In [1]:
```
# 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)
```

```
2021-12-27 14:01:46.114734: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library li
bcudart.so.11.0
(130967, 48, 48, 1)
(130967, 8)
(130967, 8)
```

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

```
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)
```

```
2021-12-27 14:01:50.492698: I tensorflow/compiler/jit/xla_cpu_device.cc:41] Not creating XLA devices, tf_xla_enable_xla_devices no
t set
2021-12-27 14:01:50.494582: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library li
bcuda.so.1
2021-12-27 14:01:50.533575: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:941] successful NUMA node read from SysFS had n
egative value (-1), but there must be at least one NUMA node, so returning NUMA node zero
2021-12-27 14:01:50.534265: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1720] Found device 0 with properties:
pciBusID: 0000:05:00.0 name: GeForce RTX 2080 Ti computeCapability: 7.5
coreClock: 1.545GHz coreCount: 68 deviceMemorySize: 10.76GiB deviceMemoryBandwidth: 573.69GiB/s
2021-12-27 14:01:50.534307: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library li
bcudart.so.11.0
2021-12-27 14:01:50.540093: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library li
bcublas.so.11
2021-12-27 14:01:50.540182: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library li
bcublasLt.so.11
```

```
egative value (-1), but there must be at least one NUMA node, so returning NUMA node zero
2021-12-27 14:01:50.557946: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1862] Adding visible gpu devices: 0
2021-12-27 14:01:50.558026: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library li
bcudart.so.11.0
2021-12-27 14:01:51.415228: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1261] Device interconnect StreamExecutor with stren
gth 1 edge matrix:
2021-12-27 14:01:51.415269: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1267]      0
2021-12-27 14:01:51.415277: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1280] 0:   N
2021-12-27 14:01:51.415508: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:941] successful NUMA node read from SysFS had n
egative value (-1), but there must be at least one NUMA node, so returning NUMA node zero
2021-12-27 14:01:51.416000: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:941] successful NUMA node read from SysFS had n
egative value (-1), but there must be at least one NUMA node, so returning NUMA node zero
2021-12-27 14:01:51.416433: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:941] successful NUMA node read from SysFS had n
egative value (-1), but there must be at least one NUMA node, so returning NUMA node zero
2021-12-27 14:01:51.416880: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1406] Created TensorFlow device (/job:localhost/rep
lica:0/task:0/device:GPU:0 with 10071 MB memory) -> physical GPU (device: 0, name: GeForce RTX 2080 Ti, pci bus id: 0000:05:00.0,
compute capability: 7.5)
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]:

```
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

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.Dropout(0.5),
        layers.Dense(4096, activation='relu'),
        layers.Dropout(0.5),
        layers.Dense(emotions_count, activation='softmax'),])
    return model

model = create_model()
```

In [5]:

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

model.fit(x=tf.image.grayscale_to_rgb(training_images),
          y=training_emotions,
          batch_size=32,
          epochs=60,
          validation_data=(tf.image.grayscale_to_rgb(test_images), test_emotions))
```

```
/userhome/cs/fym666/anaconda3/envs/tensorflow/lib/python3.8/site-packages/tensorflow/python/data/ops/dataset_ops.py:3503: UserWarn
ing: Even though the tf.config.experimental_run_functions_eagerly option is set, this option does not apply to tf.data functions.
tf.data functions are still traced and executed as graphs.
  warnings.warn(
2021-12-27 14:01:53.754027: W tensorflow/core/framework/cpu_allocator_impl.cc:80] Allocation of 3523239936 exceeds 10% of free sys
tem memory.
2021-12-27 14:01:56.471154: I tensorflow/compiler/mlir/mlir_graph_optimization_pass.cc:116] None of the MLIR optimization passes a
re enabled (registered 2)
2021-12-27 14:01:56.471922: I tensorflow/core/platform/profile_utils/cpu_utils.cc:112] CPU Frequency: 2199995000 Hz
2021-12-27 14:01:56.504933: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library li
bcudnn.so.8
Epoch 1/60
2021-12-27 14:01:58.917176: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library li
bcublas.so.11
2021-12-27 14:01:59.552443: I tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully opened dynamic library li
bcublasLt.so.11
3983/3983 [==============================] - 336s 83ms/step - loss: 0.0317 - model_acc: 0.6589 - val_loss: 0.0179 - val_model_acc:
0.7856
Epoch 2/60
3983/3983 [==============================] - 335s 84ms/step - loss: 0.0158 - model_acc: 0.8081 - val_loss: 0.0147 - val_model_acc:
0.8111
Epoch 3/60
3983/3983 [==============================] - 326s 82ms/step - loss: 0.0120 - model_acc: 0.8500 - val_loss: 0.0132 - val_model_acc:
0.8337
Epoch 4/60
3983/3983 [==============================] - 325s 82ms/step - loss: 0.0094 - model_acc: 0.8782 - val_loss: 0.0131 - val_model_acc:
0.8363
Epoch 5/60
3983/3983 [==============================] - 328s 82ms/step - loss: 0.0076 - model_acc: 0.9017 - val_loss: 0.0121 - val_model_acc:
0.8434
Epoch 6/60
```

```
3983/3983 [==============================] - 328s 82ms/step - loss: 0.0062 - model_acc: 0.9200 - val_loss: 0.0123 - val_model_acc:
0.8377
Epoch 7/60
3983/3983 [==============================] - 336s 84ms/step - loss: 0.0052 - model_acc: 0.9320 - val_loss: 0.0127 - val_model_acc:
0.8464
Epoch 8/60
3983/3983 [==============================] - 333s 84ms/step - loss: 0.0046 - model_acc: 0.9408 - val_loss: 0.0126 - val_model_acc:
0.8425
Epoch 9/60
3983/3983 [==============================] - 327s 82ms/step - loss: 0.0039 - model_acc: 0.9490 - val_loss: 0.0122 - val_model_acc:
0.8448
Epoch 10/60
3983/3983 [==============================] - 312s 78ms/step - loss: 0.0035 - model_acc: 0.9536 - val_loss: 0.0121 - val_model_acc:
0.8459
Epoch 11/60
3983/3983 [==============================] - 320s 80ms/step - loss: 0.0032 - model_acc: 0.9578 - val_loss: 0.0122 - val_model_acc:
0.8447
Epoch 12/60
3983/3983 [==============================] - 322s 81ms/step - loss: 0.0028 - model_acc: 0.9624 - val_loss: 0.0119 - val_model_acc:
0.8487
Epoch 13/60
3983/3983 [==============================] - 329s 83ms/step - loss: 0.0026 - model_acc: 0.9648 - val_loss: 0.0117 - val_model_acc:
0.8518
Epoch 14/60
3983/3983 [==============================] - 307s 77ms/step - loss: 0.0024 - model_acc: 0.9685 - val_loss: 0.0120 - val_model_acc:
0.8499
Epoch 15/60
3983/3983 [==============================] - 334s 84ms/step - loss: 0.0022 - model_acc: 0.9685 - val_loss: 0.0123 - val_model_acc:
0.8541
Epoch 16/60
3983/3983 [==============================] - 323s 81ms/step - loss: 0.0020 - model_acc: 0.9719 - val_loss: 0.0119 - val_model_acc:
0.8518
Epoch 17/60
3983/3983 [==============================] - 332s 83ms/step - loss: 0.0019 - model_acc: 0.9734 - val_loss: 0.0117 - val_model_acc:
0.8544
Epoch 18/60
3983/3983 [==============================] - 315s 79ms/step - loss: 0.0018 - model_acc: 0.9764 - val_loss: 0.0116 - val_model_acc:
0.8520
Epoch 19/60
3983/3983 [==============================] - 328s 82ms/step - loss: 0.0016 - model_acc: 0.9775 - val_loss: 0.0115 - val_model_acc:
0.8577
Epoch 20/60
3983/3983 [==============================] - 325s 82ms/step - loss: 0.0015 - model_acc: 0.9776 - val_loss: 0.0117 - val_model_acc:
0.8535
```

```
Epoch 21/60
3983/3983 [==============================] - 331s 83ms/step - loss: 0.0015 - model_acc: 0.9793 - val_loss: 0.0115 - val_model_acc:
0.8544
Epoch 22/60
3983/3983 [==============================] - 334s 84ms/step - loss: 0.0014 - model_acc: 0.9815 - val_loss: 0.0119 - val_model_acc:
0.8549
Epoch 23/60
3983/3983 [==============================] - 328s 82ms/step - loss: 0.0013 - model_acc: 0.9810 - val_loss: 0.0116 - val_model_acc:
0.8578
Epoch 24/60
3983/3983 [==============================] - 319s 80ms/step - loss: 0.0012 - model_acc: 0.9829 - val_loss: 0.0114 - val_model_acc:
0.8617
Epoch 25/60
3983/3983 [==============================] - 318s 80ms/step - loss: 0.0012 - model_acc: 0.9829 - val_loss: 0.0115 - val_model_acc:
0.8586
Epoch 26/60
3983/3983 [==============================] - 327s 82ms/step - loss: 0.0011 - model_acc: 0.9842 - val_loss: 0.0116 - val_model_acc:
0.8600
Epoch 27/60
3983/3983 [==============================] - 332s 83ms/step - loss: 0.0010 - model_acc: 0.9845 - val_loss: 0.0116 - val_model_acc:
0.8535
Epoch 28/60
3983/3983 [==============================] - 327s 82ms/step - loss: 9.7317e-04 - model_acc: 0.9863 - val_loss: 0.0118 - val_model_
acc: 0.8555
Epoch 29/60
3983/3983 [==============================] - 326s 82ms/step - loss: 9.2157e-04 - model_acc: 0.9860 - val_loss: 0.0116 - val_model_
acc: 0.8583
Epoch 30/60
3983/3983 [==============================] - 326s 82ms/step - loss: 8.9429e-04 - model_acc: 0.9875 - val_loss: 0.0116 - val_model_
acc: 0.8552
Epoch 31/60
3983/3983 [==============================] - 327s 82ms/step - loss: 8.2776e-04 - model_acc: 0.9884 - val_loss: 0.0117 - val_model_
acc: 0.8578
Epoch 32/60
3983/3983 [==============================] - 319s 80ms/step - loss: 8.0395e-04 - model_acc: 0.9882 - val_loss: 0.0115 - val_model_
acc: 0.8596
Epoch 33/60
3983/3983 [==============================] - 317s 80ms/step - loss: 7.1036e-04 - model_acc: 0.9906 - val_loss: 0.0121 - val_model_
acc: 0.8527
Epoch 34/60
3983/3983 [==============================] - 331s 83ms/step - loss: 7.3191e-04 - model_acc: 0.9895 - val_loss: 0.0119 - val_model_
acc: 0.8555
Epoch 35/60
3983/3983 [==============================] - 327s 82ms/step - loss: 6.8643e-04 - model_acc: 0.9903 - val_loss: 0.0118 - val_model_
```

```
acc: 0.8535
Epoch 36/60
3983/3983 [==============================] - 327s 82ms/step - loss: 6.3422e-04 - model_acc: 0.9913 - val_loss: 0.0119 - val_model_
acc: 0.8549
Epoch 37/60
3983/3983 [==============================] - 323s 81ms/step - loss: 6.1434e-04 - model_acc: 0.9910 - val_loss: 0.0118 - val_model_
acc: 0.8544
Epoch 38/60
3983/3983 [==============================] - 337s 85ms/step - loss: 7.0762e-04 - model_acc: 0.9898 - val_loss: 0.0126 - val_model_
acc: 0.8459
Epoch 39/60
3983/3983 [==============================] - 325s 82ms/step - loss: 8.1396e-04 - model_acc: 0.9884 - val_loss: 0.0119 - val_model_
acc: 0.8552
Epoch 40/60
3983/3983 [==============================] - 314s 79ms/step - loss: 5.0600e-04 - model_acc: 0.9939 - val_loss: 0.0121 - val_model_
acc: 0.8524
Epoch 41/60
3983/3983 [==============================] - 327s 82ms/step - loss: 5.8258e-04 - model_acc: 0.9914 - val_loss: 0.0120 - val_model_
acc: 0.8543
Epoch 42/60
3983/3983 [==============================] - 336s 84ms/step - loss: 6.1485e-04 - model_acc: 0.9913 - val_loss: 0.0118 - val_model_
acc: 0.8541
Epoch 43/60
3983/3983 [==============================] - 321s 81ms/step - loss: 4.9430e-04 - model_acc: 0.9934 - val_loss: 0.0122 - val_model_
acc: 0.8513
Epoch 44/60
3983/3983 [==============================] - 325s 82ms/step - loss: 5.2422e-04 - model_acc: 0.9925 - val_loss: 0.0117 - val_model_
acc: 0.8507
Epoch 45/60
3983/3983 [==============================] - 332s 83ms/step - loss: 4.6792e-04 - model_acc: 0.9934 - val_loss: 0.0117 - val_model_
acc: 0.8574
Epoch 46/60
3983/3983 [==============================] - 332s 83ms/step - loss: 5.0455e-04 - model_acc: 0.9931 - val_loss: 0.0120 - val_model_
acc: 0.8521
Epoch 47/60
3983/3983 [==============================] - 329s 83ms/step - loss: 4.6657e-04 - model_acc: 0.9937 - val_loss: 0.0120 - val_model_
acc: 0.8529
Epoch 48/60
3983/3983 [==============================] - 325s 82ms/step - loss: 4.6807e-04 - model_acc: 0.9939 - val_loss: 0.0121 - val_model_
acc: 0.8493
Epoch 49/60
3983/3983 [==============================] - 326s 82ms/step - loss: 4.4295e-04 - model_acc: 0.9942 - val_loss: 0.0119 - val_model_
acc: 0.8512
Epoch 50/60
```

```
3983/3983 [==============================] - 317s 80ms/step - loss: 4.3735e-04 - model_acc: 0.9937 - val_loss: 0.0122 - val_model_
acc: 0.8487
Epoch 51/60
3983/3983 [==============================] - 323s 81ms/step - loss: 5.2088e-04 - model_acc: 0.9925 - val_loss: 0.0123 - val_model_
acc: 0.8510
Epoch 52/60
3983/3983 [==============================] - 321s 81ms/step - loss: 4.0463e-04 - model_acc: 0.9948 - val_loss: 0.0125 - val_model_
acc: 0.8526
Epoch 53/60
3983/3983 [==============================] - 317s 80ms/step - loss: 4.1916e-04 - model_acc: 0.9941 - val_loss: 0.0122 - val_model_
acc: 0.8515
Epoch 54/60
3983/3983 [==============================] - 331s 83ms/step - loss: 3.8166e-04 - model_acc: 0.9949 - val_loss: 0.0122 - val_model_
acc: 0.8501
Epoch 55/60
2667/3983 [===================>.........] - ETA: 1:43 - loss: 4.0949e-04 - model_acc: 0.9946
```

```
---------------------------------------------------------------------------
KeyboardInterrupt                         Traceback (most recent call last)
/tmp/.fym666/ipykernel_21132/1304664202.py in <module>
      3                   metrics = [model_acc])
      4
----> 5 model.fit(x=tf.image.grayscale_to_rgb(training_images),
      6           y=training_emotions,
      7           batch_size=32,

~/anaconda3/envs/tensorflow/lib/python3.8/site-packages/tensorflow/python/keras/engine/training.py in fit(self, x, y, batch_size,
 epochs, verbose, callbacks, validation_split, validation_data, shuffle, class_weight, sample_weight, initial_epoch, steps_per_epo
ch, validation_steps, validation_batch_size, validation_freq, max_queue_size, workers, use_multiprocessing)
   1098                 _r=1):
   1099               callbacks.on_train_batch_begin(step)
-> 1100               tmp_logs = self.train_function(iterator)
   1101               if data_handler.should_sync:
   1102                 context.async_wait()

~/anaconda3/envs/tensorflow/lib/python3.8/site-packages/tensorflow/python/keras/engine/training.py in train_function(iterator)
    803       def train_function(iterator):
    804         """Runs a training execution with one step."""
--> 805         return step_function(self, iterator)
    806
    807     else:

~/anaconda3/envs/tensorflow/lib/python3.8/site-packages/tensorflow/python/keras/engine/training.py in step_function(model, iterato
r)
```