In [1]:
```
import numpy as np
import matplotlib.pyplot as plt
import tensorflow as tf
from tensorflow.python.keras.layers import Dense, GlobalAveragePooling2D
from tensorflow.python.keras.models import Model
from tensorflow.python.keras import layers, Sequential,losses, metrics

image_height = 48
image_width = 48
emotions_count = 8
emotion_labels = ['neutral', 'happiness', 'surprise', 'sadness',
                  'anger', 'disgust', 'fear', 'contempt']

samples = 35393 # 2~35394
training_samples = 28317  # 2~28318 (Training)
validation_samples = 3541 # 28319~31859 (PublicTest)
test_samples = 3535       # 31860~35394 (PrivateTest)
expw_samples = 91793

image_path = "./dataset/images.npy"
emotion_path = "./dataset/emotions_multi.npy"
image_path_expw = "./AffectNet/images.npy"
emotion_path_expw = "./AffectNet/emotions.npy"
```

```
2021-12-26 13:49:28.260772: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library libcudart.so.11.0
```

In [2]:
```
images = np.load(image_path)
emotions = np.load(emotion_path)
images_expw = np.load(image_path_expw)
emotions_expw = np.load(emotion_path_expw)
print(images.shape)
print(emotions.shape)
print(images_expw.shape)
print(emotions_expw.shape)
```

```
(35393, 48, 48, 1)
(35393, 8)
(291648, 48, 48, 3)
(291648, 8)
```

In [3]:
```
def rgb2grayscale(rgb):
    return np.dot(rgb[...,:3], [0.299, 0.587, 0.114])[..., np.newaxis]

def grayscale2rgb(grayscale):
    return np.repeat(grayscale, 3, axis=-1)

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 [4]:
```
print(images.shape)
print(emotions.shape)
print(images_expw.shape)
print(emotions_expw.shape)
```

```
(35393, 48, 48, 1)
(35393, 8)
(291648, 48, 48, 3)
(291648, 8)
```

In [5]:
```
images_expw = tf.convert_to_tensor(images_expw)
images = tf.image.grayscale_to_rgb(tf.convert_to_tensor(images))
images = tf.cast(images, tf.uint8)
print(images.shape)
print(images_expw.shape)
```

```
2021-12-26 13:49:44.258752: I tensorflow/compiler/jit/xla_cpu_device.cc:41] Not creating XLA devices, tf_xla_enable_xla_devices not set
2021-12-26 13:49:44.262004: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library libcuda.so.1
2021-12-26 13:49:44.324548: 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
2021-12-26 13:49:44.325314: 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
2021-12-26 13:49:44.325366: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library li
bcudart.so.11.0
2021-12-26 13:49:44.997724: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library li
bcublas.so.11
2021-12-26 13:49:44.997897: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library li
bcublasLt.so.11
2021-12-26 13:49:45.583819: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library li
bcufft.so.10
2021-12-26 13:49:46.374302: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library li
bcurand.so.10
2021-12-26 13:49:47.427098: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library li
bcusolver.so.10
2021-12-26 13:49:47.909943: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library li
bcusparse.so.11
2021-12-26 13:49:47.997214: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library li
bcudnn.so.8
2021-12-26 13:49:47.997618: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:941] successful NUMA node read from SysFS had n
egative value (-1), but there must be at least one NUMA node, so returning NUMA node zero
2021-12-26 13:49:47.999253: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:941] successful NUMA node read from SysFS had n
egative value (-1), but there must be at least one NUMA node, so returning NUMA node zero
2021-12-26 13:49:48.000599: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1862] Adding visible gpu devices: 0
2021-12-26 13:49:48.003285: I tensorflow/core/platform/cpu_feature_guard.cc:142] This TensorFlow binary is optimized with oneAPI D
eep 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.
2021-12-26 13:49:48.004122: I tensorflow/compiler/jit/xla_gpu_device.cc:99] Not creating XLA devices, tf_xla_enable_xla_devices no
t set
2021-12-26 13:49:48.004475: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:941] successful NUMA node read from SysFS had n
egative value (-1), but there must be at least one NUMA node, so returning NUMA node zero
2021-12-26 13:49:48.006570: 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
2021-12-26 13:49:48.006695: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library li
bcudart.so.11.0
2021-12-26 13:49:48.006758: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library li
bcublas.so.11
2021-12-26 13:49:48.006800: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library li
bcublasLt.so.11
2021-12-26 13:49:48.006841: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library li
bcufft.so.10
2021-12-26 13:49:48.006881: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library li
bcurand.so.10
2021-12-26 13:49:48.006921: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library li
```

```
bcusolver.so.10
2021-12-26 13:49:48.006962: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library li
bcusparse.so.11
2021-12-26 13:49:48.007003: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library li
bcudnn.so.8
2021-12-26 13:49:48.007187: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:941] successful NUMA node read from SysFS had n
egative value (-1), but there must be at least one NUMA node, so returning NUMA node zero
2021-12-26 13:49:48.008801: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:941] successful NUMA node read from SysFS had n
egative value (-1), but there must be at least one NUMA node, so returning NUMA node zero
2021-12-26 13:49:48.010305: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1862] Adding visible gpu devices: 0
2021-12-26 13:49:48.010439: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library li
bcudart.so.11.0
2021-12-26 13:49:52.798135: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1261] Device interconnect StreamExecutor with stren
gth 1 edge matrix:
2021-12-26 13:49:52.798178: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1267]      0
2021-12-26 13:49:52.798186: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1280] 0:   N
2021-12-26 13:49:52.798512: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:941] successful NUMA node read from SysFS had n
egative value (-1), but there must be at least one NUMA node, so returning NUMA node zero
2021-12-26 13:49:52.799025: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:941] successful NUMA node read from SysFS had n
egative value (-1), but there must be at least one NUMA node, so returning NUMA node zero
2021-12-26 13:49:52.799475: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:941] successful NUMA node read from SysFS had n
egative value (-1), but there must be at least one NUMA node, so returning NUMA node zero
2021-12-26 13:49:52.799903: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1406] Created TensorFlow device (/job:localhost/rep
lica: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)
2021-12-26 13:49:52.803267: W tensorflow/core/framework/cpu_allocator_impl.cc:80] Allocation of 2015870976 exceeds 10% of free sys
tem memory.
(35393, 48, 48, 3)
(291648, 48, 48, 3)
```

In [6]:

```
training_size = training_samples + validation_samples
test_size = test_samples

training_images = tf.concat([images_expw, images], 0)
test_images = images[training_size:]
training_emotions = tf.concat([emotions_expw, emotions], 0)
test_emotions = emotions[training_size:]

samples += expw_samples
print("total sample:", samples)
print("training_images shape:", training_images.shape)
print("training_emotions shape:", training_emotions.shape)
```

```
print("test_images shape:", test_images.shape)
print("test_emotions shape:", test_emotions.shape)
```

```
total sample: 127186
training_images shape: (327041, 48, 48, 3)
training_emotions shape: (327041, 8)
test_images shape: (3535, 48, 48, 3)
test_emotions shape: (3535, 8)
```

In [7]:

```
tf.random.set_seed(1)
training_images = tf.random.shuffle(training_images)

tf.random.set_seed(1)
training_emotions = tf.random.shuffle(training_emotions)

print("training_images shape:", training_images.shape)
print("training_emotions shape:", training_emotions.shape)
print("test_images shape:", test_images.shape)
print("test_emotions shape:", test_emotions.shape)
```

```
2021-12-26 13:49:55.905662: W tensorflow/core/framework/cpu_allocator_impl.cc:80] Allocation of 2260507392 exceeds 10% of free sys
tem memory.
2021-12-26 13:49:57.771597: W tensorflow/core/framework/cpu_allocator_impl.cc:80] Allocation of 2260507392 exceeds 10% of free sys
tem memory.
training_images shape: (327041, 48, 48, 3)
training_emotions shape: (327041, 8)
test_images shape: (3535, 48, 48, 3)
test_emotions shape: (3535, 8)
```

In [ ]:

```
from tensorflow.python.keras.applications import vgg16, resnet_v2
from tensorflow.python.keras import optimizers
from tensorflow.python.keras.optimizer_v2 import adam
import matplotlib.pyplot as plt

cce = losses.CategoricalCrossentropy()
mse = losses.MeanSquaredError()

def create_model():
    base_model = vgg16.VGG16(include_top=False,
                             weights="imagenet",
                             input_shape=(48,48,3))
    base_model.trainable=True
```

```
    model = Sequential([
        base_model,
        layers.GlobalAveragePooling2D(),
        layers.Dense(4096, activation='relu'),
        layers.Dense(4096, activation='relu'),
        layers.Dense(emotions_count, activation='softmax'),
    ])

    model.compile(optimizer=adam.Adam(learning_rate=1e-5),
                  loss=mse,
                  metrics = [model_acc])
    return model

model = create_model()

history = model.fit(x=training_images,
          y=training_emotions,
          batch_size=32,
          epochs=40,
          validation_data=(test_images, test_emotions))
```

```
/userhome/cs/fym666/anaconda3/envs/tensorflow/lib/python3.8/site-packages/tensorflow/python/data/ops/dataset_ops.py:3503: UserWarn
ing: 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(
2021-12-26 13:50:01.935360: I tensorflow/compiler/mlir/mlir_graph_optimization_pass.cc:116] None of the MLIR optimization passes a
re enabled (registered 2)
2021-12-26 13:50:01.936388: I tensorflow/core/platform/profile_utils/cpu_utils.cc:112] CPU Frequency: 2199995000 Hz
2021-12-26 13:50:01.984555: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library li
bcudnn.so.8
Epoch 1/40
2021-12-26 13:50:17.965959: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library li
bcublas.so.11
2021-12-26 13:50:19.447398: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library li
bcublasLt.so.11
10221/10221 [==============================] - 842s 81ms/step - loss: 0.0599 - model_acc: 0.6626 - val_loss: 0.0405 - val_model_ac
c: 0.6129
Epoch 2/40
10221/10221 [==============================] - 810s 79ms/step - loss: 0.0469 - model_acc: 0.7466 - val_loss: 0.0342 - val_model_ac
c: 0.7024
Epoch 3/40
10221/10221 [==============================] - 818s 80ms/step - loss: 0.0435 - model_acc: 0.7687 - val_loss: 0.0388 - val_model_ac
c: 0.7179
```

```
Epoch 4/40
10221/10221 [==============================] - 816s 80ms/step - loss: 0.0407 - model_acc: 0.7876 - val_loss: 0.0351 - val_model_ac
c: 0.7100
Epoch 5/40
10221/10221 [==============================] - 792s 78ms/step - loss: 0.0375 - model_acc: 0.8061 - val_loss: 0.0408 - val_model_ac
c: 0.6813
Epoch 6/40
10221/10221 [==============================] - 824s 81ms/step - loss: 0.0346 - model_acc: 0.8248 - val_loss: 0.0371 - val_model_ac
c: 0.6960
Epoch 7/40
10221/10221 [==============================] - 819s 80ms/step - loss: 0.0313 - model_acc: 0.8444 - val_loss: 0.0382 - val_model_ac
c: 0.6686
Epoch 8/40
10221/10221 [==============================] - 819s 80ms/step - loss: 0.0283 - model_acc: 0.8627 - val_loss: 0.0367 - val_model_ac
c: 0.6587
Epoch 9/40
10221/10221 [==============================] - 805s 79ms/step - loss: 0.0255 - model_acc: 0.8779 - val_loss: 0.0392 - val_model_ac
c: 0.5912
Epoch 10/40
10221/10221 [==============================] - 817s 80ms/step - loss: 0.0230 - model_acc: 0.8914 - val_loss: 0.0416 - val_model_ac
c: 0.5989
Epoch 11/40
10221/10221 [==============================] - 824s 81ms/step - loss: 0.0212 - model_acc: 0.9012 - val_loss: 0.0397 - val_model_ac
c: 0.5976
Epoch 12/40
 3403/10221 [========>.....................] - ETA: 9:05 - loss: 0.0193 - model_acc: 0.9106
```

In [ ]:

```
model.compile(optimizer=adam.Adam(learning_rate=5e-5),
                loss=mse,
                metrics = [model_acc])

model.fit(x=training_images,
          y=training_emotions,
          batch_size=32,
          epochs=30,
          validation_data=(test_images, test_emotions))
```