In [1]:
```python
# data augmentation test: rotate different degree (pay attention to adjustable filename etc.)

import os
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']

# !!! change sample size
samples = 130967 # 2~130968
training_samples = 28317 *4  # 2~113269 (Training)
validation_samples = 3541 *4 # 113270~127433 (PublicTest)
test_samples = 3535          # 127434~130968 (PrivateTest)

# !!! change npy folder name
image_path = "./dataset3/images.npy"
emotion_multi_path = "./dataset3/emotions_multi.npy"
emotion_single_path = "./dataset3/emotions_single.npy"
images = np.load(image_path)
emotions_multi = np.load(emotion_multi_path)
emotions_single = np.load(emotion_single_path)

# !!! change s/m dataset
#emotions = emotions_single
emotions = emotions_multi

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

```
(130967, 48, 48, 1)
(130967, 8)
(130967, 8)
```

In [2]:
```python
cce = losses.CategoricalCrossentropy()
```

```python
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 [3]:
```python
images = tf.convert_to_tensor(images)

emotions = tf.convert_to_tensor(emotions)

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: (127432, 48, 48, 1)
training_emotions shape: (127432, 8)
test_images shape: (3535, 48, 48, 1)
test_emotions shape: (3535, 8)
```

In [4]:
```python
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
```

In [5]:
```python
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-4),
                  loss=mse,
                  metrics = [model_acc])
    return model


model = create_model()

best_model_save_path = "best_models/FERPlus_flip_+-25_multi_mse"

model_checkpoint_callback = tf.keras.callbacks.ModelCheckpoint(
    filepath=best_model_save_path,
    save_weights_only=False,
    monitor='val_model_acc',
    mode='max',
    save_best_only=True)

history = model.fit(x=tf.image.grayscale_to_rgb(training_images),
        y=training_emotions,
        batch_size=32,
        epochs=40,
        validation_data=(tf.image.grayscale_to_rgb(test_images), test_emotions),
        callbacks=[model_checkpoint_callback])
```

```
C:\Users\Darkl\anaconda3\lib\site-packages\tensorflow\python\data\ops\dataset_ops.py:3703: UserWarning: Even though
the `tf.config.experimental_run_functions_eagerly` option is set, this option does not apply to tf.data functions. T
o force eager execution of tf.data functions, please use `tf.data.experimental.enable.debug_mode()`.
  warnings.warn(
Epoch 1/40
3983/3983 [==============================] - 264s 66ms/step - loss: 0.0243 - model_acc: 0.7277 - val_loss: 0.0165 -
val_model_acc: 0.7985
INFO:tensorflow:Assets written to: best_models\FERPlus_flip_+-25_multi_mse\assets
Epoch 2/40
```

```
3983/3983 [==============================] - 263s 66ms/step - loss: 0.0148 - model_acc: 0.8192 - val_loss: 0.0155 -
val_model_acc: 0.8143
INFO:tensorflow:Assets written to: best_models\FERPlus_flip_+-25_multi_mse\assets
Epoch 3/40
3983/3983 [==============================] - 260s 65ms/step - loss: 0.0116 - model_acc: 0.8531 - val_loss: 0.0133 -
val_model_acc: 0.8366
INFO:tensorflow:Assets written to: best_models\FERPlus_flip_+-25_multi_mse\assets
Epoch 4/40
3983/3983 [==============================] - 259s 65ms/step - loss: 0.0093 - model_acc: 0.8797 - val_loss: 0.0123 -
val_model_acc: 0.8397
