation)			
block7_sepconv2 (SeparableConv2D)	(None, 19, 19, 728)	536,536	block7
block7_sepconv2_bn (BatchNormalization)	(None, 19, 19, 728)	2,912	block7
block7_sepconv3_act (Activation)	(None, 19, 19, 728)	0	block7
block7_sepconv3 (SeparableConv2D)	(None, 19, 19, 728)	536,536	block7
block7_sepconv3_bn (BatchNormalization)	(None, 19, 19, 728)	2,912	block7
add_29 (Add)	(None, 19, 19, 728)	0	block7 add_28
block8_sepconv1_act (Activation)	(None, 19, 19, 728)	0	add_29
block8_sepconv1 (SeparableConv2D)	(None, 19, 19, 728)	536,536	block8
block8_sepconv1_bn (BatchNormalization)	(None, 19, 19, 728)	2,912	block8
block8_sepconv2_act (Activation)	(None, 19, 19, 728)	0	block8
block8_sepconv2 (SeparableConv2D)	(None, 19, 19, 728)	536,536	block8
block8_sepconv2_bn (BatchNormalization)	(None, 19, 19, 728)	2,912	block8
block8_sepconv3_act (Activation)	(None, 19, 19, 728)	0	block8
block8_sepconv3 (SeparableConv2D)	(None, 19, 19, 728)	536,536	block8
block8_sepconv3_bn (BatchNormalization)	(None, 19, 19, 728)	2,912	block8
add_30 (Add)	(None, 19, 19, 728)	0	block8 add_29
block9_sepconv1_act (Activation)	(None, 19, 19, 728)	0	add_30
block9_sepconv1	(None, 19, 19, 728)	536,536	block9

```
│ (SeparableConv2D)         │                       │            │           │
├───────────────────────────┼───────────────────────┼────────────┼───────────┤
│ block9_sepconv1_bn        │ (None, 19, 19, 728)   │      2,912 │ block9    │
│ (BatchNormalization)      │                       │            │           │
├───────────────────────────┼───────────────────────┼────────────┼───────────┤
│ block9_sepconv2_act       │ (None, 19, 19, 728)   │          0 │ block9    │
│ (Activation)              │                       │            │           │
├───────────────────────────┼───────────────────────┼────────────┼───────────┤
│ block9_sepconv2           │ (None, 19, 19, 728)   │    536,536 │ block9    │
│ (SeparableConv2D)         │                       │            │           │
├───────────────────────────┼───────────────────────┼────────────┼───────────┤
│ block9_sepconv2_bn        │ (None, 19, 19, 728)   │      2,912 │ block9    │
│ (BatchNormalization)      │                       │            │           │
├───────────────────────────┼───────────────────────┼────────────┼───────────┤
│ block9_sepconv3_act       │ (None, 19, 19, 728)   │          0 │ block9    │
│ (Activation)              │                       │            │           │
├───────────────────────────┼───────────────────────┼────────────┼───────────┤
│ block9_sepconv3           │ (None, 19, 19, 728)   │    536,536 │ block9    │
│ (SeparableConv2D)         │                       │            │           │
├───────────────────────────┼───────────────────────┼────────────┼───────────┤
│ block9_sepconv3_bn        │ (None, 19, 19, 728)   │      2,912 │ block9    │
│ (BatchNormalization)      │                       │            │           │
├───────────────────────────┼───────────────────────┼────────────┼───────────┤
│ add_31 (Add)              │ (None, 19, 19, 728)   │          0 │ block9    │
│                           │                       │            │ add_30    │
├───────────────────────────┼───────────────────────┼────────────┼───────────┤
│ block10_sepconv1_act      │ (None, 19, 19, 728)   │          0 │ add_31    │
│ (Activation)              │                       │            │           │
├───────────────────────────┼───────────────────────┼────────────┼───────────┤
│ block10_sepconv1          │ (None, 19, 19, 728)   │    536,536 │ block1    │
│ (SeparableConv2D)         │                       │            │           │
├───────────────────────────┼───────────────────────┼────────────┼───────────┤
│ block10_sepconv1_bn       │ (None, 19, 19, 728)   │      2,912 │ block1    │
│ (BatchNormalization)      │                       │            │           │
├───────────────────────────┼───────────────────────┼────────────┼───────────┤
│ block10_sepconv2_act      │ (None, 19, 19, 728)   │          0 │ block1    │
│ (Activation)              │                       │            │           │
├───────────────────────────┼───────────────────────┼────────────┼───────────┤
│ block10_sepconv2          │ (None, 19, 19, 728)   │    536,536 │ block1    │
│ (SeparableConv2D)         │                       │            │           │
├───────────────────────────┼───────────────────────┼────────────┼───────────┤
│ block10_sepconv2_bn       │ (None, 19, 19, 728)   │      2,912 │ block1    │
│ (BatchNormalization)      │                       │            │           │
├───────────────────────────┼───────────────────────┼────────────┼───────────┤
│ block10_sepconv3_act      │ (None, 19, 19, 728)   │          0 │ block1    │
│ (Activation)              │                       │            │           │
├───────────────────────────┼───────────────────────┼────────────┼───────────┤
│ block10_sepconv3          │ (None, 19, 19, 728)   │    536,536 │ block1    │
│ (SeparableConv2D)         │                       │            │           │
├───────────────────────────┼───────────────────────┼────────────┼───────────┤
│ block10_sepconv3_bn       │ (None, 19, 19, 728)   │      2,912 │ block1    │
│ (BatchNormalization)      │                       │            │           │
├───────────────────────────┼───────────────────────┼────────────┼───────────┤
│ add_32 (Add)              │ (None, 19, 19, 728)   │          0 │ block1    │
```

add_32 (Add)	(None, 19, 19, 728)	0	block1 add_31
block11_sepconv1_act (Activation)	(None, 19, 19, 728)	0	add_32
block11_sepconv1 (SeparableConv2D)	(None, 19, 19, 728)	536,536	block1
block11_sepconv1_bn (BatchNormalization)	(None, 19, 19, 728)	2,912	block1
block11_sepconv2_act (Activation)	(None, 19, 19, 728)	0	block1
block11_sepconv2 (SeparableConv2D)	(None, 19, 19, 728)	536,536	block1
block11_sepconv2_bn (BatchNormalization)	(None, 19, 19, 728)	2,912	block1
block11_sepconv3_act (Activation)	(None, 19, 19, 728)	0	block1
block11_sepconv3 (SeparableConv2D)	(None, 19, 19, 728)	536,536	block1
block11_sepconv3_bn (BatchNormalization)	(None, 19, 19, 728)	2,912	block1
add_33 (Add)	(None, 19, 19, 728)	0	block1 add_32
block12_sepconv1_act (Activation)	(None, 19, 19, 728)	0	add_33
block12_sepconv1 (SeparableConv2D)	(None, 19, 19, 728)	536,536	block1
block12_sepconv1_bn (BatchNormalization)	(None, 19, 19, 728)	2,912	block1
block12_sepconv2_act (Activation)	(None, 19, 19, 728)	0	block1
block12_sepconv2 (SeparableConv2D)	(None, 19, 19, 728)	536,536	block1
block12_sepconv2_bn (BatchNormalization)	(None, 19, 19, 728)	2,912	block1
block12_sepconv3_act (Activation)	(None, 19, 19, 728)	0	block1

block12_sepconv3 (SeparableConv2D)	(None, 19, 19, 728)	536,536	block1
block12_sepconv3_bn (BatchNormalization)	(None, 19, 19, 728)	2,912	block1
add_34 (Add)	(None, 19, 19, 728)	0	block1 add_3
block13_sepconv1_act (Activation)	(None, 19, 19, 728)	0	add_3
block13_sepconv1 (SeparableConv2D)	(None, 19, 19, 728)	536,536	block1
block13_sepconv1_bn (BatchNormalization)	(None, 19, 19, 728)	2,912	block1
block13_sepconv2_act (Activation)	(None, 19, 19, 728)	0	block1
block13_sepconv2 (SeparableConv2D)	(None, 19, 19, 1024)	752,024	block1
block13_sepconv2_bn (BatchNormalization)	(None, 19, 19, 1024)	4,096	block1
conv2d_11 (Conv2D)	(None, 10, 10, 1024)	745,472	add_3
block13_pool (MaxPooling2D)	(None, 10, 10, 1024)	0	block1
batch_normalization_11 (BatchNormalization)	(None, 10, 10, 1024)	4,096	conv2
add_35 (Add)	(None, 10, 10, 1024)	0	block1 batch_
block14_sepconv1 (SeparableConv2D)	(None, 10, 10, 1536)	1,582,080	add_3
block14_sepconv1_bn (BatchNormalization)	(None, 10, 10, 1536)	6,144	block1
block14_sepconv1_act (Activation)	(None, 10, 10, 1536)	0	block1
block14_sepconv2 (SeparableConv2D)	(None, 10, 10, 2048)	3,159,552	block1
block14_sepconv2_bn (BatchNormalization)	(None, 10, 10, 2048)	8,192	block1
block14_sepconv2_act	(None, 10, 10, 2048)	0	block1

```
│ block14_sepconv2_act        │ (None, 10, 10, 2048)      │          0 │ block…
│ (Activation)                │                           │            │
├─────────────────────────────┼───────────────────────────┼────────────┼──────
│ global_average_pooling2d    │ (None, 2048)              │          0 │ block1
│ (GlobalAveragePooling2D)    │                           │            │
├─────────────────────────────┼───────────────────────────┼────────────┼──────
│ batch_normalization_12      │ (None, 2048)              │      8,192 │ globa
│ (BatchNormalization)        │                           │            │
├─────────────────────────────┼───────────────────────────┼────────────┼──────
│ dropout (Dropout)           │ (None, 2048)              │          0 │ batch_
├─────────────────────────────┼───────────────────────────┼────────────┼──────
│ dense (Dense)               │ (None, 3)                 │      6,147 │ dropou
└─────────────────────────────┴───────────────────────────┴────────────┴──────
 Total params: 20,875,821 (79.63 MB)
 Trainable params: 20,817,195 (79.41 MB)
 Non-trainable params: 58,624 (229.00 KB)
 Optimizer params: 2 (12.00 B)
```

Fine tuning:

Settings initial 25% layers (of the feature extractor) as non-trainable (not updated during backpropogation) and the remaining as trainable

```
train_threshold = int(0.25*(len(model1_FT.layers)-4)) #last 4 layers belong to th

for layer in model1_FT.layers[:train_threshold]:
    layer.trainable = False

for layer in model1_FT.layers[train_threshold:]:
    layer.trainable = True
```

Compile and train the model

Save the best waits during training

```
from tensorflow.keras import regularizers
from tensorflow.keras.callbacks import EarlyStopping, ReduceLROnPlateau
from tensorflow.keras.optimizers import Adam
from tensorflow.keras.preprocessing.image import ImageDataGenerator
```

```
import numpy as np

model1_FT.compile(loss='sparse_categorical_crossentropy',
                 optimizer='adam',
                 metrics=['accuracy'])


#Use the same data augmentation setup we used for transfer learning
datagen = ImageDataGenerator(
    rotation_range=20,
    width_shift_range=0.2,
    height_shift_range=0.2,
    horizontal_flip=True,
    fill_mode='nearest',
    validation_split=0.1
)

#Create generators
train_generator = datagen.flow(
    X_train_std,
    y_train,
    batch_size=16,
    subset='training'
)

validation_generator = datagen.flow(
    X_train_std,
    y_train,
    batch_size=16,
    subset='validation'
)

callbacks1_FT = [
    keras.callbacks.ModelCheckpoint(
        "best_xception_FT.weights.h5",
        monitor='val_accuracy',
        save_weights_only=True,
        save_best_only=True
    ),
]

#Train
history1_FT = model1_FT.fit(
    train_generator,
    validation_data=validation_generator,
    epochs=10,
    callbacks=callbacks1_FT
)
```

