In [1]:

```
import numpy as np
import matplotlib.pyplot as plt


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

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

In [2]:

```
import tensorflow as tf
from tensorflow.python.keras.layers import Dense, GlobalAveragePooling2D, MaxPool2D,
from tensorflow.python.keras.models import Model
from tensorflow.python.keras import layers, Sequential,losses, metrics
from tensorflow.python.keras import optimizers, callbacks, models
from tensorflow.python.keras.optimizer_v2 import adam
```

```
2021-12-24 19:17:22.048653: I tensorflow/stream_executor/platform/default/dso_loade
r.cc:49] Successfully opened dynamic library libcudart.so.11.0
```

In [3]:

```
image_path = "./dataset/images.npy"
emotion_multi_path = "./dataset/emotions_multi.npy"
emotion_single_path = "./dataset/emotions_single.npy"

images = np.load(image_path)
emotions_multi = np.load(emotion_multi_path)
emotions_single = np.load(emotion_single_path)

print(images.shape)
print(emotions_multi.shape)
print(emotions_single.shape)
```

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

In [4]:

```
#emotions = emotions_single
emotions = emotions_multi

images = tf.convert_to_tensor(images)
#images = tf.image.grayscale_to_rgb(images)
emotions = tf.convert_to_tensor(emotions)
print("images shape:", images.shape)
print("emotions shape:", emotions.shape)
```

```
images shape: (35393, 48, 48, 1)
emotions shape: (35393, 8)
```

```
2021-12-24 19:17:25.107491: I tensorflow/compiler/jit/xla_cpu_device.cc:41] Not crea
ting XLA devices, tf_xla_enable_xla_devices not set
2021-12-24 19:17:25.109040: I tensorflow/stream_executor/platform/default/dso_loade
r.cc:49] Successfully opened dynamic library libcuda.so.1
2021-12-24 19:17:25.761127: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:9
41] successful NUMA node read from SysFS had negative value (-1), but there must be
at least one NUMA node, so returning NUMA node zero
2021-12-24 19:17:25.761756: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1720]
```

```
41] successful NUMA node read from SysFS had negative value (-1), but there must be
at least one NUMA node, so returning NUMA node zero
2021-12-24 19:17:25.789622: I tensorflow/core/common
```

In [5]:

```python
from tensorflow.python.keras import layers
# choose one method:
images = layers.Rescaling(1./127.5, offset= -1)(images)
```

```
_runtime/gpu/gpu_device.cc:1862] Adding visible gpu devices: 0
2021-12-24 19:17:25.789667: I tensorflow/stream_executor/platform/default/dso_loade
r.cc:49] Successfully opened dynamic library libcudart.so.11.0
2021-12-24 19:17:26.566378: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1261]
Device interconnect StreamExecutor with strength 1 edge matrix:
2021-12-24 19:17:26.566424: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1267]
0
2021-12-24 19:17:26.566432: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1280]
0:   N
2021-12-24 19:17:26.566683: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:9
41] successful NUMA node read from SysFS had negative value (-1), but there must be
at least one NUMA node, so returning NUMA node zero
2021-12-24 19:17:26.567266: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:9
41] successful NUMA node read from SysFS had negative value (-1), but there must be
at least one NUMA node, so returning NUMA node zero
2021-12-24 19:17:26.567750: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:9
41] successful NUMA node read from SysFS had negative value (-1), but there must be
at least one NUMA node, so returning NUMA node zero
2021-12-24 19:17:26.568238: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1406]
Created TensorFlow device (/job:localhost/replica:0/task:0/device:GPU:0 with 10072 M
B memory) -> physical GPU (device: 0, name: GeForce RTX 2080 Ti, pci bus id: 0000:0
5:00.0, compute capability: 7.5)
```

In [6]:

```python
training_size = training_samples + validation_samples
test_size = test_samples

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

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)
```

```
training_images shape: (31858, 48, 48, 1)
training_emotions shape: (31858, 8)
test_images shape: (3535, 48, 48, 1)
test_emotions shape: (3535, 8)
```

In [7]:

```python
from tensorflow.python.keras import losses, metrics
from tensorflow.python.keras.optimizer_v2 import adam

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

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 [8]:

```
from tensorflow.python.keras.applications import vgg16, resnet_v2, densenet, efficie
from tensorflow.python.keras.layers import Dense, GlobalAveragePooling2D, MaxPool2D,
from tensorflow.python.keras.models import Model
from tensorflow.python.keras import layers, Sequential

# VGG13
input_layer = Input(shape=(48,48,3))
print(input_layer.shape, Flatten()(input_layer).shape)
x = Conv2D (filters=64, kernel_size=3, padding='same', activation='relu')(input_laye
x = Conv2D (filters=64, kernel_size=3, padding='same', activation='relu')(x)
x = MaxPool2D(pool_size=2, strides=2, padding='same')(x)
print(x.shape, Flatten()(x).shape)
x = Conv2D (filters=128, kernel_size=3, padding='same', activation='relu')(x)
x = Conv2D (filters=128, kernel_size=3, padding='same', activation='relu')(x)
x = MaxPool2D(pool_size=2, strides=2, padding='same')(x)
print(x.shape, Flatten()(x).shape)
x = Conv2D (filters=256, kernel_size=3, padding='same', activation='relu')(x)
x = Conv2D (filters=256, kernel_size=3, padding='same', activation='relu')(x)
#x = Conv2D (filters=256, kernel_size=3, padding='same', activation='relu')(x)
x = MaxPool2D(pool_size=2, strides=2, padding='same')(x)
print(x.shape, Flatten()(x).shape)
x = Conv2D (filters=512, kernel_size=3, padding='same', activation='relu')(x)
x = Conv2D (filters=512, kernel_size=3, padding='same', activation='relu')(x)
#x = Conv2D (filters=512, kernel_size=3, padding='same', activation='relu')(x)
x = MaxPool2D(pool_size=2, strides=2, padding='same')(x)
print(x.shape, Flatten()(x).shape)
x = Conv2D (filters=512, kernel_size=3, padding='same', activation='relu')(x)
x = Conv2D (filters=512, kernel_size=3, padding='same', activation='relu')(x)
#x = Conv2D (filters=512, kernel_size=3, padding='same', activation='relu')(x)
#x = MaxPool2D(pool_size=3, strides=1, padding='same')(x)
#print(x.shape, Flatten()(x).shape)
x = GlobalAveragePooling2D()(x)
print(x.shape, Flatten()(x).shape)
x = Dense(units=4096, activation='relu')(x)
x = Dense(units=4096, activation='relu')(x)
output_layer = Dense(units=8, activation='softmax')(x)
print(output_layer.shape, Flatten()(output_layer).shape)
model = Model(inputs=input_layer, outputs=output_layer)
print()
model.summary()

model.compile(optimizer=adam.Adam(learning_rate=2e-4),
              loss=mse,
              metrics = [model_acc])

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

```
(None, 48, 48, 3) (None, 6912)
(None, 24, 24, 64) (None, 36864)
(None, 12, 12, 128) (None, 18432)
(None, 6, 6, 256) (None, 9216)
(None, 3, 3, 512) (None, 4608)
(None, 512) (None, 512)
```

```
(None, 8) (None, 8)

Model: "model"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
input_1 (InputLayer)         [(None, 48, 48, 3)]       0
_________________________________________________________________
conv2d (Conv2D)              (None, 48, 48, 64)        1792
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 48, 48, 64)        36928
_________________________________________________________________
max_pooling2d (MaxPooling2D) (None, 24, 24, 64)        0
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 24, 24, 128)       73856
_________________________________________________________________
conv2d_3 (Conv2D)            (None, 24, 24, 128)       147584
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 12, 12, 128)       0
_________________________________________________________________
conv2d_4 (Conv2D)            (None, 12, 12, 256)       295168
_________________________________________________________________
conv2d_5 (Conv2D)            (None, 12, 12, 256)       590080
_________________________________________________________________
max_pooling2d_2 (MaxPooling2 (None, 6, 6, 256)         0
_________________________________________________________________
conv2d_6 (Conv2D)            (None, 6, 6, 512)         1180160
_________________________________________________________________
conv2d_7 (Conv2D)            (None, 6, 6, 512)         2359808
_________________________________________________________________
max_pooling2d_3 (MaxPooling2 (None, 3, 3, 512)         0
_________________________________________________________________
conv2d_8 (Conv2D)            (None, 3, 3, 512)         2359808
_________________________________________________________________
conv2d_9 (Conv2D)            (None, 3, 3, 512)         2359808
_________________________________________________________________
global_average_pooling2d (Gl (None, 512)               0
_________________________________________________________________
dense (Dense)                (None, 4096)              2101248
_________________________________________________________________
dense_1 (Dense)              (None, 4096)              16781312
_________________________________________________________________
dense_2 (Dense)              (None, 8)                 32776
=================================================================
Total params: 28,320,328
Trainable params: 28,320,328
Non-trainable params: 0
_________________________________________________________________
```

```
/userhome/cs/fym666/anaconda3/envs/tensorflow/lib/python3.8/site-packages/tensorflo
w/python/data/ops/dataset_ops.py:3503: UserWarning: Even though the tf.config.experi
mental_run_functions_eagerly option is set, this option does not apply to tf.data fu
nctions. tf.data functions are still traced and executed as graphs.
  warnings.warn(
2021-12-24 19:17:28.164647: I tensorflow/compiler/mlir/mlir_graph_optimization_pass.
cc:116] None of the MLIR optimization passes are enabled (registered 2)
2021-12-24 19:17:28.165185: I tensorflow/core/platform/profile_utils/cpu_utils.cc:11
2] CPU Frequency: 2199980000 Hz
2021-12-24 19:17:28.191402: I tensorflow/stream_executor/platform/default/dso_loade
r.cc:49] Successfully opened dynamic library libcudnn.so.8
```

```
Epoch 1/30
```

```
2021-12-24 19:17:30.578955: I tensorflow/stream_executor/platform/default/dso_loade
r.cc:49] Successfully opened dynamic library libcublas.so.11
```

```
2021-12-24 19:17:31.171872: I tensorflow/stream_executor/platform/default/dso_loade
r.cc:49] Successfully opened dynamic library libcublasLt.so.11
996/996 [==============================] - 81s 78ms/step - loss: 0.0584 - model_acc:
0.3755 - val_loss: 0.0377 - val_model_acc: 0.5988
Epoch 2/30
996/996 [==============================] - 73s 74ms/step - loss: 0.0337 - model_acc:
0.6434 - val_loss: 0.0303 - val_model_acc: 0.6737
Epoch 3/30
996/996 [==============================] - 75s 75ms/step - loss: 0.0258 - model_acc:
0.7147 - val_loss: 0.0259 - val_model_acc: 0.7074
Epoch 4/30
996/996 [==============================] - 74s 75ms/step - loss: 0.0198 - model_acc:
0.7782 - val_loss: 0.0221 - val_model_acc: 0.7379
Epoch 5/30
996/996 [==============================] - 75s 75ms/step - loss: 0.0163 - model_acc:
0.8047 - val_loss: 0.0200 - val_model_acc: 0.7697
Epoch 6/30
996/996 [==============================] - 68s 68ms/step - loss: 0.0131 - model_acc:
0.8394 - val_loss: 0.0191 - val_model_acc: 0.7790
Epoch 7/30
996/996 [==============================] - 78s 78ms/step - loss: 0.0107 - model_acc:
0.8690 - val_loss: 0.0192 - val_model_acc: 0.7754
Epoch 8/30
996/996 [==============================] - 77s 77ms/step - loss: 0.0088 - model_acc:
0.8916 - val_loss: 0.0179 - val_model_acc: 0.7877
Epoch 9/30
996/996 [==============================] - 76s 76ms/step - loss: 0.0071 - model_acc:
0.9080 - val_loss: 0.0179 - val_model_acc: 0.7830
Epoch 10/30
996/996 [==============================] - 74s 75ms/step - loss: 0.0062 - model_acc:
0.9219 - val_loss: 0.0167 - val_model_acc: 0.8015
Epoch 11/30
996/996 [==============================] - 74s 74ms/step - loss: 0.0055 - model_acc:
0.9300 - val_loss: 0.0173 - val_model_acc: 0.7923
Epoch 12/30
996/996 [==============================] - 72s 72ms/step - loss: 0.0049 - model_acc:
0.9365 - val_loss: 0.0169 - val_model_acc: 0.7979
Epoch 13/30
996/996 [==============================] - 75s 75ms/step - loss: 0.0044 - model_acc:
0.9458 - val_loss: 0.0173 - val_model_acc: 0.7917
Epoch 14/30
996/996 [==============================] - 77s 77ms/step - loss: 0.0039 - model_acc:
0.9510 - val_loss: 0.0161 - val_model_acc: 0.8069
Epoch 15/30
996/996 [==============================] - 75s 75ms/step - loss: 0.0037 - model_acc:
0.9493 - val_loss: 0.0155 - val_model_acc: 0.8066
Epoch 16/30
996/996 [==============================] - 77s 78ms/step - loss: 0.0034 - model_acc:
0.9556 - val_loss: 0.0156 - val_model_acc: 0.8052
Epoch 17/30
996/996 [==============================] - 72s 73ms/step - loss: 0.0030 - model_acc:
0.9591 - val_loss: 0.0155 - val_model_acc: 0.8070
Epoch 18/30
996/996 [==============================] - 72s 72ms/step - loss: 0.0027 - model_acc:
0.9643 - val_loss: 0.0157 - val_model_acc: 0.8075
Epoch 19/30
996/996 [==============================] - 76s 76ms/step - loss: 0.0026 - model_acc:
0.9645 - val_loss: 0.0156 - val_model_acc: 0.8091
Epoch 20/30
996/996 [==============================] - 77s 77ms/step - loss: 0.0025 - model_acc:
0.9667 - val_loss: 0.0159 - val_model_acc: 0.8072
Epoch 21/30
996/996 [==============================] - 76s 77ms/step - loss: 0.0024 - model_acc:
0.9666 - val_loss: 0.0158 - val_model_acc: 0.8035
```

```
Epoch 22/30
996/996 [==============================] - 77s 78ms/step - loss: 0.0027 - model_acc:
0.9602 - val_loss: 0.0163 - val_model_acc: 0.8075
Epoch 23/30
996/996 [==============================] - 77s 78ms/step - loss: 0.0020 - model_acc:
0.9745 - val_loss: 0.0156 - val_model_acc: 0.8131
Epoch 24/30
996/996 [==============================] - 75s 76ms/step - loss: 0.0018 - model_acc:
0.9797 - val_loss: 0.0151 - val_model_acc: 0.8187
Epoch 25/30
996/996 [==============================] - 74s 74ms/step - loss: 0.0018 - model_acc:
0.9754 - val_loss: 0.0153 - val_model_acc: 0.8117
Epoch 26/30
996/996 [==============================] - 77s 77ms/step - loss: 0.0017 - model_acc:
0.9741 - val_loss: 0.0154 - val_model_acc: 0.8114
Epoch 27/30
996/996 [==============================] - 76s 76ms/step - loss: 0.0017 - model_acc:
0.9765 - val_loss: 0.0158 - val_model_acc: 0.8123
Epoch 28/30
996/996 [==============================] - 76s 76ms/step - loss: 0.0017 - model_acc:
0.9754 - val_loss: 0.0153 - val_model_acc: 0.8157
Epoch 29/30
996/996 [==============================] - 73s 73ms/step - loss: 0.0014 - model_acc:
0.9798 - val_loss: 0.0151 - val_model_acc: 0.8159
Epoch 30/30
996/996 [==============================] - 74s 74ms/step - loss: 0.0013 - model_acc:
0.9825 - val_loss: 0.0153 - val_model_acc: 0.8173
```

Out[8]:

```
<tensorflow.python.keras.callbacks.History at 0x15184a5396d0>
```

In [9]:

```python
model.compile(optimizer=adam.Adam(learning_rate=1e-4),
              loss=mse,
              metrics = [model_acc])

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

```
Epoch 1/30
996/996 [==============================] - 74s 74ms/step - loss: 0.0011 - model_acc:
0.9850 - val_loss: 0.0146 - val_model_acc: 0.8260
Epoch 2/30
996/996 [==============================] - 72s 73ms/step - loss: 6.7845e-04 - model_
acc: 0.9949 - val_loss: 0.0144 - val_model_acc: 0.8278
Epoch 3/30
996/996 [==============================] - 76s 76ms/step - loss: 6.0003e-04 - model_
acc: 0.9959 - val_loss: 0.0145 - val_model_acc: 0.8198
Epoch 4/30
996/996 [==============================] - 77s 78ms/step - loss: 5.8967e-04 - model_
acc: 0.9955 - val_loss: 0.0147 - val_model_acc: 0.8204
Epoch 5/30
996/996 [==============================] - 76s 77ms/step - loss: 5.9071e-04 - model_
acc: 0.9935 - val_loss: 0.0145 - val_model_acc: 0.8255
Epoch 6/30
996/996 [==============================] - 72s 72ms/step - loss: 5.3854e-04 - model_
acc: 0.9947 - val_loss: 0.0146 - val_model_acc: 0.8187
Epoch 7/30
996/996 [==============================] - 75s 75ms/step - loss: 4.9261e-04 - model_
acc: 0.9961 - val_loss: 0.0147 - val_model_acc: 0.8218
Epoch 8/30
996/996 [==============================] - 77s 77ms/step - loss: 4.5688e-04 - model_
```

```
acc: 0.9967 - val_loss: 0.0147 - val_model_acc: 0.8224
Epoch 9/30
996/996 [==============================] - 76s 76ms/step - loss: 4.4127e-04 - model_
acc: 0.9957 - val_loss: 0.0146 - val_model_acc: 0.8224
Epoch 10/30
996/996 [==============================] - 78s 78ms/step - loss: 4.3255e-04 - model_
acc: 0.9956 - val_loss: 0.0146 - val_model_acc: 0.8252
Epoch 11/30
996/996 [==============================] - 78s 78ms/step - loss: 4.0973e-04 - model_
acc: 0.9962 - val_loss: 0.0145 - val_model_acc: 0.8235
Epoch 12/30
996/996 [==============================] - 75s 76ms/step - loss: 3.8582e-04 - model_
acc: 0.9964 - val_loss: 0.0146 - val_model_acc: 0.8224
Epoch 13/30
996/996 [==============================] - 74s 75ms/step - loss: 3.6645e-04 - model_
acc: 0.9972 - val_loss: 0.0147 - val_model_acc: 0.8184
Epoch 14/30
996/996 [==============================] - 76s 77ms/step - loss: 3.6555e-04 - model_
acc: 0.9964 - val_loss: 0.0147 - val_model_acc: 0.8252
Epoch 15/30
996/996 [==============================] - 77s 78ms/step - loss: 3.5638e-04 - model_
acc: 0.9964 - val_loss: 0.0146 - val_model_acc: 0.8202
Epoch 16/30
996/996 [==============================] - 73s 74ms/step - loss: 3.3235e-04 - model_
acc: 0.9969 - val_loss: 0.0145 - val_model_acc: 0.8249
Epoch 17/30
996/996 [==============================] - 76s 77ms/step - loss: 3.1534e-04 - model_
acc: 0.9972 - val_loss: 0.0145 - val_model_acc: 0.8204
Epoch 18/30
996/996 [==============================] - 76s 76ms/step - loss: 3.1579e-04 - model_
acc: 0.9972 - val_loss: 0.0145 - val_model_acc: 0.8204
Epoch 19/30
996/996 [==============================] - 77s 77ms/step - loss: 3.1990e-04 - model_
acc: 0.9969 - val_loss: 0.0146 - val_model_acc: 0.8204
Epoch 20/30
996/996 [==============================] - 74s 75ms/step - loss: 2.9163e-04 - model_
acc: 0.9979 - val_loss: 0.0144 - val_model_acc: 0.8235
Epoch 21/30
996/996 [==============================] - 75s 76ms/step - loss: 2.8045e-04 - model_
acc: 0.9973 - val_loss: 0.0146 - val_model_acc: 0.8193
Epoch 22/30
996/996 [==============================] - 75s 75ms/step - loss: 2.6699e-04 - model_
acc: 0.9973 - val_loss: 0.0146 - val_model_acc: 0.8224
Epoch 23/30
996/996 [==============================] - 75s 75ms/step - loss: 2.6905e-04 - model_
acc: 0.9977 - val_loss: 0.0147 - val_model_acc: 0.8238
Epoch 24/30
996/996 [==============================] - 76s 76ms/step - loss: 2.7202e-04 - model_
acc: 0.9973 - val_loss: 0.0146 - val_model_acc: 0.8229
Epoch 25/30
996/996 [==============================] - 74s 74ms/step - loss: 2.5701e-04 - model_
acc: 0.9976 - val_loss: 0.0146 - val_model_acc: 0.8229
Epoch 26/30
996/996 [==============================] - 74s 74ms/step - loss: 2.3452e-04 - model_
acc: 0.9977 - val_loss: 0.0146 - val_model_acc: 0.8204
Epoch 27/30
996/996 [==============================] - 77s 77ms/step - loss: 2.4913e-04 - model_
acc: 0.9968 - val_loss: 0.0145 - val_model_acc: 0.8199
Epoch 28/30
996/996 [==============================] - 73s 73ms/step - loss: 2.4768e-04 - model_
acc: 0.9976 - val_loss: 0.0145 - val_model_acc: 0.8283
Epoch 29/30
996/996 [==============================] - 74s 74ms/step - loss: 2.4190e-04 - model_
acc: 0.9982 - val_loss: 0.0145 - val_model_acc: 0.8224
```

```
Epoch 30/30
996/996 [==============================] - 77s 77ms/step - loss: 2.2743e-04 - model_
acc: 0.9979 - val_loss: 0.0146 - val_model_acc: 0.8193
```

Out[9]:

```
<tensorflow.python.keras.callbacks.History at 0x15182d880850>
```

In [ ]: