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"
```

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]:

```
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]:

```
images_expw = 0.299*images_expw[:, :, :, 0] + 0.587*images_expw[:, :, :, 1] + 0.114*images_expw[:, :, :, 2]
np.shape(images_expw)
```

Out[4]:

```
(291648, 48, 48)
```

In [5]:

```
images_expw = np.stack([images_expw,images_expw,images_expw], axis=3)
np.shape(images_expw)
```

Out[5]:

```
(291648, 48, 48, 3)
```

In [6]:

```
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)
```

In [7]:

```
print(images.shape)
print(emotions.shape)
print(images_expw.shape)
print(emotions_expw.shape)
```

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

In [8]:

```
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()
```

In [9]:

```
training_size = training_samples + validation_samples
print(images[:training_size].shape)
print(emotions[:training_size].shape)
print(images[training_size:].shape)
print(emotions[training_size:].shape)
```

```
(31858, 48, 48, 3)
(31858, 8)
(3535, 48, 48, 3)
(3535, 8)
```

In [10]:

```
base_model = vgg16.VGG16(include_top=False,
                             weights=None,
                             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])
model.fit(x=images_expw,
          y=emotions_expw,
          batch_size=32,
          epochs=40)
```

```
C:\Users\Darkl\anaconda3\lib\site-packages\tensorflow\python\data\ops\dataset_ops.py:3703: UserWarning: Even though the `tf.confi
g.experimental_run_functions_eagerly` option is set, this option does not apply to tf.data functions. To force eager execution of
tf.data functions, please use `tf.data.experimental.enable.debug_mode()`.
  warnings.warn(
Epoch 1/40
```

```
9114/9114 [==============================] - 599s 65ms/step - loss: 0.0624 - model_acc: 0.6298
Epoch 2/40
9114/9114 [==============================] - 586s 64ms/step - loss: 0.0546 - model_acc: 0.6816
Epoch 3/40
9114/9114 [==============================] - 583s 64ms/step - loss: 0.0509 - model_acc: 0.7055
Epoch 4/40
9114/9114 [==============================] - 579s 64ms/step - loss: 0.0484 - model_acc: 0.7239
Epoch 5/40
9114/9114 [==============================] - 585s 64ms/step - loss: 0.0460 - model_acc: 0.7392
Epoch 6/40
9114/9114 [==============================] - 583s 64ms/step - loss: 0.0437 - model_acc: 0.7546
Epoch 7/40
9114/9114 [==============================] - 581s 64ms/step - loss: 0.0412 - model_acc: 0.7720
Epoch 8/40
9114/9114 [==============================] - 590s 65ms/step - loss: 0.0384 - model_acc: 0.7906
Epoch 9/40
9114/9114 [==============================] - 584s 64ms/step - loss: 0.0355 - model_acc: 0.8092
Epoch 10/40
9114/9114 [==============================] - 580s 64ms/step - loss: 0.0328 - model_acc: 0.8256
Epoch 11/40
9114/9114 [==============================] - 583s 64ms/step - loss: 0.0302 - model_acc: 0.8407
Epoch 12/40
9114/9114 [==============================] - 581s 64ms/step - loss: 0.0279 - model_acc: 0.8540
Epoch 13/40
9114/9114 [==============================] - 581s 64ms/step - loss: 0.0260 - model_acc: 0.8648
Epoch 14/40
9114/9114 [==============================] - 582s 64ms/step - loss: 0.0243 - model_acc: 0.8738
Epoch 15/40
9114/9114 [==============================] - 581s 64ms/step - loss: 0.0227 - model_acc: 0.8826
Epoch 16/40
9114/9114 [==============================] - 579s 63ms/step - loss: 0.0215 - model_acc: 0.8891
Epoch 17/40
9114/9114 [==============================] - 582s 64ms/step - loss: 0.0202 - model_acc: 0.8960
Epoch 18/40
9114/9114 [==============================] - 585s 64ms/step - loss: 0.0193 - model_acc: 0.90100s - loss: 0.0193 - mo
Epoch 19/40
9114/9114 [==============================] - 583s 64ms/step - loss: 0.0183 - model_acc: 0.9060
Epoch 20/40
9114/9114 [==============================] - 582s 64ms/step - loss: 0.0176 - model_acc: 0.9101
Epoch 21/40
9114/9114 [==============================] - 583s 64ms/step - loss: 0.0168 - model_acc: 0.9143
Epoch 22/40
9114/9114 [==============================] - 580s 64ms/step - loss: 0.0160 - model_acc: 0.9179
Epoch 23/40
```

```
9114/9114 [==============================] - 578s 63ms/step - loss: 0.0154 - model_acc: 0.9217
Epoch 24/40
9114/9114 [==============================] - 581s 64ms/step - loss: 0.0148 - model_acc: 0.9247
Epoch 25/40
9114/9114 [==============================] - 585s 64ms/step - loss: 0.0142 - model_acc: 0.9279
Epoch 26/40
9114/9114 [==============================] - 578s 63ms/step - loss: 0.0136 - model_acc: 0.9309
Epoch 27/40
9114/9114 [==============================] - 584s 64ms/step - loss: 0.0131 - model_acc: 0.9334
Epoch 28/40
9114/9114 [==============================] - 582s 64ms/step - loss: 0.0127 - model_acc: 0.9354
Epoch 29/40
9114/9114 [==============================] - 578s 63ms/step - loss: 0.0123 - model_acc: 0.9379
Epoch 30/40
9114/9114 [==============================] - 581s 64ms/step - loss: 0.0118 - model_acc: 0.9405
Epoch 31/40
9114/9114 [==============================] - 580s 64ms/step - loss: 0.0115 - model_acc: 0.9425
Epoch 32/40
9114/9114 [==============================] - 578s 63ms/step - loss: 0.0111 - model_acc: 0.9442
Epoch 33/40
9114/9114 [==============================] - 582s 64ms/step - loss: 0.0108 - model_acc: 0.9458
Epoch 34/40
9114/9114 [==============================] - 583s 64ms/step - loss: 0.0105 - model_acc: 0.9473
Epoch 35/40
9114/9114 [==============================] - 578s 63ms/step - loss: 0.0102 - model_acc: 0.9489
Epoch 36/40
9114/9114 [==============================] - 582s 64ms/step - loss: 0.0099 - model_acc: 0.9508
Epoch 37/40
9114/9114 [==============================] - 581s 64ms/step - loss: 0.0096 - model_acc: 0.9524
Epoch 38/40
9114/9114 [==============================] - 578s 63ms/step - loss: 0.0094 - model_acc: 0.9536
Epoch 39/40
9114/9114 [==============================] - 579s 64ms/step - loss: 0.0092 - model_acc: 0.9542
Epoch 40/40
9114/9114 [==============================] - 583s 64ms/step - loss: 0.0090 - model_acc: 0.9558
```

Out[10]:

```
<tensorflow.python.keras.callbacks.History at 0x181008a0a00>
```

In [11]:

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

model.fit(x=images[:training_samples],
          y=emotions[:training_samples],
          batch_size=32,
          epochs=10,
          validation_data=(images[training_samples:], emotions[training_samples:]))
```

```
Epoch 1/10
885/885 [==============================] - 65s 73ms/step - loss: 0.0299 - model_acc: 0.6760 - val_loss: 0.0259 - val_model_acc: 0.
7199
Epoch 2/10
885/885 [==============================] - 64s 72ms/step - loss: 0.0220 - model_acc: 0.7475 - val_loss: 0.0255 - val_model_acc: 0.
7216
Epoch 3/10
885/885 [==============================] - 64s 72ms/step - loss: 0.0184 - model_acc: 0.7870 - val_loss: 0.0232 - val_model_acc: 0.
7421
Epoch 4/10
885/885 [==============================] - 64s 72ms/step - loss: 0.0152 - model_acc: 0.8151 - val_loss: 0.0209 - val_model_acc: 0.
7624
Epoch 5/10
885/885 [==============================] - 64s 72ms/step - loss: 0.0133 - model_acc: 0.8395 - val_loss: 0.0206 - val_model_acc: 0.
7720
Epoch 6/10
885/885 [==============================] - 64s 72ms/step - loss: 0.0113 - model_acc: 0.8627 - val_loss: 0.0224 - val_model_acc: 0.
7532
Epoch 7/10
885/885 [==============================] - 64s 73ms/step - loss: 0.0093 - model_acc: 0.8874 - val_loss: 0.0196 - val_model_acc: 0.
7786
Epoch 8/10
885/885 [==============================] - 66s 74ms/step - loss: 0.0084 - model_acc: 0.8976 - val_loss: 0.0195 - val_model_acc: 0.
7808
Epoch 9/10
885/885 [==============================] - 66s 75ms/step - loss: 0.0071 - model_acc: 0.9133 - val_loss: 0.0193 - val_model_acc: 0.
7869
Epoch 10/10
885/885 [==============================] - 63s 72ms/step - loss: 0.0066 - model_acc: 0.9182 - val_loss: 0.0200 - val_model_acc: 0.
7717
```

Out[11]:

```
<tensorflow.python.keras.callbacks.History at 0x180df0f3190>
```

In [12]:

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

model.fit(x=images[:training_samples],
          y=emotions[:training_samples],
          batch_size=32,
          epochs=30,
          validation_data=(images[training_samples:], emotions[training_samples:]))
```

```
Epoch 1/30
885/885 [==============================] - 64s 72ms/step - loss: 0.0048 - model_acc: 0.9407 - val_loss: 0.0170 - val_model_acc: 0.
8011
Epoch 2/30
885/885 [==============================] - 64s 72ms/step - loss: 0.0035 - model_acc: 0.9637 - val_loss: 0.0168 - val_model_acc: 0.
8070
Epoch 3/30
885/885 [==============================] - 64s 72ms/step - loss: 0.0029 - model_acc: 0.9743 - val_loss: 0.0167 - val_model_acc: 0.
8055
Epoch 4/30
885/885 [==============================] - 64s 72ms/step - loss: 0.0024 - model_acc: 0.9816 - val_loss: 0.0168 - val_model_acc: 0.
8069
Epoch 5/30
885/885 [==============================] - 64s 72ms/step - loss: 0.0021 - model_acc: 0.9867 - val_loss: 0.0168 - val_model_acc: 0.
8063
Epoch 6/30
885/885 [==============================] - 64s 72ms/step - loss: 0.0018 - model_acc: 0.9899 - val_loss: 0.0169 - val_model_acc: 0.
8039
Epoch 7/30
885/885 [==============================] - 63s 72ms/step - loss: 0.0016 - model_acc: 0.9913 - val_loss: 0.0168 - val_model_acc: 0.
8022
Epoch 8/30
885/885 [==============================] - 64s 72ms/step - loss: 0.0015 - model_acc: 0.9925 - val_loss: 0.0168 - val_model_acc: 0.
8057
Epoch 9/30
885/885 [==============================] - 65s 74ms/step - loss: 0.0013 - model_acc: 0.9936 - val_loss: 0.0169 - val_model_acc: 0.
8067
Epoch 10/30
885/885 [==============================] - 67s 76ms/step - loss: 0.0012 - model_acc: 0.9937 - val_loss: 0.0168 - val_model_acc: 0.
8066
Epoch 11/30
885/885 [==============================] - 64s 73ms/step - loss: 0.0011 - model_acc: 0.9946 - val_loss: 0.0168 - val_model_acc: 0.
8032
Epoch 12/30
885/885 [==============================] - 64s 72ms/step - loss: 0.0011 - model_acc: 0.9948 - val_loss: 0.0169 - val_model_acc: 0.
8073
Epoch 13/30
885/885 [==============================] - 64s 72ms/step - loss: 9.9289e-04 - model_acc: 0.9957 - val_loss: 0.0168 - val_model_ac
```

```
c: 0.8060
Epoch 14/30
885/885 [==============================] - 64s 72ms/step - loss: 9.2558e-04 - model_acc: 0.9957 - val_loss: 0.0169 - val_model_ac
c: 0.8069
Epoch 15/30
885/885 [==============================] - 64s 73ms/step - loss: 8.6760e-04 - model_acc: 0.9964 - val_loss: 0.0168 - val_model_ac
c: 0.8083
Epoch 16/30
885/885 [==============================] - 64s 72ms/step - loss: 8.2051e-04 - model_acc: 0.9961 - val_loss: 0.0168 - val_model_ac
c: 0.8083
Epoch 17/30
885/885 [==============================] - 64s 72ms/step - loss: 7.7872e-04 - model_acc: 0.9960 - val_loss: 0.0169 - val_model_ac
c: 0.8063
Epoch 18/30
885/885 [==============================] - 63s 72ms/step - loss: 7.3991e-04 - model_acc: 0.9965 - val_loss: 0.0168 - val_model_ac
c: 0.8093
Epoch 19/30
885/885 [==============================] - 64s 73ms/step - loss: 6.9579e-04 - model_acc: 0.9969 - val_loss: 0.0168 - val_model_ac
c: 0.8064
Epoch 20/30
885/885 [==============================] - 65s 74ms/step - loss: 6.5936e-04 - model_acc: 0.9972 - val_loss: 0.0168 - val_model_ac
c: 0.8076
Epoch 21/30
885/885 [==============================] - 67s 75ms/step - loss: 6.2729e-04 - model_acc: 0.9969 - val_loss: 0.0168 - val_model_ac
c: 0.8088
Epoch 22/30
885/885 [==============================] - 64s 72ms/step - loss: 6.0373e-04 - model_acc: 0.9972 - val_loss: 0.0168 - val_model_ac
c: 0.8094
Epoch 23/30
885/885 [==============================] - 64s 72ms/step - loss: 5.7610e-04 - model_acc: 0.9971 - val_loss: 0.0168 - val_model_ac
c: 0.8066
Epoch 24/30
885/885 [==============================] - 64s 72ms/step - loss: 5.4445e-04 - model_acc: 0.9976 - val_loss: 0.0167 - val_model_ac
c: 0.8088
Epoch 25/30
885/885 [==============================] - 64s 72ms/step - loss: 5.2591e-04 - model_acc: 0.9976 - val_loss: 0.0167 - val_model_ac
c: 0.8095
Epoch 26/30
885/885 [==============================] - 64s 72ms/step - loss: 5.1084e-04 - model_acc: 0.9975 - val_loss: 0.0168 - val_model_ac
c: 0.8107
Epoch 27/30
885/885 [==============================] - 64s 73ms/step - loss: 4.8741e-04 - model_acc: 0.9979 - val_loss: 0.0168 - val_model_ac
c: 0.8107
Epoch 28/30
```

```
885/885 [==============================] - 64s 72ms/step - loss: 4.6409e-04 - model_acc: 0.9977 - val_loss: 0.0168 - val_model_ac
c: 0.8097
Epoch 29/30
885/885 [==============================] - 64s 72ms/step - loss: 4.4750e-04 - model_acc: 0.9976 - val_loss: 0.0167 - val_model_ac
c: 0.8132
Epoch 30/30
885/885 [==============================] - 63s 72ms/step - loss: 4.3360e-04 - model_acc: 0.9978 - val_loss: 0.0168 - val_model_ac
c: 0.8095
```

Out[12]:

```
<tensorflow.python.keras.callbacks.History at 0x181009a8b80>
```

In [13]:

```python
# data augmentation: mirror and rotate +-25 degree (use read_dataset3, dataset3)
# 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)
```