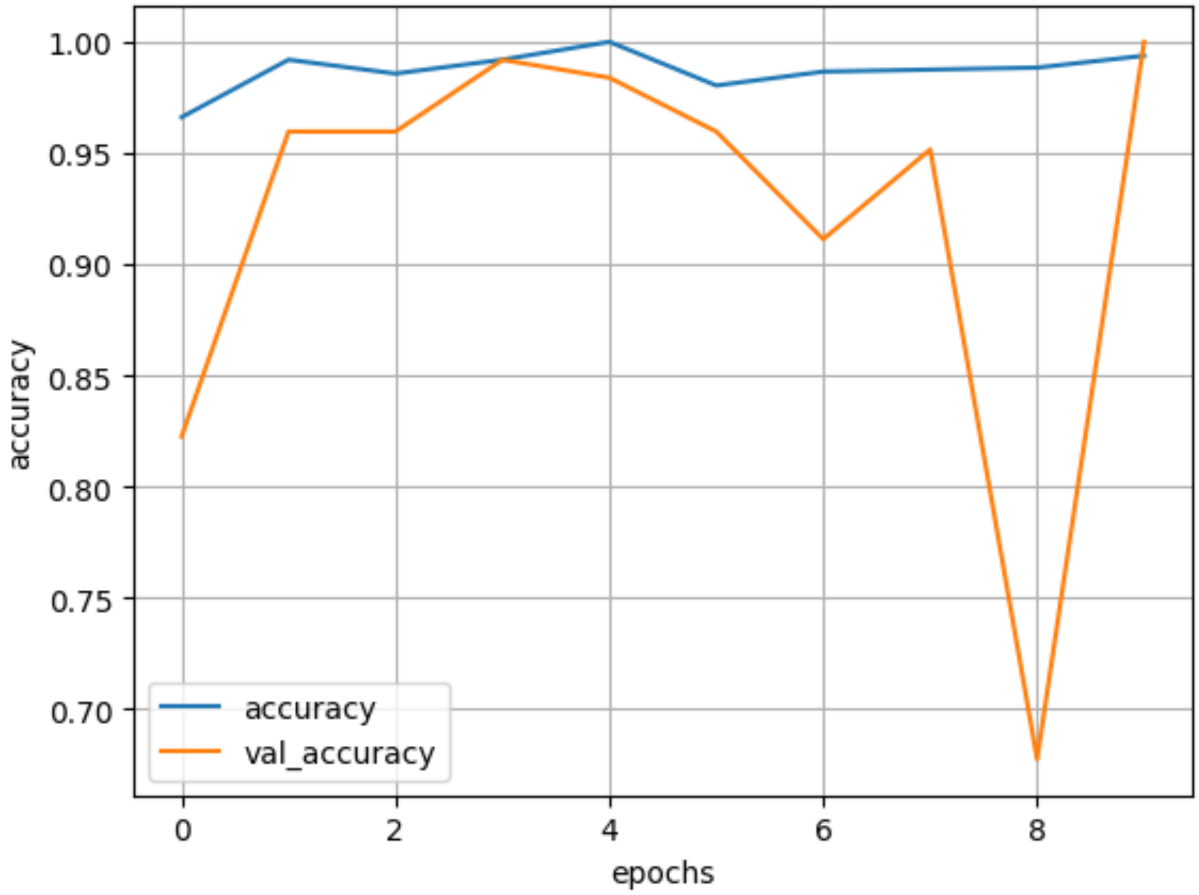
```
Epoch 1/10
/usr/local/lib/python3.10/dist-packages/keras/src/trainers/data_adapters/py_da
  self._warn_if_super_not_called()
71/71 ━━━━━━━━━━━━━━━━━━━━ 85s 636ms/step - accuracy: 0.9523 - loss: 0.2152 -
Epoch 2/10
71/71 ━━━━━━━━━━━━━━━━━━━━ 24s 303ms/step - accuracy: 0.9854 - loss: 0.0503 -
Epoch 3/10
71/71 ━━━━━━━━━━━━━━━━━━━━ 24s 313ms/step - accuracy: 0.9683 - loss: 0.1058 -
Epoch 4/10
71/71 ━━━━━━━━━━━━━━━━━━━━ 25s 318ms/step - accuracy: 0.9912 - loss: 0.0149 -
Epoch 5/10
71/71 ━━━━━━━━━━━━━━━━━━━━ 23s 299ms/step - accuracy: 1.0000 - loss: 0.0049 -
Epoch 6/10
71/71 ━━━━━━━━━━━━━━━━━━━━ 23s 300ms/step - accuracy: 0.9876 - loss: 0.0378 -
Epoch 7/10
71/71 ━━━━━━━━━━━━━━━━━━━━ 24s 306ms/step - accuracy: 0.9860 - loss: 0.0698 -
Epoch 8/10
71/71 ━━━━━━━━━━━━━━━━━━━━ 23s 301ms/step - accuracy: 0.9888 - loss: 0.0527 -
Epoch 9/10
71/71 ━━━━━━━━━━━━━━━━━━━━ 24s 303ms/step - accuracy: 0.9827 - loss: 0.0622 -
Epoch 10/10
71/71 ━━━━━━━━━━━━━━━━━━━━ 24s 316ms/step - accuracy: 0.9973 - loss: 0.0082 -
```

```
#Visualize accuracy

import pandas as pd

progress = {k:v for k,v in history1_FT.history.items() if k in ['accuracy', 'val_

pd.DataFrame(progress).plot()
plt.xlabel("epochs")
plt.ylabel("accuracy")
plt.grid(True)
plt.show()
```



Evaluate the Fine-tuned model

```
testLoss1_FT, testAccuracy1_FT = model1_FT.evaluate(x = X_test_std, y = y_test)
print("Test-loss: %f, Test-accuracy: %f" % (testLoss1_FT, testAccuracy1_FT))
```

```
13/13 ━━━━━━━━━━━━━━━━━━━━ 23s 227ms/step - accuracy: 0.9977 - loss: 0.0382
Test-loss: 0.047461, Test-accuracy: 0.995192
```

Update model using the best weights

```
model1_FT.load_weights("best_xception_FT.weights.h5")

testLoss1_FT, testAccuracy1_FT = model1_FT.evaluate(x = X_test_std, y = y_test)

print("Test-loss: %f, Test-accuracy: %f" % (testLoss1_FT, testAccuracy1_FT))
```

```
13/13 ━━━━━━━━━━━━━━━━━━━━ 3s 227ms/step - accuracy: 0.9977 - loss: 0.0382
Test-loss: 0.047461, Test-accuracy: 0.995192
```

Check model performance

```
y_prob = model1_FT.predict(X_test_std)
y_predict = np.argmax(y_prob, axis=-1)
print(y_predict)
```

```
13/13 ━━━━━━━━━━━━━━━━━━━━ 5s 218ms/step
[1 1 0 0 0 0 0 1 0 0 0 1 0 0 1 1 1 1 0 1 1 1 1 1 1 0 0 0 1 1 0 1 0 0 0 0 1
 0 0 0 1 0 1 0 0 1 1 0 0 1 1 1 1 1 0 1 1 1 1 0 0 0 1 0 0 1 1 1 0 0 0 0 1 0
 0 1 1 0 1 0 1 0 2 1 0 1 0 0 0 0 1 1 1 0 0 2 0 0 1 0 0 0 0 0 1 1 1 1 1 0 0
 0 0 0 1 1 1 1 1 1 1 0 0 0 1 1 1 1 0 2 0 1 1 1 0 1 0 0 1 1 0 1 1 1 0 1 1 1
 1 0 1 0 1 1 1 1 0 2 1 0 0 1 0 1 1 0 0 0 1 0 0 1 1 1 0 1 0 0 0 0 0 0 0 1 1
 1 0 1 0 0 1 1 0 1 1 0 1 0 2 0 0 0 1 1 1 1 0 1 0 1 0 0 0 1 2 0 0 1 0 0 0 1
 0 1 0 0 0 0 1 0 1 1 0 1 0 1 1 1 1 1 1 1 0 0 0 0 0 0 0 1 0 1 0 1 1 1 0 0 1
 0 1 0 1 0 0 1 1 1 0 0 1 0 0 1 1 1 0 0 0 0 1 0 1 0 1 0 0 1 0 2 2 1 1 1 1 0
 0 2 1 0 0 1 0 1 1 0 0 1 0 1 1 1 0 0 1 1 0 2 1 2 0 0 0 0 1 0 1 0 0 0 1 1 2
 1 0 1 1 1 1 0 0 1 0 1 2 0 2 0 1 1 0 0 0 0 1 1 0 0 0 1 0 1 1 0 1 1 1 1 1 1
 0 0 1 1 0 0 1 0 1 0 1 0 0 0 0 0 1 1 0 1 1 0 2 1 1 1 1 1 1 1 0 1 0 1 1 0 1
 0 1 0 2 1 0 1 0 0]
```

```
#confusion matrix

from sklearn.metrics import confusion_matrix
```

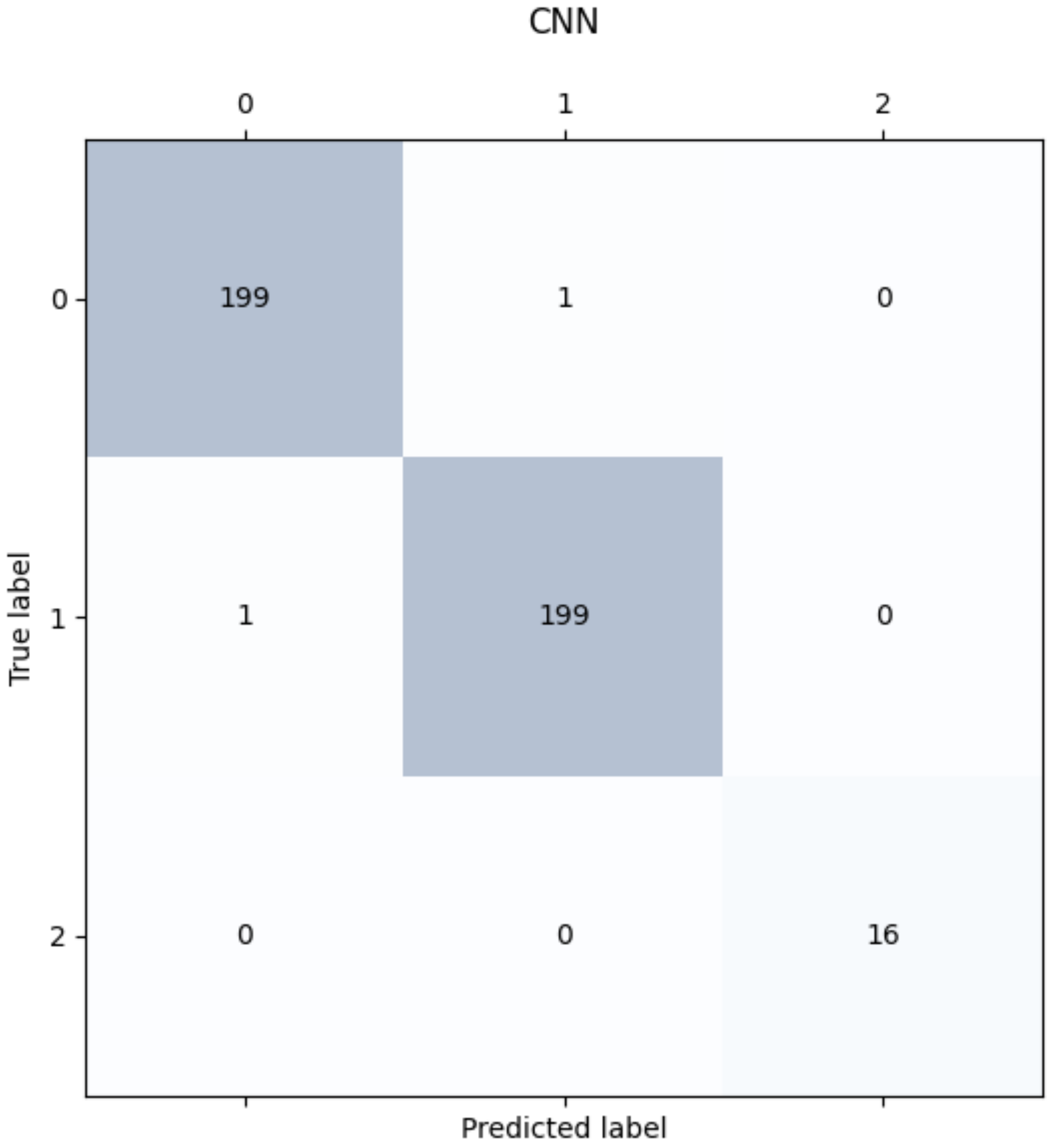
```
cm = confusion_matrix(y_true = y_test, y_pred = y_predict)

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_Xception_FT.png", dpi=300, format='png', pad_inches=
plt.show()
```


CNN
0
1
2
True label
0
1
2
199
1
0
1
199
0
0
0
16
Predicted label

```
#classification scores

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)

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)
```

```
Precision:  0.9951923076923077
Recall:  0.9951923076923077
F1-score:  0.9951923076923077
```

Save the fine tuned model

```
model1_FT.save('/content/gdrive/MyDrive/DL/Xception_Best_Model_FT.h5')
```

```
WARNING:absl:You are saving your model as an HDF5 file via `model.save()` or `
```