INFO:tensorflow:Assets written to: best_models\FERPlus_flip_+-25_multi_mse\assets
Epoch 5/40
3983/3983 [==============================] - 258s 65ms/step - loss: 0.0077 - model_acc: 0.8982 - val_loss: 0.0123 -
val_model_acc: 0.8467
INFO:tensorflow:Assets written to: best_models\FERPlus_flip_+-25_multi_mse\assets
Epoch 6/40
3983/3983 [==============================] - 258s 65ms/step - loss: 0.0065 - model_acc: 0.9155 - val_loss: 0.0118 -
val_model_acc: 0.8467
INFO:tensorflow:Assets written to: best_models\FERPlus_flip_+-25_multi_mse\assets
Epoch 7/40
3983/3983 [==============================] - 258s 65ms/step - loss: 0.0055 - model_acc: 0.9277 - val_loss: 0.0119 -
val_model_acc: 0.8479
INFO:tensorflow:Assets written to: best_models\FERPlus_flip_+-25_multi_mse\assets
Epoch 8/40
3983/3983 [==============================] - 259s 65ms/step - loss: 0.0048 - model_acc: 0.9373 - val_loss: 0.0116 -
val_model_acc: 0.8535
INFO:tensorflow:Assets written to: best_models\FERPlus_flip_+-25_multi_mse\assets
Epoch 9/40
3983/3983 [==============================] - 261s 66ms/step - loss: 0.0042 - model_acc: 0.9446 - val_loss: 0.0116 -
val_model_acc: 0.8473
Epoch 10/40
3983/3983 [==============================] - 261s 66ms/step - loss: 0.0038 - model_acc: 0.9498 - val_loss: 0.0118 -
val_model_acc: 0.8510
Epoch 11/40
3983/3983 [==============================] - 265s 67ms/step - loss: 0.0034 - model_acc: 0.9556 - val_loss: 0.0116 -
val_model_acc: 0.8529
Epoch 12/40
3983/3983 [==============================] - 267s 67ms/step - loss: 0.0030 - model_acc: 0.9583 - val_loss: 0.0115 -
val_model_acc: 0.8572
INFO:tensorflow:Assets written to: best_models\FERPlus_flip_+-25_multi_mse\assets
Epoch 13/40
3983/3983 [==============================] - 265s 66ms/step - loss: 0.0028 - model_acc: 0.9636 - val_loss: 0.0115 -
val_model_acc: 0.8527
Epoch 14/40
3983/3983 [==============================] - 271s 68ms/step - loss: 0.0026 - model_acc: 0.9647 - val_loss: 0.0113 -
val_model_acc: 0.8561
```

```
Epoch 15/40
3983/3983 [==============================] - 267s 67ms/step - loss: 0.0023 - model_acc: 0.9685 - val_loss: 0.0118 -
val_model_acc: 0.8518
Epoch 16/40
3983/3983 [==============================] - 269s 68ms/step - loss: 0.0022 - model_acc: 0.9692 - val_loss: 0.0112 -
val_model_acc: 0.8555
Epoch 17/40
3983/3983 [==============================] - 268s 67ms/step - loss: 0.0021 - model_acc: 0.9713 - val_loss: 0.0112 -
val_model_acc: 0.8608
INFO:tensorflow:Assets written to: best_models\FERPlus_flip_+-25_multi_mse\assets
Epoch 18/40
3983/3983 [==============================] - 271s 68ms/step - loss: 0.0019 - model_acc: 0.9732 - val_loss: 0.0113 -
val_model_acc: 0.8568
Epoch 19/40
3983/3983 [==============================] - 268s 67ms/step - loss: 0.0017 - model_acc: 0.9776 - val_loss: 0.0124 -
val_model_acc: 0.8489
Epoch 20/40
3983/3983 [==============================] - 265s 67ms/step - loss: 0.0017 - model_acc: 0.9756 - val_loss: 0.0122 -
val_model_acc: 0.8515
Epoch 21/40
3983/3983 [==============================] - 261s 66ms/step - loss: 0.0017 - model_acc: 0.9765 - val_loss: 0.0114 -
val_model_acc: 0.8614
INFO:tensorflow:Assets written to: best_models\FERPlus_flip_+-25_multi_mse\assets
Epoch 22/40
3983/3983 [==============================] - 264s 66ms/step - loss: 0.0014 - model_acc: 0.9815 - val_loss: 0.0112 -
val_model_acc: 0.8600
Epoch 23/40
3983/3983 [==============================] - 262s 66ms/step - loss: 0.0013 - model_acc: 0.9827 - val_loss: 0.0115 -
val_model_acc: 0.8524
Epoch 24/40
3983/3983 [==============================] - 263s 66ms/step - loss: 0.0014 - model_acc: 0.9797 - val_loss: 0.0117 -
val_model_acc: 0.8489
Epoch 25/40
3983/3983 [==============================] - 262s 66ms/step - loss: 0.0013 - model_acc: 0.9821 - val_loss: 0.0116 -
val_model_acc: 0.8532
Epoch 26/40
3983/3983 [==============================] - 264s 66ms/step - loss: 0.0011 - model_acc: 0.9864 - val_loss: 0.0114 -
val_model_acc: 0.8591
Epoch 27/40
3983/3983 [==============================] - 264s 66ms/step - loss: 0.0010 - model_acc: 0.9861 - val_loss: 0.0112 -
val_model_acc: 0.8577
Epoch 28/40
3983/3983 [==============================] - 264s 66ms/step - loss: 0.0012 - model_acc: 0.9823 - val_loss: 0.0115 -
val_model_acc: 0.8541
Epoch 29/40
3983/3983 [==============================] - 261s 66ms/step - loss: 8.9154e-04 - model_acc: 0.9883 - val_loss: 0.011
```

```
3 - val_model_acc: 0.8578
Epoch 30/40
3983/3983 [==============================] - 264s 66ms/step - loss: 0.0011 - model_acc: 0.9843 - val_loss: 0.0115 -
val_model_acc: 0.8561
Epoch 31/40
3983/3983 [==============================] - 262s 66ms/step - loss: 8.3565e-04 - model_acc: 0.9889 - val_loss: 0.013
0 - val_model_acc: 0.8411
Epoch 32/40
3983/3983 [==============================] - 264s 66ms/step - loss: 9.8853e-04 - model_acc: 0.9860 - val_loss: 0.013
2 - val_model_acc: 0.8434
Epoch 33/40
3983/3983 [==============================] - 263s 66ms/step - loss: 7.8449e-04 - model_acc: 0.9896 - val_loss: 0.011
5 - val_model_acc: 0.8597
Epoch 34/40
3983/3983 [==============================] - 259s 65ms/step - loss: 0.0011 - model_acc: 0.9848 - val_loss: 0.0130 -
val_model_acc: 0.8417_acc: 0.9
Epoch 35/40
3983/3983 [==============================] - 258s 65ms/step - loss: 8.6350e-04 - model_acc: 0.9884 - val_loss: 0.011
8 - val_model_acc: 0.8526
Epoch 36/40
3983/3983 [==============================] - 259s 65ms/step - loss: 6.4743e-04 - model_acc: 0.9918 - val_loss: 0.011
8 - val_model_acc: 0.8574
Epoch 37/40
3983/3983 [==============================] - 265s 67ms/step - loss: 7.0790e-04 - model_acc: 0.9904 - val_loss: 0.011
4 - val_model_acc: 0.8600
Epoch 38/40
3983/3983 [==============================] - 294s 74ms/step - loss: 8.5347e-04 - model_acc: 0.9884 - val_loss: 0.011
6 - val_model_acc: 0.8532
Epoch 39/40
3983/3983 [==============================] - 270s 68ms/step - loss: 7.6045e-04 - model_acc: 0.9900 - val_loss: 0.012
7 - val_model_acc: 0.8454
Epoch 40/40
3983/3983 [==============================] - 267s 67ms/step - loss: 8.3590e-04 - model_acc: 0.9883 - val_loss: 0.014
7 - val_model_acc: 0.8298
```

In [7]:
```python
best_model_path = "best_models/FERPlus_flip_+-25_multi_mse"
best_model = tf.keras.models.load_model(best_model_path, custom_objects={'model_acc': model_acc})
best_model.summary()
```

Model: "sequential"

```
_____
Layer (type)                 Output Shape              Param #
=================================================================
vgg16 (Functional)           (None, 1, 1, 512)         14714688
_____
```

```
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: 33,630,024
Trainable params: 33,630,024
Non-trainable params: 0
_____
```

In [ ]: