In [1]:

```
import tensorflow as tf
import numpy as np
import matplotlib.pyplot as plt
import os
import pickle
import gc
from tensorflow.python.keras import layers, Sequential,losses, metrics, optimizers,
from tensorflow.python.keras.models import Model
from tensorflow.python.keras.applications import vgg16
from tensorflow.python.keras.optimizer_v2 import adam
```

In [2]:

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

In [3]:

```
image_path = "./dataset/images.npy"
emotion_path = "./dataset/emotions_multi.npy"

images = np.load(image_path)
images = tf.convert_to_tensor(images)
images = layers.Rescaling(1./127.5, offset=-1)(images)
images = tf.image.grayscale_to_rgb(images)

emotions = np.load(emotion_path)
emotions = tf.convert_to_tensor(emotions)

training_samples = 28317
validation_samples = 3541
training_size = training_samples + validation_samples

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

In [4]:

```
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 [5]:

```
def train(model, learning_rate, loss, num_epochs, batch_size):
    model.compile(optimizer=adam.Adam(learning_rate=learning_rate),
                  loss=loss,
                  metrics = [model_acc])
    history = model.fit(x=training_images,
                        y=training_emotions,
                        batch_size=batch_size,
                        epochs=num_epochs,
                        validation_data=(test_images, test_emotions))
```

```
    del model
    gc.collect()
    return history
```

In [6]:

```
from tensorflow.keras.initializers import RandomNormal, Constant
def create_model(base_model):
    base_model.trainable=True
    return Sequential([
        base_model,
        layers.GlobalAveragePooling2D(),
        layers.Dense(4096, activation='relu'),
        layers.BatchNormalization(
            momentum=0.9,
            epsilon=0.01,
            beta_initializer=RandomNormal(mean=0.0, stddev=0.05),
            gamma_initializer=Constant(value=0.9)

        ),
        layers.Dense(4096, activation='relu'),
        layers.BatchNormalization(
            momentum=0.9,
            epsilon=0.01,
            beta_initializer=RandomNormal(mean=0.0, stddev=0.05),
            gamma_initializer=Constant(value=0.9)
        ),
        layers.Dense(emotions_count, activation='softmax'),
    ])
```

In [7]:

```
if not os.path.isdir('./results/'):
    os.mkdir('./results/')

learning_rate = 5e-5
num_epochs = 80
batch_size = 32
loss = losses.MeanSquaredError()

for i in range(0,1,1):
    base_model = vgg16.VGG16(include_top=False, weights='imagenet', input_shape=(48,
    history_save_path = './history/BN_4.txt'
    model = create_model(base_model)
    history = train(model, learning_rate, loss, num_epochs, batch_size)
    with open(history_save_path, 'wb') as file_pi:
        pickle.dump(history.history, file_pi)
```

```
C:\Users\Darkl\anaconda3\lib\site-packages\tensorflow\python\data\ops\dataset_ops.p
y:3703: UserWarning: Even though the `tf.config.experimental_run_functions_eagerly`
option is set, this option does not apply to tf.data functions. To force eager execu
tion of tf.data functions, please use `tf.data.experimental.enable.debug_mode()`.
  warnings.warn(
Epoch 1/80
996/996 [==============================] - 80s 76ms/step - loss: 0.0357 - model_acc:
0.6468 - val_loss: 0.0351 - val_model_acc: 0.6675
Epoch 2/80
996/996 [==============================] - 74s 75ms/step - loss: 0.0225 - model_acc:
0.7486 - val_loss: 0.0251 - val_model_acc: 0.7335
Epoch 3/80
996/996 [==============================] - 74s 75ms/step - loss: 0.0184 - model_acc:
0.7885 - val_loss: 0.0194 - val_model_acc: 0.7742
Epoch 4/80
996/996 [==============================] - 74s 74ms/step - loss: 0.0154 - model_acc:
0.8180 - val_loss: 0.0180 - val_model_acc: 0.7872
```

```
Epoch 5/80
996/996 [==============================] - 72s 72ms/step - loss: 0.0132 - model_acc:
0.8373 - val_loss: 0.0276 - val_model_acc: 0.7113
Epoch 6/80
996/996 [==============================] - 71s 71ms/step - loss: 0.0113 - model_acc:
0.8622 - val_loss: 0.0170 - val_model_acc: 0.8025
Epoch 7/80
996/996 [==============================] - 71s 71ms/step - loss: 0.0095 - model_acc:
0.8834 - val_loss: 0.0196 - val_model_acc: 0.7779
Epoch 8/80
996/996 [==============================] - 73s 73ms/step - loss: 0.0083 - model_acc:
0.8993 - val_loss: 0.0145 - val_model_acc: 0.8220
Epoch 9/80
996/996 [==============================] - 73s 73ms/step - loss: 0.0074 - model_acc:
0.9106 - val_loss: 0.0153 - val_model_acc: 0.8135
Epoch 10/80
996/996 [==============================] - 73s 73ms/step - loss: 0.0065 - model_acc:
0.9200 - val_loss: 0.0159 - val_model_acc: 0.8098
Epoch 11/80
996/996 [==============================] - 72s 73ms/step - loss: 0.0059 - model_acc:
0.9246 - val_loss: 0.0147 - val_model_acc: 0.8281
Epoch 12/80
996/996 [==============================] - 72s 73ms/step - loss: 0.0054 - model_acc:
0.9336 - val_loss: 0.0150 - val_model_acc: 0.8200
Epoch 13/80
996/996 [==============================] - 72s 72ms/step - loss: 0.0050 - model_acc:
0.9372 - val_loss: 0.0143 - val_model_acc: 0.8284
Epoch 14/80
996/996 [==============================] - 72s 72ms/step - loss: 0.0046 - model_acc:
0.9411 - val_loss: 0.0155 - val_model_acc: 0.8144
Epoch 15/80
996/996 [==============================] - 71s 71ms/step - loss: 0.0042 - model_acc:
0.9437 - val_loss: 0.0140 - val_model_acc: 0.8380
Epoch 16/80
996/996 [==============================] - 71s 71ms/step - loss: 0.0040 - model_acc:
0.9485 - val_loss: 0.0135 - val_model_acc: 0.8431
Epoch 17/80
996/996 [==============================] - 72s 73ms/step - loss: 0.0038 - model_acc:
0.9486 - val_loss: 0.0135 - val_model_acc: 0.8358
Epoch 18/80
996/996 [==============================] - 73s 73ms/step - loss: 0.0035 - model_acc:
0.9501 - val_loss: 0.0136 - val_model_acc: 0.8380
Epoch 19/80
996/996 [==============================] - 73s 73ms/step - loss: 0.0033 - model_acc:
0.9531 - val_loss: 0.0134 - val_model_acc: 0.8347
Epoch 20/80
996/996 [==============================] - 72s 73ms/step - loss: 0.0031 - model_acc:
0.9571 - val_loss: 0.0131 - val_model_acc: 0.8425
Epoch 21/80
996/996 [==============================] - 72s 73ms/step - loss: 0.0030 - model_acc:
0.9559 - val_loss: 0.0131 - val_model_acc: 0.8380
Epoch 22/80
996/996 [==============================] - 72s 73ms/step - loss: 0.0027 - model_acc:
0.9587 - val_loss: 0.0131 - val_model_acc: 0.8377
Epoch 23/80
996/996 [==============================] - 72s 72ms/step - loss: 0.0026 - model_acc:
0.9600 - val_loss: 0.0128 - val_model_acc: 0.8392
Epoch 24/80
996/996 [==============================] - 71s 71ms/step - loss: 0.0024 - model_acc:
0.9641 - val_loss: 0.0129 - val_model_acc: 0.8349
Epoch 25/80
996/996 [==============================] - 71s 71ms/step - loss: 0.0024 - model_acc:
0.9625 - val_loss: 0.0128 - val_model_acc: 0.8422
Epoch 26/80
```

```
996/996 [==============================] - 72s 72ms/step - loss: 0.0023 - model_acc:
0.9619 - val_loss: 0.0127 - val_model_acc: 0.8397
Epoch 27/80
996/996 [==============================] - 73s 73ms/step - loss: 0.0021 - model_acc:
0.9663 - val_loss: 0.0126 - val_model_acc: 0.8405
Epoch 28/80
996/996 [==============================] - 73s 73ms/step - loss: 0.0021 - model_acc:
0.9644 - val_loss: 0.0127 - val_model_acc: 0.8413
Epoch 29/80
996/996 [==============================] - 72s 73ms/step - loss: 0.0020 - model_acc:
0.9688 - val_loss: 0.0126 - val_model_acc: 0.8371
Epoch 30/80
996/996 [==============================] - 72s 73ms/step - loss: 0.0019 - model_acc:
0.9668 - val_loss: 0.0130 - val_model_acc: 0.8371
Epoch 31/80
996/996 [==============================] - 72s 73ms/step - loss: 0.0018 - model_acc:
0.9692 - val_loss: 0.0125 - val_model_acc: 0.8402
Epoch 32/80
996/996 [==============================] - 72s 73ms/step - loss: 0.0018 - model_acc:
0.9702 - val_loss: 0.0127 - val_model_acc: 0.8343
Epoch 33/80
996/996 [==============================] - 71s 72ms/step - loss: 0.0018 - model_acc:
0.9682 - val_loss: 0.0126 - val_model_acc: 0.8425
Epoch 34/80
996/996 [==============================] - 71s 71ms/step - loss: 0.0017 - model_acc:
0.9706 - val_loss: 0.0128 - val_model_acc: 0.8442
Epoch 35/80
996/996 [==============================] - 71s 72ms/step - loss: 0.0016 - model_acc:
0.9718 - val_loss: 0.0125 - val_model_acc: 0.8481
Epoch 36/80
996/996 [==============================] - 73s 73ms/step - loss: 0.0016 - model_acc:
0.9723 - val_loss: 0.0124 - val_model_acc: 0.8470
Epoch 37/80
996/996 [==============================] - 73s 73ms/step - loss: 0.0015 - model_acc:
0.9735 - val_loss: 0.0126 - val_model_acc: 0.8417
Epoch 38/80
996/996 [==============================] - 73s 73ms/step - loss: 0.0015 - model_acc:
0.9724 - val_loss: 0.0125 - val_model_acc: 0.8419
Epoch 39/80
996/996 [==============================] - 72s 73ms/step - loss: 0.0014 - model_acc:
0.9746 - val_loss: 0.0125 - val_model_acc: 0.8419
Epoch 40/80
996/996 [==============================] - 72s 72ms/step - loss: 0.0014 - model_acc:
0.9738 - val_loss: 0.0124 - val_model_acc: 0.8397
Epoch 41/80
996/996 [==============================] - 72s 72ms/step - loss: 0.0013 - model_acc:
0.9760 - val_loss: 0.0124 - val_model_acc: 0.8419
Epoch 42/80
996/996 [==============================] - 71s 72ms/step - loss: 0.0013 - model_acc:
0.9748 - val_loss: 0.0126 - val_model_acc: 0.8389
Epoch 43/80
996/996 [==============================] - 71s 71ms/step - loss: 0.0013 - model_acc:
0.9756 - val_loss: 0.0124 - val_model_acc: 0.8450
Epoch 44/80
996/996 [==============================] - 71s 71ms/step - loss: 0.0012 - model_acc:
0.9770 - val_loss: 0.0125 - val_model_acc: 0.8399
Epoch 45/80
996/996 [==============================] - 73s 73ms/step - loss: 0.0012 - model_acc:
0.9772 - val_loss: 0.0124 - val_model_acc: 0.8484
Epoch 46/80
996/996 [==============================] - 73s 73ms/step - loss: 0.0012 - model_acc:
0.9782 - val_loss: 0.0124 - val_model_acc: 0.8397
Epoch 47/80
996/996 [==============================] - 73s 73ms/step - loss: 0.0012 - model_acc:
```

```
0.9773 - val_loss: 0.0124 - val_model_acc: 0.8444
Epoch 48/80
996/996 [==============================] - 72s 73ms/step - loss: 0.0011 - model_acc:
0.9773 - val_loss: 0.0125 - val_model_acc: 0.8422
Epoch 49/80
996/996 [==============================] - 72s 73ms/step - loss: 0.0011 - model_acc:
0.9788 - val_loss: 0.0125 - val_model_acc: 0.8461
Epoch 50/80
996/996 [==============================] - 72s 72ms/step - loss: 0.0011 - model_acc:
0.9781 - val_loss: 0.0126 - val_model_acc: 0.8467
Epoch 51/80
996/996 [==============================] - 72s 72ms/step - loss: 0.0010 - model_acc:
0.9792 - val_loss: 0.0127 - val_model_acc: 0.8442
Epoch 52/80
996/996 [==============================] - 71s 71ms/step - loss: 0.0010 - model_acc:
0.9804 - val_loss: 0.0124 - val_model_acc: 0.8470
Epoch 53/80
996/996 [==============================] - 71s 71ms/step - loss: 9.7398e-04 - model_
acc: 0.9818 - val_loss: 0.0123 - val_model_acc: 0.8453
Epoch 54/80
996/996 [==============================] - 72s 72ms/step - loss: 9.1498e-04 - model_
acc: 0.9814 - val_loss: 0.0125 - val_model_acc: 0.8456
Epoch 55/80
996/996 [==============================] - 73s 73ms/step - loss: 9.4049e-04 - model_
acc: 0.9809 - val_loss: 0.0125 - val_model_acc: 0.8405
Epoch 56/80
996/996 [==============================] - 73s 73ms/step - loss: 0.0010 - model_acc:
0.9795 - val_loss: 0.0123 - val_model_acc: 0.8492
Epoch 57/80
996/996 [==============================] - 72s 73ms/step - loss: 8.7881e-04 - model_
acc: 0.9818 - val_loss: 0.0124 - val_model_acc: 0.8405
Epoch 58/80
996/996 [==============================] - 72s 73ms/step - loss: 8.3142e-04 - model_
acc: 0.9840 - val_loss: 0.0124 - val_model_acc: 0.8504
Epoch 59/80
996/996 [==============================] - 72s 73ms/step - loss: 8.5819e-04 - model_
acc: 0.9820 - val_loss: 0.0124 - val_model_acc: 0.8453
Epoch 60/80
996/996 [==============================] - 72s 72ms/step - loss: 8.4392e-04 - model_
acc: 0.9822 - val_loss: 0.0124 - val_model_acc: 0.8405
Epoch 61/80
996/996 [==============================] - 71s 71ms/step - loss: 8.4237e-04 - model_
acc: 0.9826 - val_loss: 0.0126 - val_model_acc: 0.8438
Epoch 62/80
996/996 [==============================] - 71s 71ms/step - loss: 8.1799e-04 - model_
acc: 0.9818 - val_loss: 0.0124 - val_model_acc: 0.8434
Epoch 63/80
996/996 [==============================] - 72s 72ms/step - loss: 8.4567e-04 - model_
acc: 0.9818 - val_loss: 0.0125 - val_model_acc: 0.8397
Epoch 64/80
996/996 [==============================] - 73s 73ms/step - loss: 8.1530e-04 - model_
acc: 0.9837 - val_loss: 0.0126 - val_model_acc: 0.8447
Epoch 65/80
996/996 [==============================] - 73s 73ms/step - loss: 8.0465e-04 - model_
acc: 0.9828 - val_loss: 0.0124 - val_model_acc: 0.8479
Epoch 66/80
996/996 [==============================] - 73s 73ms/step - loss: 7.4417e-04 - model_
acc: 0.9848 - val_loss: 0.0122 - val_model_acc: 0.8442
Epoch 67/80
996/996 [==============================] - 72s 73ms/step - loss: 7.4762e-04 - model_
acc: 0.9843 - val_loss: 0.0121 - val_model_acc: 0.8475
Epoch 68/80
996/996 [==============================] - 72s 72ms/step - loss: 7.2010e-04 - model_
acc: 0.9860 - val_loss: 0.0123 - val_model_acc: 0.8487
```

```
Epoch 69/80
996/996 [==============================] - 72s 72ms/step - loss: 7.5227e-04 - model_
acc: 0.9847 - val_loss: 0.0125 - val_model_acc: 0.8470
Epoch 70/80
996/996 [==============================] - 71s 71ms/step - loss: 7.1343e-04 - model_
acc: 0.9853 - val_loss: 0.0122 - val_model_acc: 0.8459
Epoch 71/80
996/996 [==============================] - 71s 71ms/step - loss: 6.9936e-04 - model_
acc: 0.9844 - val_loss: 0.0122 - val_model_acc: 0.8493
Epoch 72/80
996/996 [==============================] - 71s 71ms/step - loss: 7.1146e-04 - model_
acc: 0.9842 - val_loss: 0.0124 - val_model_acc: 0.8405
Epoch 73/80
996/996 [==============================] - 73s 73ms/step - loss: 6.8772e-04 - model_
acc: 0.9852 - val_loss: 0.0122 - val_model_acc: 0.8447
Epoch 74/80
996/996 [==============================] - 73s 73ms/step - loss: 6.6843e-04 - model_
acc: 0.9857 - val_loss: 0.0120 - val_model_acc: 0.8498
Epoch 75/80
996/996 [==============================] - 73s 73ms/step - loss: 7.1868e-04 - model_
acc: 0.9838 - val_loss: 0.0122 - val_model_acc: 0.8487
Epoch 76/80
996/996 [==============================] - 72s 73ms/step - loss: 6.8046e-04 - model_
acc: 0.9853 - val_loss: 0.0122 - val_model_acc: 0.8470
Epoch 77/80
996/996 [==============================] - 72s 73ms/step - loss: 6.1120e-04 - model_
acc: 0.9864 - val_loss: 0.0129 - val_model_acc: 0.8430
Epoch 78/80
996/996 [==============================] - 72s 72ms/step - loss: 6.2511e-04 - model_
acc: 0.9873 - val_loss: 0.0124 - val_model_acc: 0.8444
Epoch 79/80
996/996 [==============================] - 72s 72ms/step - loss: 6.3227e-04 - model_
acc: 0.9856 - val_loss: 0.0125 - val_model_acc: 0.8407
Epoch 80/80
996/996 [==============================] - 71s 71ms/step - loss: 6.3250e-04 - model_
acc: 0.9873 - val_loss: 0.0121 - val_model_acc: 0.8478
```

In [ ]: