

```
In [1]: import tensorflow as tf
import numpy as np
import matplotlib.pyplot as plt
import os
import pickle
import gc
from tensorflow.python.keras import layers, Sequential, losses, metrics, optimizers,
from tensorflow.python.keras.models import Model
from tensorflow.python.keras.applications import vgg16
from tensorflow.python.keras.optimizer_v2 import adam
```

```
2022-01-24 18:50:48.163771: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library libcudart.so.11.0
```

```
In [2]: image_height = 48
image_width = 48
emotions_count = 8
emotion_labels = ['neutral', 'happiness', 'surprise', 'sadness', 'anger', 'disgust',
```

```
In [3]: image_path = "./dataset/images.npy"
emotion_path = "./dataset/emotions_multi.npy"

images = np.load(image_path)
images = tf.convert_to_tensor(images)
images = layers.Rescaling(1./127.5, offset=-1)(images)
images = tf.image.grayscale_to_rgb(images)

emotions = np.load(emotion_path)
emotions = tf.convert_to_tensor(emotions)

training_samples = 28317
validation_samples = 3541
training_size = training_samples + validation_samples

training_images = images[:training_size]
test_images = images[training_size:]
training_emotions = emotions[:training_size]
test_emotions = emotions[training_size:]
```

```
2022-01-24 18:50:53.318224: I tensorflow/compiler/jit/xla_cpu_device.cc:41] Not creating XLA devices, tf_xla_enable_xla_devices not set
2022-01-24 18:50:53.319468: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library libcudart.so.11.0
2022-01-24 18:50:53.383568: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:941] successful NUMA node read from SysFS had negative value (-1), but there must be at least one NUMA node, so returning NUMA node zero
2022-01-24 18:50:53.385095: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1720] Found device 0 with properties:
pciBusID: 0000:05:00.0 name: GeForce RTX 2080 Ti computeCapability: 7.5
coreClock: 1.545GHz coreCount: 68 deviceMemorySize: 10.76GiB deviceMemoryBandwidth: 573.69GiB/s
2022-01-24 18:50:53.385166: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library libcudart.so.11.0
2022-01-24 18:50:53.394223: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library libcublas.so.11
2022-01-24 18:50:53.394318: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library libcublasLt.so.11
2022-01-24 18:50:53.397092: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library libcufft.so.10
```

```
2022-01-24 18:50:53.398213: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library libcurand.so.10
2022-01-24 18:50:53.403358: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library libcusolver.so.10
2022-01-24 18:50:53.405413: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library libcusparsesparse.so.11
2022-01-24 18:50:53.406555: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library libcudnn.so.8
2022-01-24 18:50:53.406728: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:941] successful NUMA node read from SysFS had negative value (-1), but there must be at least one NUMA node, so returning NUMA node zero
2022-01-24 18:50:53.407452: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:941] successful NUMA node read from SysFS had negative value (-1), but there must be at least one NUMA node, so returning NUMA node zero
2022-01-24 18:50:53.408105: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1862] Adding visible gpu devices: 0
2022-01-24 18:50:53.408984: I tensorflow/core/platform/cpu_feature_guard.cc:142] This TensorFlow binary is optimized with oneAPI Deep Neural Network Library (oneDNN) to use the following CPU instructions in performance-critical operations: AVX2 AVX512F FMA
To enable them in other operations, rebuild TensorFlow with the appropriate compiler flags.
2022-01-24 18:50:53.409361: I tensorflow/compiler/jit/xla_gpu_device.cc:99] Not creating XLA devices, tf_xla_enable_xla_devices not set
2022-01-24 18:50:53.409615: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:941] successful NUMA node read from SysFS had negative value (-1), but there must be at least one NUMA node, so returning NUMA node zero
2022-01-24 18:50:53.410515: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1720] Found device 0 with properties:
pciBusID: 0000:05:00.0 name: GeForce RTX 2080 Ti computeCapability: 7.5
coreClock: 1.545GHz coreCount: 68 deviceMemorySize: 10.76GiB deviceMemoryBandwidth: 573.69GiB/s
2022-01-24 18:50:53.410554: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library libcudart.so.11.0
2022-01-24 18:50:53.410586: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library libcublas.so.11
2022-01-24 18:50:53.410604: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library libcublasLt.so.11
2022-01-24 18:50:53.410622: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library libcufft.so.10
2022-01-24 18:50:53.410640: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library libcurand.so.10
2022-01-24 18:50:53.410657: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library libcusolver.so.10
2022-01-24 18:50:53.410677: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library libcusparsesparse.so.11
2022-01-24 18:50:53.410695: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library libcudnn.so.8
2022-01-24 18:50:53.410779: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:941] successful NUMA node read from SysFS had negative value (-1), but there must be at least one NUMA node, so returning NUMA node zero
2022-01-24 18:50:53.411672: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:941] successful NUMA node read from SysFS had negative value (-1), but there must be at least one NUMA node, so returning NUMA node zero
2022-01-24 18:50:53.412395: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1862] Adding visible gpu devices: 0
2022-01-24 18:50:53.412449: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library libcudart.so.11.0
2022-01-24 18:50:54.265546: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1261] Device interconnect StreamExecutor with strength 1 edge matrix:
2022-01-24 18:50:54.265589: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1267] 0
2022-01-24 18:50:54.265597: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1280] 0: N
```

```
2022-01-24 18:50:54.265871: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:941] successful NUMA node read from SysFS had negative value (-1), but there must be at least one NUMA node, so returning NUMA node zero
2022-01-24 18:50:54.266363: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:941] successful NUMA node read from SysFS had negative value (-1), but there must be at least one NUMA node, so returning NUMA node zero
2022-01-24 18:50:54.266796: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:941] successful NUMA node read from SysFS had negative value (-1), but there must be at least one NUMA node, so returning NUMA node zero
2022-01-24 18:50:54.267216: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1406] Created TensorFlow device (/job:localhost/replica:0/task:0/device:GPU:0 with 10071 MB memory) -> physical GPU (device: 0, name: GeForce RTX 2080 Ti, pci bus id: 0000:05:00.0, compute capability: 7.5)
```

```
In [4]: tf.config.run_functions_eagerly(True)
def model_acc(y_true, y_pred):
    size = y_true.shape[0]
    acc = 0
    for i in range(size):
        true = y_true[i]
        pred = y_pred[i]
        index_max = tf.argmax(pred).numpy()
        if true[index_max].numpy()==tf.reduce_max(true).numpy():
            acc += 1
    return acc/size
```

```
In [5]: def train(model, learning_rate, loss, num_epochs, batch_size):
        model.compile(optimizer=adam.Adam(learning_rate=learning_rate),
                      loss=loss,
                      metrics = [model_acc])
        history = model.fit(x=training_images,
                           y=training_emotions,
                           batch_size=batch_size,
                           epochs=num_epochs,
                           validation_data=(test_images, test_emotions))

        del model
        gc.collect()
        return history
```

```
In [6]: def create_model(base_model):
        base_model.trainable=True
        return Sequential([
            base_model,
            layers.GlobalAveragePooling2D(),
            layers.Dense(4096, activation='relu'),
            layers.BatchNormalization(
                momentum=0.95,
                epsilon=0.005,
            ),
            layers.Dense(4096, activation='relu'),
            layers.BatchNormalization(
                momentum=0.95,
                epsilon=0.005,
            ),
            layers.Dense(emotions_count, activation='softmax'),
        ])
```

```
In [ ]: if not os.path.isdir('./results/'):
        os.mkdir('./results/')
```

```

learning_rate = 5e-5
num_epochs = 50
batch_size = 32
loss = losses.MeanSquaredError()

for i in range(0,1,1):
    base_model = vgg16.VGG16(include_top=False, weights='imagenet', input_shape=(48,
    history_save_path = './history/BN_1.txt'
    model = create_model(base_model)
    history = train(model, learning_rate, loss, num_epochs, batch_size)
    with open(history_save_path, 'wb') as file_pi:
        pickle.dump(history.history, file_pi)

```

/userhome/cs/fym666/anaconda3/envs/tensorflow/lib/python3.8/site-packages/tensorflow/python/data/ops/dataset_ops.py:3503: UserWarning: Even though the tf.config.experimental_run_functions_eagerly option is set, this option does not apply to tf.data functions. tf.data functions are still traced and executed as graphs.

warnings.warn(

2022-01-24 18:50:56.212932: I tensorflow/compiler/mlir/mlir_graph_optimization_pass.cc:116] None of the MLIR optimization passes are enabled (registered 2)

2022-01-24 18:50:56.213475: I tensorflow/core/platform/profile_utils/cpu_utils.cc:112] CPU Frequency: 2199880000 Hz

2022-01-24 18:50:56.240248: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library libcudnn.so.8

Epoch 1/50

2022-01-24 18:50:58.491872: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library libcublas.so.11

2022-01-24 18:50:59.055077: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library libcublasLt.so.11

996/996 [=====] - 100s 97ms/step - loss: 0.0551 - model_acc: 0.5152 - val_loss: 0.0490 - val_model_acc: 0.5310

Epoch 2/50

996/996 [=====] - 94s 94ms/step - loss: 0.0243 - model_acc: 0.7270 - val_loss: 0.0766 - val_model_acc: 0.3848

Epoch 3/50

996/996 [=====] - 93s 94ms/step - loss: 0.0186 - model_acc: 0.7873 - val_loss: 0.1344 - val_model_acc: 0.2264

Epoch 4/50

996/996 [=====] - 94s 95ms/step - loss: 0.0156 - model_acc: 0.8157 - val_loss: 0.0267 - val_model_acc: 0.7329

Epoch 5/50

996/996 [=====] - 95s 96ms/step - loss: 0.0131 - model_acc: 0.8379 - val_loss: 0.0238 - val_model_acc: 0.7365

Epoch 6/50

996/996 [=====] - 85s 86ms/step - loss: 0.0110 - model_acc: 0.8641 - val_loss: 0.0261 - val_model_acc: 0.7371

Epoch 7/50

996/996 [=====] - 93s 93ms/step - loss: 0.0096 - model_acc: 0.8790 - val_loss: 0.0887 - val_model_acc: 0.3206

Epoch 8/50

996/996 [=====] - 92s 92ms/step - loss: 0.0079 - model_acc: 0.9002 - val_loss: 0.0328 - val_model_acc: 0.6792

Epoch 9/50

996/996 [=====] - 91s 92ms/step - loss: 0.0067 - model_acc: 0.9133 - val_loss: 0.0372 - val_model_acc: 0.6310

Epoch 10/50

996/996 [=====] - 95s 95ms/step - loss: 0.0059 - model_acc: 0.9246 - val_loss: 0.0602 - val_model_acc: 0.5075

Epoch 11/50

996/996 [=====] - 96s 97ms/step - loss: 0.0052 - model_acc: 0.9321 - val_loss: 0.0441 - val_model_acc: 0.6782

Epoch 12/50

```
996/996 [=====] - 96s 96ms/step - loss: 0.0046 - model_acc:
0.9413 - val_loss: 0.0475 - val_model_acc: 0.5662
Epoch 13/50
996/996 [=====] - 92s 93ms/step - loss: 0.0041 - model_acc:
0.9470 - val_loss: 0.0229 - val_model_acc: 0.7439
Epoch 14/50
996/996 [=====] - 93s 94ms/step - loss: 0.0038 - model_acc:
0.9491 - val_loss: 0.0265 - val_model_acc: 0.7336
Epoch 15/50
996/996 [=====] - 92s 93ms/step - loss: 0.0036 - model_acc:
0.9522 - val_loss: 0.0245 - val_model_acc: 0.7287
Epoch 16/50
996/996 [=====] - 90s 90ms/step - loss: 0.0033 - model_acc:
0.9550 - val_loss: 0.0320 - val_model_acc: 0.6575
Epoch 17/50
247/996 [=====>.....] - ETA: 1:03 - loss: 0.0031 - model_acc: 0.9
509
```

In []: