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', 'fear', 'contempt']

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, Input, Conv2D, Flatten
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
```

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)
```

In [5]:

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

In [6]:

```
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]:

```
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):
```

```
Epoch 18/30
996/996 [==============================] - 72s 72ms/step - loss: 6.0470e-04 - model_acc: 0.9941 - val_loss: 0.0135 - val_model_ac
c: 0.8317
Epoch 19/30
996/996 [==============================] - 72s 72ms/step - loss: 5.8416e-04 - model_acc: 0.9944 - val_loss: 0.0133 - val_model_ac
c: 0.8306
Epoch 20/30
996/996 [==============================] - 72s 72ms/step - loss: 5.6881e-04 - model_acc: 0.9935 - val_loss: 0.0134 - val_model_ac
c: 0.8320
Epoch 21/30
996/996 [==============================] - 72s 72ms/step - loss: 5.5340e-04 - model_acc: 0.9937 - val_loss: 0.0136 - val_model_ac
c: 0.8292
Epoch 22/30
996/996 [==============================] - 72s 72ms/step - loss: 5.4054e-04 - model_acc: 0.9942 - val_loss: 0.0135 - val_model_ac
c: 0.8264
Epoch 23/30
996/996 [==============================] - 72s 72ms/step - loss: 5.3157e-04 - model_acc: 0.9939 - val_loss: 0.0136 - val_model_ac
c: 0.8306
Epoch 24/30
996/996 [==============================] - 72s 72ms/step - loss: 5.0337e-04 - model_acc: 0.9951 - val_loss: 0.0135 - val_model_ac
c: 0.8264
Epoch 25/30
996/996 [==============================] - 72s 72ms/step - loss: 4.9640e-04 - model_acc: 0.9944 - val_loss: 0.0133 - val_model_ac
c: 0.8311
Epoch 26/30
996/996 [==============================] - 72s 72ms/step - loss: 4.9555e-04 - model_acc: 0.9945 - val_loss: 0.0135 - val_model_ac
c: 0.8314
Epoch 27/30
996/996 [==============================] - 72s 72ms/step - loss: 4.8011e-04 - model_acc: 0.9946 - val_loss: 0.0135 - val_model_ac
c: 0.8314
Epoch 28/30
996/996 [==============================] - 72s 72ms/step - loss: 4.6740e-04 - model_acc: 0.9951 - val_loss: 0.0135 - val_model_ac
c: 0.8306
Epoch 29/30
996/996 [==============================] - 72s 72ms/step - loss: 4.5285e-04 - model_acc: 0.9948 - val_loss: 0.0135 - val_model_ac
c: 0.8292
Epoch 30/30
996/996 [==============================] - 72s 72ms/step - loss: 4.4600e-04 - model_acc: 0.9949 - val_loss: 0.0134 - val_model_ac
c: 0.8280
```

Out[9]:
```
<tensorflow.python.keras.callbacks.History at 0x224c395b2b0>
```

In [10]:
```
# VGG16 no drop/combine
```

```
input_layer = Input(shape=(48,48,3))
print(input_layer.shape)


x = Conv2D (filters=64, kernel_size=3, padding='same', activation='relu')(input_layer)
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)

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)

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)

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)

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)
x = GlobalAveragePooling2D()(x)
print(x.shape)

x = Dense(units=4096, activation='relu')(x)

x = Dense(units=4096, activation='relu')(x)

output_layer = Dense(units=8, activation='softmax')(x)
model = Model(inputs=input_layer, outputs=output_layer)
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))

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))
```

```
(None, 48, 48, 3)
(None, 24, 24, 64)
(None, 12, 12, 128)
(None, 6, 6, 256)
(None, 3, 3, 512)
(None, 2, 2, 512)
(None, 512)
Model: "model_2"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
input_3 (InputLayer)         [(None, 48, 48, 3)]       0
_________________________________________________________________
conv2d_23 (Conv2D)           (None, 48, 48, 64)        1792
_________________________________________________________________
conv2d_24 (Conv2D)           (None, 48, 48, 64)        36928
_________________________________________________________________
max_pooling2d_9 (MaxPooling2 (None, 24, 24, 64)        0
_________________________________________________________________
conv2d_25 (Conv2D)           (None, 24, 24, 128)       73856
_________________________________________________________________
conv2d_26 (Conv2D)           (None, 24, 24, 128)       147584
_________________________________________________________________
max_pooling2d_10 (MaxPooling (None, 12, 12, 128)       0
_________________________________________________________________
```

```
conv2d_27 (Conv2D)           (None, 12, 12, 256)       295168
_________________________________________________________________
conv2d_28 (Conv2D)           (None, 12, 12, 256)       590080
_________________________________________________________________
conv2d_29 (Conv2D)           (None, 12, 12, 256)       590080
_________________________________________________________________
max_pooling2d_11 (MaxPooling (None, 6, 6, 256)         0
_________________________________________________________________
conv2d_30 (Conv2D)           (None, 6, 6, 512)         1180160
_________________________________________________________________
conv2d_31 (Conv2D)           (None, 6, 6, 512)         2359808
_________________________________________________________________
conv2d_32 (Conv2D)           (None, 6, 6, 512)         2359808
_________________________________________________________________
max_pooling2d_12 (MaxPooling (None, 3, 3, 512)         0
_________________________________________________________________
conv2d_33 (Conv2D)           (None, 3, 3, 512)         2359808
_________________________________________________________________
conv2d_34 (Conv2D)           (None, 3, 3, 512)         2359808
_________________________________________________________________
conv2d_35 (Conv2D)           (None, 3, 3, 512)         2359808
_________________________________________________________________
max_pooling2d_13 (MaxPooling (None, 2, 2, 512)         0
_________________________________________________________________
global_average_pooling2d_12  (None, 512)               0
_________________________________________________________________
dense_6 (Dense)              (None, 4096)              2101248
_________________________________________________________________
dense_7 (Dense)              (None, 4096)              16781312
_________________________________________________________________
dense_8 (Dense)              (None, 8)                 32776
=================================================================
Total params: 33,630,024
Trainable params: 33,630,024
Non-trainable params: 0
_________________________________________________________________
Epoch 1/30
996/996 [==============================] - 69s 69ms/step - loss: 0.0543 - model_acc: 0.4292 - val_loss: 0.0399 - val_model_acc: 0.
5915
Epoch 2/30
996/996 [==============================] - 69s 69ms/step - loss: 0.0333 - model_acc: 0.6428 - val_loss: 0.0304 - val_model_acc: 0.
6709
Epoch 3/30
996/996 [==============================] - 69s 69ms/step - loss: 0.0271 - model_acc: 0.7042 - val_loss: 0.0271 - val_model_acc: 0.
```

```
7073
Epoch 4/30
996/996 [==============================] - 69s 69ms/step - loss: 0.0225 - model_acc: 0.7456 - val_loss: 0.0246 - val_model_acc: 0.
7256
Epoch 5/30
996/996 [==============================] - 69s 69ms/step - loss: 0.0189 - model_acc: 0.7828 - val_loss: 0.0214 - val_model_acc: 0.
7458
Epoch 6/30
996/996 [==============================] - 69s 69ms/step - loss: 0.0158 - model_acc: 0.8125 - val_loss: 0.0200 - val_model_acc: 0.
7664
Epoch 7/30
996/996 [==============================] - 69s 69ms/step - loss: 0.0137 - model_acc: 0.8353 - val_loss: 0.0182 - val_model_acc: 0.
7889
Epoch 8/30
996/996 [==============================] - 69s 69ms/step - loss: 0.0115 - model_acc: 0.8602 - val_loss: 0.0175 - val_model_acc: 0.
7968
Epoch 9/30
996/996 [==============================] - 69s 69ms/step - loss: 0.0098 - model_acc: 0.8791 - val_loss: 0.0176 - val_model_acc: 0.
7951
Epoch 10/30
996/996 [==============================] - 69s 69ms/step - loss: 0.0087 - model_acc: 0.8926 - val_loss: 0.0169 - val_model_acc: 0.
8019
Epoch 11/30
996/996 [==============================] - 69s 69ms/step - loss: 0.0075 - model_acc: 0.9071 - val_loss: 0.0169 - val_model_acc: 0.
7980
Epoch 12/30
996/996 [==============================] - 69s 69ms/step - loss: 0.0067 - model_acc: 0.9171 - val_loss: 0.0171 - val_model_acc: 0.
7994
Epoch 13/30
996/996 [==============================] - 69s 69ms/step - loss: 0.0057 - model_acc: 0.9279 - val_loss: 0.0167 - val_model_acc: 0.
8006
Epoch 14/30
996/996 [==============================] - 69s 69ms/step - loss: 0.0054 - model_acc: 0.9313 - val_loss: 0.0171 - val_model_acc: 0.
7928
Epoch 15/30
996/996 [==============================] - 69s 69ms/step - loss: 0.0053 - model_acc: 0.9335 - val_loss: 0.0177 - val_model_acc: 0.
7992
Epoch 16/30
996/996 [==============================] - 69s 69ms/step - loss: 0.0047 - model_acc: 0.9421 - val_loss: 0.0156 - val_model_acc: 0.
8160
Epoch 17/30
996/996 [==============================] - 69s 69ms/step - loss: 0.0042 - model_acc: 0.9460 - val_loss: 0.0161 - val_model_acc: 0.
8078
Epoch 18/30
```

```
996/996 [==============================] - 69s 69ms/step - loss: 0.0040 - model_acc: 0.9490 - val_loss: 0.0159 - val_model_acc: 0.
8087
Epoch 19/30
996/996 [==============================] - 69s 69ms/step - loss: 0.0036 - model_acc: 0.9546 - val_loss: 0.0153 - val_model_acc: 0.
8188
Epoch 20/30
996/996 [==============================] - 69s 69ms/step - loss: 0.0037 - model_acc: 0.9519 - val_loss: 0.0181 - val_model_acc: 0.
7965
Epoch 21/30
996/996 [==============================] - 69s 69ms/step - loss: 0.0036 - model_acc: 0.9532 - val_loss: 0.0157 - val_model_acc: 0.
8129
Epoch 22/30
996/996 [==============================] - 69s 69ms/step - loss: 0.0028 - model_acc: 0.9642 - val_loss: 0.0152 - val_model_acc: 0.
8132
Epoch 23/30
996/996 [==============================] - 69s 69ms/step - loss: 0.0026 - model_acc: 0.9667 - val_loss: 0.0152 - val_model_acc: 0.
8142
Epoch 24/30
996/996 [==============================] - 69s 69ms/step - loss: 0.0026 - model_acc: 0.9660 - val_loss: 0.0152 - val_model_acc: 0.
8152
Epoch 25/30
996/996 [==============================] - 69s 69ms/step - loss: 0.0027 - model_acc: 0.9640 - val_loss: 0.0160 - val_model_acc: 0.
8109
Epoch 26/30
996/996 [==============================] - 69s 69ms/step - loss: 0.0027 - model_acc: 0.9646 - val_loss: 0.0154 - val_model_acc: 0.
8132
Epoch 27/30
996/996 [==============================] - 69s 69ms/step - loss: 0.0022 - model_acc: 0.9719 - val_loss: 0.0155 - val_model_acc: 0.
8115
Epoch 28/30
996/996 [==============================] - 69s 69ms/step - loss: 0.0021 - model_acc: 0.9734 - val_loss: 0.0149 - val_model_acc: 0.
8228
Epoch 29/30
996/996 [==============================] - 69s 69ms/step - loss: 0.0024 - model_acc: 0.9686 - val_loss: 0.0157 - val_model_acc: 0.
8188
Epoch 30/30
996/996 [==============================] - 69s 69ms/step - loss: 0.0021 - model_acc: 0.9716 - val_loss: 0.0154 - val_model_acc: 0.
8152
Epoch 1/30
996/996 [==============================] - 69s 69ms/step - loss: 0.0015 - model_acc: 0.9837 - val_loss: 0.0147 - val_model_acc: 0.
8267
Epoch 2/30
996/996 [==============================] - 69s 69ms/step - loss: 0.0012 - model_acc: 0.9921 - val_loss: 0.0147 - val_model_acc: 0.
8202
```

```
Epoch 3/30
996/996 [==============================] - 69s 69ms/step - loss: 0.0010 - model_acc: 0.9925 - val_loss: 0.0146 - val_model_acc: 0.
8244
Epoch 4/30
996/996 [==============================] - 69s 69ms/step - loss: 9.7084e-04 - model_acc: 0.9928 - val_loss: 0.0146 - val_model_ac
c: 0.8245
Epoch 5/30
996/996 [==============================] - 69s 69ms/step - loss: 9.2127e-04 - model_acc: 0.9915 - val_loss: 0.0146 - val_model_ac
c: 0.8256
Epoch 6/30
996/996 [==============================] - 69s 69ms/step - loss: 8.4856e-04 - model_acc: 0.9935 - val_loss: 0.0145 - val_model_ac
c: 0.8228
Epoch 7/30
996/996 [==============================] - 69s 69ms/step - loss: 7.8512e-04 - model_acc: 0.9934 - val_loss: 0.0147 - val_model_ac
c: 0.8278
Epoch 8/30
996/996 [==============================] - 69s 69ms/step - loss: 7.3493e-04 - model_acc: 0.9933 - val_loss: 0.0147 - val_model_ac
c: 0.8234
Epoch 9/30
996/996 [==============================] - 69s 69ms/step - loss: 6.8525e-04 - model_acc: 0.9938 - val_loss: 0.0146 - val_model_ac
c: 0.8264
Epoch 10/30
996/996 [==============================] - 69s 69ms/step - loss: 6.4406e-04 - model_acc: 0.9942 - val_loss: 0.0146 - val_model_ac
c: 0.8236
Epoch 11/30
996/996 [==============================] - 69s 69ms/step - loss: 6.1519e-04 - model_acc: 0.9944 - val_loss: 0.0147 - val_model_ac
c: 0.8236
Epoch 12/30
996/996 [==============================] - 69s 69ms/step - loss: 5.9157e-04 - model_acc: 0.9947 - val_loss: 0.0146 - val_model_ac
c: 0.8278
Epoch 13/30
996/996 [==============================] - 69s 69ms/step - loss: 5.5908e-04 - model_acc: 0.9948 - val_loss: 0.0147 - val_model_ac
c: 0.8244
Epoch 14/30
996/996 [==============================] - 69s 69ms/step - loss: 5.2996e-04 - model_acc: 0.9950 - val_loss: 0.0147 - val_model_ac
c: 0.8225
Epoch 15/30
996/996 [==============================] - 69s 69ms/step - loss: 5.0204e-04 - model_acc: 0.9951 - val_loss: 0.0146 - val_model_ac
c: 0.8224
Epoch 16/30
996/996 [==============================] - 69s 69ms/step - loss: 4.8815e-04 - model_acc: 0.9953 - val_loss: 0.0147 - val_model_ac
c: 0.8236
Epoch 17/30
996/996 [==============================] - 69s 69ms/step - loss: 4.6363e-04 - model_acc: 0.9959 - val_loss: 0.0147 - val_model_ac
```

```
c: 0.8233
Epoch 18/30
996/996 [==============================] - 69s 69ms/step - loss: 4.5697e-04 - model_acc: 0.9959 - val_loss: 0.0145 - val_model_ac
c: 0.8230
Epoch 19/30
996/996 [==============================] - 69s 69ms/step - loss: 4.3336e-04 - model_acc: 0.9962 - val_loss: 0.0147 - val_model_ac
c: 0.8267
Epoch 20/30
996/996 [==============================] - 69s 69ms/step - loss: 4.0983e-04 - model_acc: 0.9960 - val_loss: 0.0148 - val_model_ac
c: 0.8225
Epoch 21/30
996/996 [==============================] - 69s 69ms/step - loss: 4.0305e-04 - model_acc: 0.9970 - val_loss: 0.0147 - val_model_ac
c: 0.8270
Epoch 22/30
996/996 [==============================] - 69s 69ms/step - loss: 3.9349e-04 - model_acc: 0.9957 - val_loss: 0.0146 - val_model_ac
c: 0.8222
Epoch 23/30
996/996 [==============================] - 69s 69ms/step - loss: 3.7863e-04 - model_acc: 0.9963 - val_loss: 0.0147 - val_model_ac
c: 0.8259
Epoch 24/30
996/996 [==============================] - 69s 69ms/step - loss: 3.6817e-04 - model_acc: 0.9972 - val_loss: 0.0146 - val_model_ac
c: 0.8304
Epoch 25/30
996/996 [==============================] - 69s 69ms/step - loss: 3.6779e-04 - model_acc: 0.9968 - val_loss: 0.0144 - val_model_ac
c: 0.8278
Epoch 26/30
996/996 [==============================] - 69s 69ms/step - loss: 3.4248e-04 - model_acc: 0.9970 - val_loss: 0.0146 - val_model_ac
c: 0.8256
Epoch 27/30
996/996 [==============================] - 69s 69ms/step - loss: 3.4004e-04 - model_acc: 0.9972 - val_loss: 0.0145 - val_model_ac
c: 0.8261
Epoch 28/30
996/996 [==============================] - 69s 69ms/step - loss: 3.4439e-04 - model_acc: 0.9974 - val_loss: 0.0146 - val_model_ac
c: 0.8261
Epoch 29/30
996/996 [==============================] - 69s 69ms/step - loss: 3.1543e-04 - model_acc: 0.9970 - val_loss: 0.0145 - val_model_ac
c: 0.8287
Epoch 30/30
996/996 [==============================] - 69s 69ms/step - loss: 3.0162e-04 - model_acc: 0.9981 - val_loss: 0.0147 - val_model_ac
c: 0.8230
```

Out[10]: <tensorflow.python.keras.callbacks.History at 0x224ff4c40a0>