In [7]:
```
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)

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

In [8]:
```
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 [9]:
```
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 [10]:

```
#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)
# images = tf.image.resize(images, [224,224])
images = layers.Rescaling(1./127.5, offset= -1)(images)

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, 3)
training_emotions shape: (31858, 8)
test_images shape: (3535, 48, 48, 3)
test_emotions shape: (3535, 8)
```

In [11]:

```
from tensorflow.python.keras.applications import vgg16, resnet
from tensorflow.python.keras import optimizers
from tensorflow.python.keras.optimizer_v2 import adam
```

In [12]:

```
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(2048, activation='relu'),
    layers.Dense(2048, activation='relu'),
    layers.Dense(emotions_count, activation='softmax'),
])

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

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

```
Epoch 1/40
996/996 [==============================] - 69s 69ms/step - loss: 1.1444 - model_acc: 0.6925 - val_loss: 0.9857 - val_model_acc: 0.
7588
Epoch 2/40
996/996 [==============================] - 70s 70ms/step - loss: 0.9346 - model_acc: 0.7985 - val_loss: 0.9110 - val_model_acc: 0.
7873
Epoch 3/40
996/996 [==============================] - 71s 71ms/step - loss: 0.8594 - model_acc: 0.8366 - val_loss: 0.8812 - val_model_acc: 0.
8039
Epoch 4/40
996/996 [==============================] - 72s 72ms/step - loss: 0.8099 - model_acc: 0.8634 - val_loss: 0.8664 - val_model_acc: 0.
8191
Epoch 5/40
996/996 [==============================] - 69s 69ms/step - loss: 0.7706 - model_acc: 0.8893 - val_loss: 0.8616 - val_model_acc: 0.
8143
Epoch 6/40
996/996 [==============================] - 68s 68ms/step - loss: 0.7423 - model_acc: 0.9043 - val_loss: 0.8592 - val_model_acc: 0.
8213
Epoch 7/40
996/996 [==============================] - 68s 69ms/step - loss: 0.7180 - model_acc: 0.9182 - val_loss: 0.8572 - val_model_acc: 0.
8228
Epoch 8/40
996/996 [==============================] - 68s 68ms/step - loss: 0.6959 - model_acc: 0.9278 - val_loss: 0.8523 - val_model_acc: 0.
8304
Epoch 9/40
996/996 [==============================] - 68s 69ms/step - loss: 0.6747 - model_acc: 0.9344 - val_loss: 0.8543 - val_model_acc: 0.
```

```
8304
Epoch 10/40
996/996 [==============================] - 68s 68ms/step - loss: 0.6573 - model_acc: 0.9379 - val_loss: 0.8634 - val_model_acc: 0.
8337
Epoch 11/40
996/996 [==============================] - 69s 69ms/step - loss: 0.6396 - model_acc: 0.9427 - val_loss: 0.8802 - val_model_acc: 0.
8391
Epoch 12/40
996/996 [==============================] - 67s 68ms/step - loss: 0.6242 - model_acc: 0.9486 - val_loss: 0.8866 - val_model_acc: 0.
8357
Epoch 13/40
996/996 [==============================] - 68s 68ms/step - loss: 0.6118 - model_acc: 0.9478 - val_loss: 0.9274 - val_model_acc: 0.
8349
Epoch 14/40
996/996 [==============================] - 67s 68ms/step - loss: 0.5995 - model_acc: 0.9531 - val_loss: 0.9310 - val_model_acc: 0.
8368
Epoch 15/40
996/996 [==============================] - 68s 68ms/step - loss: 0.5919 - model_acc: 0.9520 - val_loss: 0.9733 - val_model_acc: 0.
8326
Epoch 16/40
996/996 [==============================] - 68s 68ms/step - loss: 0.5873 - model_acc: 0.9561 - val_loss: 0.9637 - val_model_acc: 0.
8332
Epoch 17/40
996/996 [==============================] - 68s 68ms/step - loss: 0.5811 - model_acc: 0.9574 - val_loss: 0.9898 - val_model_acc: 0.
8312
Epoch 18/40
996/996 [==============================] - 68s 68ms/step - loss: 0.5775 - model_acc: 0.9587 - val_loss: 0.9733 - val_model_acc: 0.
8340
Epoch 19/40
996/996 [==============================] - 68s 68ms/step - loss: 0.5737 - model_acc: 0.9593 - val_loss: 1.0345 - val_model_acc: 0.
8326
Epoch 20/40
996/996 [==============================] - 68s 68ms/step - loss: 0.5728 - model_acc: 0.9584 - val_loss: 1.0470 - val_model_acc: 0.
8325
Epoch 21/40
996/996 [==============================] - 68s 68ms/step - loss: 0.5697 - model_acc: 0.9607 - val_loss: 1.0166 - val_model_acc: 0.
8397
Epoch 22/40
996/996 [==============================] - 67s 68ms/step - loss: 0.5685 - model_acc: 0.9611 - val_loss: 1.0410 - val_model_acc: 0.
8390
Epoch 23/40
996/996 [==============================] - 68s 68ms/step - loss: 0.5667 - model_acc: 0.9629 - val_loss: 1.0235 - val_model_acc: 0.
8368
Epoch 24/40
```

```
996/996 [==============================] - 68s 69ms/step - loss: 0.5652 - model_acc: 0.9637 - val_loss: 1.0229 - val_model_acc: 0.
8349
Epoch 25/40
996/996 [==============================] - 68s 69ms/step - loss: 0.5634 - model_acc: 0.9631 - val_loss: 1.0995 - val_model_acc: 0.
8329
Epoch 26/40
996/996 [==============================] - 68s 69ms/step - loss: 0.5622 - model_acc: 0.9650 - val_loss: 1.0907 - val_model_acc: 0.
8352
Epoch 27/40
996/996 [==============================] - 68s 68ms/step - loss: 0.5620 - model_acc: 0.9644 - val_loss: 1.0778 - val_model_acc: 0.
8363
Epoch 28/40
996/996 [==============================] - 68s 68ms/step - loss: 0.5620 - model_acc: 0.9639 - val_loss: 1.0448 - val_model_acc: 0.
8419
Epoch 29/40
996/996 [==============================] - 68s 68ms/step - loss: 0.5601 - model_acc: 0.9667 - val_loss: 1.0516 - val_model_acc: 0.
8397
Epoch 30/40
996/996 [==============================] - 68s 68ms/step - loss: 0.5611 - model_acc: 0.9666 - val_loss: 1.0638 - val_model_acc: 0.
8380
Epoch 31/40
996/996 [==============================] - 68s 68ms/step - loss: 0.5589 - model_acc: 0.9673 - val_loss: 1.0715 - val_model_acc: 0.
8360
Epoch 32/40
996/996 [==============================] - 68s 68ms/step - loss: 0.5571 - model_acc: 0.9698 - val_loss: 1.0517 - val_model_acc: 0.
8453
Epoch 33/40
996/996 [==============================] - 67s 68ms/step - loss: 0.5566 - model_acc: 0.9685 - val_loss: 1.0656 - val_model_acc: 0.
8374
Epoch 34/40
996/996 [==============================] - 68s 68ms/step - loss: 0.5564 - model_acc: 0.9698 - val_loss: 1.0606 - val_model_acc: 0.
8377
Epoch 35/40
996/996 [==============================] - 68s 68ms/step - loss: 0.5564 - model_acc: 0.9683 - val_loss: 1.0707 - val_model_acc: 0.
8374
Epoch 36/40
996/996 [==============================] - 68s 68ms/step - loss: 0.5557 - model_acc: 0.9693 - val_loss: 1.0861 - val_model_acc: 0.
8343
Epoch 37/40
996/996 [==============================] - 68s 68ms/step - loss: 0.5558 - model_acc: 0.9696 - val_loss: 1.0628 - val_model_acc: 0.
8410
Epoch 38/40
996/996 [==============================] - 68s 68ms/step - loss: 0.5546 - model_acc: 0.9698 - val_loss: 1.0940 - val_model_acc: 0.
8371
```

```
Epoch 39/40
996/996 [==============================] - 68s 68ms/step - loss: 0.5529 - model_acc: 0.9722 - val_loss: 1.0729 - val_model_acc: 0.
8388
Epoch 40/40
996/996 [==============================] - 68s 68ms/step - loss: 0.5539 - model_acc: 0.9707 - val_loss: 1.0698 - val_model_acc: 0.
8391
```

Out[12]:
```
<tensorflow.python.keras.callbacks.History at 0x19664f1b070>
```

In [13]:
```
base_model = resnet.ResNet50(include_top=False,
                         weights="imagenet",
                         input_shape=(48,48,3))
base_model.trainable=True
model = Sequential([
    base_model,
    layers.GlobalAveragePooling2D(),
    layers.Dense(2048, activation='relu'),
    #layers.Dense(2048, activation='relu'),
    layers.Dense(emotions_count, activation='softmax'),
])

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

model.fit(x=training_images,
          y=training_emotions,
          batch_size=16,
          epochs=40,
          validation_data=(test_images, test_emotions))
```

```
Epoch 1/40
1992/1992 [==============================] - 276s 138ms/step - loss: 1.2649 - model_acc: 0.6411 - val_loss: 1.0522 - val_model_ac
c: 0.7120
Epoch 2/40
1992/1992 [==============================] - 275s 138ms/step - loss: 1.0025 - model_acc: 0.7649 - val_loss: 0.9809 - val_model_ac
c: 0.7700
Epoch 3/40
1992/1992 [==============================] - 275s 138ms/step - loss: 0.9030 - model_acc: 0.8163 - val_loss: 0.9703 - val_model_ac
c: 0.7728
Epoch 4/40
1992/1992 [==============================] - 275s 138ms/step - loss: 0.8425 - model_acc: 0.8474 - val_loss: 0.9534 - val_model_ac
c: 0.7794
Epoch 5/40
```

```
1992/1992 [==============================] - 276s 138ms/step - loss: 0.7925 - model_acc: 0.8735 - val_loss: 0.9441 - val_model_ac
c: 0.7892
Epoch 6/40
1992/1992 [==============================] - 275s 138ms/step - loss: 0.7556 - model_acc: 0.8915 - val_loss: 0.9466 - val_model_ac
c: 0.7938
Epoch 7/40
1992/1992 [==============================] - 275s 138ms/step - loss: 0.7286 - model_acc: 0.9037 - val_loss: 0.9393 - val_model_ac
c: 0.8028
Epoch 8/40
1992/1992 [==============================] - 275s 138ms/step - loss: 0.7067 - model_acc: 0.9102 - val_loss: 0.9416 - val_model_ac
c: 0.8022
Epoch 9/40
1992/1992 [==============================] - 275s 138ms/step - loss: 0.6833 - model_acc: 0.9193 - val_loss: 0.9449 - val_model_ac
c: 0.8048
Epoch 10/40
1992/1992 [==============================] - 275s 138ms/step - loss: 0.6663 - model_acc: 0.9234 - val_loss: 0.9454 - val_model_ac
c: 0.8048
Epoch 11/40
1992/1992 [==============================] - 275s 138ms/step - loss: 0.6510 - model_acc: 0.9287 - val_loss: 0.9573 - val_model_ac
c: 0.8034
Epoch 12/40
1992/1992 [==============================] - 276s 138ms/step - loss: 0.6377 - model_acc: 0.9306 - val_loss: 0.9632 - val_model_ac
c: 0.8034
Epoch 13/40
1992/1992 [==============================] - 276s 138ms/step - loss: 0.6275 - model_acc: 0.9333 - val_loss: 1.0024 - val_model_ac
c: 0.8020
Epoch 14/40
1992/1992 [==============================] - 275s 138ms/step - loss: 0.6172 - model_acc: 0.9374 - val_loss: 0.9912 - val_model_ac
c: 0.8044
Epoch 15/40
1992/1992 [==============================] - 275s 138ms/step - loss: 0.6096 - model_acc: 0.9398 - val_loss: 1.0046 - val_model_ac
c: 0.8084
Epoch 16/40
1992/1992 [==============================] - 275s 138ms/step - loss: 0.6019 - model_acc: 0.9454 - val_loss: 1.0442 - val_model_ac
c: 0.8074
Epoch 17/40
1992/1992 [==============================] - 275s 138ms/step - loss: 0.5975 - model_acc: 0.9442 - val_loss: 1.0380 - val_model_ac
c: 0.8144
Epoch 18/40
1992/1992 [==============================] - 275s 138ms/step - loss: 0.5917 - model_acc: 0.9486 - val_loss: 1.0361 - val_model_ac
c: 0.8170
Epoch 19/40
1992/1992 [==============================] - 274s 138ms/step - loss: 0.5882 - model_acc: 0.9533 - val_loss: 1.0779 - val_model_ac
c: 0.8079
```

```
Epoch 20/40
1992/1992 [==============================] - 275s 138ms/step - loss: 0.5850 - model_acc: 0.9522 - val_loss: 1.0828 - val_model_ac
c: 0.8130
Epoch 21/40
1992/1992 [==============================] - 275s 138ms/step - loss: 0.5814 - model_acc: 0.9533 - val_loss: 1.0678 - val_model_ac
c: 0.8141
Epoch 22/40
1992/1992 [==============================] - 275s 138ms/step - loss: 0.5761 - model_acc: 0.9575 - val_loss: 1.0935 - val_model_ac
c: 0.8110
Epoch 23/40
1992/1992 [==============================] - 276s 138ms/step - loss: 0.5749 - model_acc: 0.9565 - val_loss: 1.1248 - val_model_ac
c: 0.8079
Epoch 24/40
1992/1992 [==============================] - 275s 138ms/step - loss: 0.5760 - model_acc: 0.9565 - val_loss: 1.1476 - val_model_ac
c: 0.8098
Epoch 25/40
1992/1992 [==============================] - 275s 138ms/step - loss: 0.5690 - model_acc: 0.9614 - val_loss: 1.1397 - val_model_ac
c: 0.8153
Epoch 26/40
1992/1992 [==============================] - 276s 138ms/step - loss: 0.5699 - model_acc: 0.9605 - val_loss: 1.1469 - val_model_ac
c: 0.8084
Epoch 27/40
1992/1992 [==============================] - 275s 138ms/step - loss: 0.5721 - model_acc: 0.9595 - val_loss: 1.1834 - val_model_ac
c: 0.8093
Epoch 28/40
1992/1992 [==============================] - 275s 138ms/step - loss: 0.5631 - model_acc: 0.9653 - val_loss: 1.1702 - val_model_ac
c: 0.8082
Epoch 29/40
1992/1992 [==============================] - 276s 138ms/step - loss: 0.5685 - model_acc: 0.9627 - val_loss: 1.2130 - val_model_ac
c: 0.8031
Epoch 30/40
1992/1992 [==============================] - 275s 138ms/step - loss: 0.5668 - model_acc: 0.9615 - val_loss: 1.2004 - val_model_ac
c: 0.8107
Epoch 31/40
1992/1992 [==============================] - 274s 138ms/step - loss: 0.5631 - model_acc: 0.9672 - val_loss: 1.1814 - val_model_ac
c: 0.8073
Epoch 32/40
1992/1992 [==============================] - 275s 138ms/step - loss: 0.5678 - model_acc: 0.9615 - val_loss: 1.2284 - val_model_ac
c: 0.8073
Epoch 33/40
1992/1992 [==============================] - 273s 137ms/step - loss: 0.5598 - model_acc: 0.9683 - val_loss: 1.1951 - val_model_ac
c: 0.8152
Epoch 34/40
1992/1992 [==============================] - 274s 137ms/step - loss: 0.5600 - model_acc: 0.9681 - val_loss: 1.2533 - val_model_ac
```

```
c: 0.8056
Epoch 35/40
1992/1992 [==============================] - 274s 137ms/step - loss: 0.5644 - model_acc: 0.9655 - val_loss: 1.3300 - val_model_ac
c: 0.8019
Epoch 36/40
1992/1992 [==============================] - 282s 141ms/step - loss: 0.5619 - model_acc: 0.9662 - val_loss: 1.1947 - val_model_ac
c: 0.8096
Epoch 37/40
1992/1992 [==============================] - 276s 139ms/step - loss: 0.5589 - model_acc: 0.9697 - val_loss: 1.2849 - val_model_ac
c: 0.8034
Epoch 38/40
1992/1992 [==============================] - 275s 138ms/step - loss: 0.5617 - model_acc: 0.9672 - val_loss: 1.4332 - val_model_ac
c: 0.7813
Epoch 39/40
1992/1992 [==============================] - 283s 142ms/step - loss: 0.5636 - model_acc: 0.9664 - val_loss: 1.2364 - val_model_ac
c: 0.8102
Epoch 40/40
1992/1992 [==============================] - 281s 141ms/step - loss: 0.5533 - model_acc: 0.9732 - val_loss: 1.2485 - val_model_ac
c: 0.8150
```

Out[13]: `<tensorflow.python.keras.callbacks.History at 0x195b4a8b550>`