gesture_recog_light

September 4, 2020

[1]:
```
# gesture_recog.ipynb

# The model is to train the guesture of images with the Leap Motion
# T. Mantecón, C.R. del Blanco, F. Jaureguizar, N. García, "Hand Gesture␣
 ↪Recognition using Infrared
# Imagery Provided by Leap Motion Controller", Int. Conf. on Advanced Concepts␣
 ↪for Intelligent Vision
# Systems, ACIVS 2016, Lecce, Italy, pp. 47-57, 24-27 Oct. 2016. (doi: 10.1007/
 ↪978-3-319-48680-2_5)

# Please download the leapgestrecog dataset from Kaggle.
# https://www.kaggle.com/gti-upm/leapgestrecog
```

[2]:
```
import tensorflow as tf
from keras.preprocessing.image import ImageDataGenerator
from keras import optimizers
import matplotlib.pyplot as plt
from alexnet import AlexNet
from keras.preprocessing import image

import numpy as np
import datetime
import os
import shutil
from PIL import Image
from numba import cuda
```

[3]:
```
# Set up the GPU growth to avoid the sudden runtime error.

gpus = tf.config.experimental.list_physical_devices('GPU')
for gpu in gpus:
    tf.config.experimental.set_memory_growth(gpu, True)
```

[4]:
```
# Move the iamges from the original path to the source path

orig_dir = '/home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog'
src_dir  = '/home/mike/Documents/image_gesture/leapgestrecog/src_data'
```

```
if not os.path.exists(src_dir):
    os.makedirs(src_dir)

def move_data(orig_dir, src_dir):

    # Conduct three iterations with i, j and k counters
    for i in os.listdir(orig_dir):
        label = 0
        # Get the original category(ca) with i pointing to any folder from 00␣
 ↪to 09
        origca_dir = os.path.join(orig_dir, i)
        print("[INFO]Category %s %s"% (origca_dir,i))

        # The counter j points to any folder from 01_palm to 10_down.
        for j in os.listdir(origca_dir):
            # The label is related to str(label) in the k iterations.
            label = label + 1
            # Create the origcaty_dir.Type(ty) represents the type of the above␣
 ↪folders
            origcaty_dir = os.path.join(origca_dir, j)
            print("[INFO]Type %s %s"% (origcaty_dir,j))

            for k in os.listdir(origcaty_dir):
                # origimg_path is the absolute path that holds the images such␣
 ↪as frame_00_7_0001.png
                origimg_path = os.path.join(origcaty_dir, k)
                # Create the diretort for the label with str(label) ranging␣
 ↪from 1 to 10
                srclbl_dir = os.path.join(src_dir, str(label))
                if not os.path.exists(srclbl_dir):
                    os.makedirs(srclbl_dir)
                # Create the absolute path
                srcimg_path = os.path.join(srclbl_dir, k)
                 # Move the images
                shutil.move(origimg_path, srcimg_path)

        print("[INFO]One Person Finished ", origcaty_dir)

    print("[INFO]All Finished!")

move_data(orig_dir, src_dir)
```

```
[INFO]Category /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/06
06
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/06/03_
fist 03_fist
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/06/04_
```

```
fist_moved 04_fist_moved
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/06/08_
palm_moved 08_palm_moved
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/06/02_
l 02_l
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/06/06_
index 06_index
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/06/05_
thumb 05_thumb
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/06/10_
down 10_down
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/06/01_
palm 01_palm
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/06/09_
c 09_c
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/06/07_
ok 07_ok
[INFO]One Person Finished
/home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/06/07_ok
[INFO]Category /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/02
02
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/02/03_
fist 03_fist
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/02/04_
fist_moved 04_fist_moved
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/02/08_
palm_moved 08_palm_moved
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/02/02_
l 02_l
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/02/06_
index 06_index
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/02/05_
thumb 05_thumb
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/02/10_
down 10_down
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/02/01_
palm 01_palm
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/02/09_
c 09_c
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/02/07_
ok 07_ok
[INFO]One Person Finished
/home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/02/07_ok
[INFO]Category /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/05
05
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/05/03_
fist 03_fist
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/05/04_
```

```
fist_moved 04_fist_moved
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/05/08_
palm_moved 08_palm_moved
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/05/02_
l 02_l
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/05/06_
index 06_index
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/05/05_
thumb 05_thumb
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/05/10_
down 10_down
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/05/01_
palm 01_palm
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/05/09_
c 09_c
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/05/07_
ok 07_ok
[INFO]One Person Finished
/home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/05/07_ok
[INFO]Category /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/08
08
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/08/03_
fist 03_fist
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/08/04_
fist_moved 04_fist_moved
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/08/08_
palm_moved 08_palm_moved
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/08/02_
l 02_l
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/08/06_
index 06_index
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/08/05_
thumb 05_thumb
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/08/10_
down 10_down
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/08/01_
palm 01_palm
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/08/09_
c 09_c
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/08/07_
ok 07_ok
[INFO]One Person Finished
/home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/08/07_ok
[INFO]Category /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/07
07
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/07/03_
fist 03_fist
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/07/04_
```

```
fist_moved 04_fist_moved
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/07/08_
palm_moved 08_palm_moved
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/07/02_
l 02_l
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/07/06_
index 06_index
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/07/05_
thumb 05_thumb
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/07/10_
down 10_down
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/07/01_
palm 01_palm
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/07/09_
c 09_c
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/07/07_
ok 07_ok
[INFO]One Person Finished
/home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/07/07_ok
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04
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[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/04/08_
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l 02_l
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index 06_index
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/04/05_
thumb 05_thumb
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c 09_c
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ok 07_ok
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/home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/04/07_ok
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09
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fist 03_fist
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fist_moved 04_fist_moved
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[INFO]Category /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/03
03
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down 10_down
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/03/01_
palm 01_palm
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/03/09_
c 09_c
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/03/07_
ok 07_ok
[INFO]One Person Finished
/home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/03/07_ok
[INFO]Category /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/00
00
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/00/03_
fist 03_fist
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/00/04_
```

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[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/00/02_
l 02_l
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/00/06_
index 06_index
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/00/05_
thumb 05_thumb
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/00/10_
down 10_down
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/00/01_
palm 01_palm
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/00/09_
c 09_c
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/00/07_
ok 07_ok
[INFO]One Person Finished
/home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/00/07_ok
[INFO]Category /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/01
01
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/01/03_
fist 03_fist
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/01/04_
fist_moved 04_fist_moved
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/01/08_
palm_moved 08_palm_moved
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/01/02_
l 02_l
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/01/06_
index 06_index
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/01/05_
thumb 05_thumb
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/01/10_
down 10_down
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/01/01_
palm 01_palm
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/01/09_
c 09_c
[INFO]Type /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/01/07_
ok 07_ok
[INFO]One Person Finished
/home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/01/07_ok
[INFO]All Finished!
```

[5]:
```
# Divide the dataset into train, validation and test sets.
```

```
# Designate source and division datasets
src_dir = '/home/mike/Documents/image_gesture/leapgestrecog/src_data'
dset_dir = '/home/mike/Documents/image_gesture/dset_data'
if not os.path.exists(dset_dir):
    os.makedirs(dset_dir)

if not os.path.exists(dset_dir):
    os.makedirs(dset_dir)

# Make three directories for training, validation and test
train_dir = os.path.join(dset_dir, 'train')
if not os.path.exists(train_dir):
    os.mkdir(train_dir)

validation_dir = os.path.join(dset_dir, 'validation')
if not os.path.exists(validation_dir):
    os.mkdir(validation_dir)

test_dir = os.path.join(dset_dir, 'test')
if not os.path.exists(test_dir):
    os.mkdir(test_dir)


for num in os.listdir(src_dir):
    # Folder 1~10
    train_idx_dir = os.path.join(train_dir, num)
    if not os.path.exists(train_idx_dir):
        os.mkdir(train_idx_dir)

    validation_idx_dir = os.path.join(validation_dir, num)
    if not os.path.exists(validation_idx_dir):
        os.mkdir(validation_idx_dir)

    test_idx_dir = os.path.join(test_dir, num)
    if not os.path.exists(test_idx_dir):
        os.mkdir(test_idx_dir)

    # Index is increasing.
    src_idx_dir = os.path.join(src_dir, num)

    # print(src_idx_dir)

    j = 0

    for fname in os.listdir(src_idx_dir):

        if j < 1000:  # Copy 1000 images to the train directory
```

```
            src = os.path.join(src_idx_dir, fname)
            dst = os.path.join(train_idx_dir, fname)
            shutil.copyfile(src, dst)
        elif (j >= 1000 and j < 1500):  # Copy 500 images to the val directory
            src = os.path.join(src_idx_dir, fname)
            dst = os.path.join(validation_idx_dir, fname)
            shutil.copyfile(src, dst)
        elif (j >= 1500):  # Copy 500 images to the test directory
            src = os.path.join(src_idx_dir, fname)
            dst = os.path.join(test_idx_dir, fname)
            shutil.copyfile(src, dst)

        j = j + 1

    print("[INFO]Copy finished! :", train_idx_dir)
    print("[INFO]Copy finished! :", validation_idx_dir)
    print("[INFO]Copy finished! :", test_idx_dir)


print('[INFO]training files:', len(os.listdir(train_dir)))
print('[INFO]validation files:', len(os.listdir(validation_dir)))
print('[INFO]test files:', len(os.listdir(test_dir)))

print('[INFO]1 training images:', len(os.listdir(train_dir+"/1/")))
print('[INFO]1 validation images:', len(os.listdir(validation_dir+"/1/")))
print('[INFO]1 test images:', len(os.listdir(test_dir+"/1/")))
```

```
[INFO]Copy finished! : /home/mike/Documents/image_gesture/dset_data/train/9
[INFO]Copy finished! : /home/mike/Documents/image_gesture/dset_data/validation/9
[INFO]Copy finished! : /home/mike/Documents/image_gesture/dset_data/test/9
[INFO]Copy finished! : /home/mike/Documents/image_gesture/dset_data/train/2
[INFO]Copy finished! : /home/mike/Documents/image_gesture/dset_data/validation/2
[INFO]Copy finished! : /home/mike/Documents/image_gesture/dset_data/test/2
[INFO]Copy finished! : /home/mike/Documents/image_gesture/dset_data/train/4
[INFO]Copy finished! : /home/mike/Documents/image_gesture/dset_data/validation/4
[INFO]Copy finished! : /home/mike/Documents/image_gesture/dset_data/test/4
[INFO]Copy finished! : /home/mike/Documents/image_gesture/dset_data/train/7
[INFO]Copy finished! : /home/mike/Documents/image_gesture/dset_data/validation/7
[INFO]Copy finished! : /home/mike/Documents/image_gesture/dset_data/test/7
[INFO]Copy finished! : /home/mike/Documents/image_gesture/dset_data/train/5
[INFO]Copy finished! : /home/mike/Documents/image_gesture/dset_data/validation/5
[INFO]Copy finished! : /home/mike/Documents/image_gesture/dset_data/test/5
[INFO]Copy finished! : /home/mike/Documents/image_gesture/dset_data/train/3
[INFO]Copy finished! : /home/mike/Documents/image_gesture/dset_data/validation/3
[INFO]Copy finished! : /home/mike/Documents/image_gesture/dset_data/test/3
[INFO]Copy finished! : /home/mike/Documents/image_gesture/dset_data/train/1
[INFO]Copy finished! : /home/mike/Documents/image_gesture/dset_data/validation/1
```

```
[INFO]Copy finished! : /home/mike/Documents/image_gesture/dset_data/test/1
[INFO]Copy finished! : /home/mike/Documents/image_gesture/dset_data/train/6
[INFO]Copy finished! : /home/mike/Documents/image_gesture/dset_data/validation/6
[INFO]Copy finished! : /home/mike/Documents/image_gesture/dset_data/test/6
[INFO]Copy finished! : /home/mike/Documents/image_gesture/dset_data/train/10
[INFO]Copy finished! :
/home/mike/Documents/image_gesture/dset_data/validation/10
[INFO]Copy finished! : /home/mike/Documents/image_gesture/dset_data/test/10
[INFO]Copy finished! : /home/mike/Documents/image_gesture/dset_data/train/8
[INFO]Copy finished! : /home/mike/Documents/image_gesture/dset_data/validation/8
[INFO]Copy finished! : /home/mike/Documents/image_gesture/dset_data/test/8
[INFO]training files: 10
[INFO]validation files: 10
[INFO]test files: 10
[INFO]1 training images: 1000
[INFO]1 validation images: 500
[INFO]1 test images: 500
```

[6]:
```
# Assign the global arguments

EPOCHS = 32
BATCH_SIZE = 64
image_width = 227
image_height = 227
channels = 3
num_classes = 1
```

[7]:
```
# Call the cnn/alexnet model

model = AlexNet((image_width,image_height,channels), num_classes)
```

[8]:
```
# Model configuration

model.compile(optimizer=optimizers.RMSprop(lr=1e-4),
              loss='binary_crossentropy',
              metrics=['acc'])
```

[9]:
```
# Summary

model.summary()
```

```
Model: "alex_net"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d (Conv2D)              (None, 55, 55, 96)        34944
_________________________________________________________________
max_pooling2d (MaxPooling2D) (None, 27, 27, 96)        0
```

```
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 27, 27, 256)       614656
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 13, 13, 256)       0
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 13, 13, 384)       885120
_________________________________________________________________
conv2d_3 (Conv2D)            (None, 13, 13, 384)       1327488
_________________________________________________________________
conv2d_4 (Conv2D)            (None, 13, 13, 256)       884992
_________________________________________________________________
max_pooling2d_2 (MaxPooling2 (None, 6, 6, 256)         0
_________________________________________________________________
flatten (Flatten)            (None, 9216)              0
_________________________________________________________________
dense (Dense)                (None, 4096)              37752832
_________________________________________________________________
dropout (Dropout)            (None, 4096)              0
_________________________________________________________________
dense_1 (Dense)              (None, 4096)              16781312
_________________________________________________________________
dropout_1 (Dropout)          (None, 4096)              0
_________________________________________________________________
dense_2 (Dense)              (None, 1000)              4097000
_________________________________________________________________
dense_3 (Dense)              (None, 1)                 1001
=================================================================
Total params: 62,379,345
Trainable params: 62,379,345
Non-trainable params: 0
_________________________________________________________________
```

[10]:
```
# Preprocess the images

train_datagen = ImageDataGenerator(rescale=1.0/255)
train_generator = train_datagen.flow_from_directory(train_dir,
                                                    ␣
 ↪target_size=(image_width,image_height),
                                                     batch_size=BATCH_SIZE,
                                                     class_mode='binary')
train_num = train_generator.samples

validation_generator = train_datagen.flow_from_directory(validation_dir,
                                                         ␣
 ↪target_size=(image_width,image_height),
                                                          batch_size=BATCH_SIZE,
                                                          class_mode='binary')
```

```
val_num = validation_generator.samples


test_datagen = ImageDataGenerator(rescale=1.0/255)
test_generator = train_datagen.flow_from_directory(test_dir,
                                                   ␣
 ↪target_size=(image_width,image_height),
                                                    batch_size=BATCH_SIZE,
                                                    class_mode='binary')
test_num = test_generator.samples
```

```
Found 10000 images belonging to 10 classes.
Found 5000 images belonging to 10 classes.
Found 5000 images belonging to 10 classes.
```

[12]:
```
# Get the batch shape

for data_batch, label_batch in train_generator:
    print("data batch shape:", data_batch.shape)
    print("labels batch shape:", label_batch)

    break
```

```
data batch shape: (64, 227, 227, 3)
labels batch shape: [6. 4. 1. 8. 0. 0. 0. 6. 4. 5. 0. 3. 8. 8. 0. 9. 4. 9. 0. 9.
7. 8. 6. 2.
 9. 5. 8. 5. 5. 2. 7. 9. 7. 5. 9. 1. 8. 1. 9. 3. 4. 6. 5. 5. 0. 0. 3. 1.
 9. 4. 0. 5. 9. 8. 9. 2. 9. 5. 9. 0. 0. 9. 9. 0.]
```

[13]:
```
# Train the model
history = model.fit(train_generator,
                    steps_per_epoch=train_num//BATCH_SIZE,
                    epochs=EPOCHS,
                    validation_data=validation_generator,
                    validation_steps=val_num//BATCH_SIZE)
```

```
Epoch 1/32
156/156 [==============================] - 28s 181ms/step - loss: -53.3370 -
acc: 0.1002 - val_loss: -53.3937 - val_acc: 0.1002
Epoch 2/32
156/156 [==============================] - 28s 176ms/step - loss: -53.3983 -
acc: 0.0998 - val_loss: -53.4304 - val_acc: 0.1000
Epoch 3/32
156/156 [==============================] - 27s 176ms/step - loss: -53.3125 -
acc: 0.1005 - val_loss: -53.3876 - val_acc: 0.1002
Epoch 4/32
156/156 [==============================] - 27s 175ms/step - loss: -53.3370 -
acc: 0.0999 - val_loss: -53.3998 - val_acc: 0.1000
```

```
Epoch 5/32
156/156 [==============================] - 27s 175ms/step - loss: -53.4414 -
acc: 0.0994 - val_loss: -53.3632 - val_acc: 0.1002
Epoch 6/32
156/156 [==============================] - 27s 175ms/step - loss: -53.3723 -
acc: 0.1007 - val_loss: -53.3448 - val_acc: 0.1002
Epoch 7/32
156/156 [==============================] - 27s 176ms/step - loss: -53.4015 -
acc: 0.0986 - val_loss: -53.3357 - val_acc: 0.1002
Epoch 8/32
156/156 [==============================] - 27s 175ms/step - loss: -53.2496 -
acc: 0.1008 - val_loss: -53.3326 - val_acc: 0.1000
Epoch 9/32
156/156 [==============================] - 27s 175ms/step - loss: -53.4414 -
acc: 0.1007 - val_loss: -53.3509 - val_acc: 0.0998
Epoch 10/32
156/156 [==============================] - 27s 175ms/step - loss: -53.5197 -
acc: 0.0981 - val_loss: -53.2990 - val_acc: 0.1002
Epoch 11/32
156/156 [==============================] - 27s 175ms/step - loss: -53.3462 -
acc: 0.1015 - val_loss: -53.4304 - val_acc: 0.1000
Epoch 12/32
156/156 [==============================] - 27s 175ms/step - loss: -53.1866 -
acc: 0.1000 - val_loss: -53.3815 - val_acc: 0.1000
Epoch 13/32
156/156 [==============================] - 27s 175ms/step - loss: -53.6379 -
acc: 0.1004 - val_loss: -53.3510 - val_acc: 0.1002
Epoch 14/32
156/156 [==============================] - 27s 176ms/step - loss: -53.2664 -
acc: 0.0988 - val_loss: -53.3784 - val_acc: 0.1000
Epoch 15/32
156/156 [==============================] - 27s 175ms/step - loss: -53.4445 -
acc: 0.0997 - val_loss: -53.3418 - val_acc: 0.1000
Epoch 16/32
156/156 [==============================] - 27s 176ms/step - loss: -53.0777 -
acc: 0.1006 - val_loss: -53.3601 - val_acc: 0.1002
Epoch 17/32
156/156 [==============================] - 27s 175ms/step - loss: -53.4828 -
acc: 0.0999 - val_loss: -53.3662 - val_acc: 0.1002
Epoch 18/32
156/156 [==============================] - 27s 175ms/step - loss: -53.9202 -
acc: 0.0977 - val_loss: -53.3418 - val_acc: 0.1000
Epoch 19/32
156/156 [==============================] - 27s 175ms/step - loss: -53.3140 -
acc: 0.1013 - val_loss: -53.3815 - val_acc: 0.1000
Epoch 20/32
156/156 [==============================] - 27s 175ms/step - loss: -53.0286 -
acc: 0.1017 - val_loss: -53.3632 - val_acc: 0.1002
```

```
Epoch 21/32
156/156 [==============================] - 27s 175ms/step - loss: -53.2511 -
acc: 0.0998 - val_loss: -53.3357 - val_acc: 0.1002
Epoch 22/32
156/156 [==============================] - 27s 175ms/step - loss: -53.3754 -
acc: 0.0986 - val_loss: -53.3601 - val_acc: 0.1000
Epoch 23/32
156/156 [==============================] - 27s 175ms/step - loss: -53.7637 -
acc: 0.1018 - val_loss: -53.3907 - val_acc: 0.1002
Epoch 24/32
156/156 [==============================] - 28s 177ms/step - loss: -52.7431 -
acc: 0.1006 - val_loss: -53.3754 - val_acc: 0.1002
Epoch 25/32
156/156 [==============================] - 27s 176ms/step - loss: -53.8067 -
acc: 0.1000 - val_loss: -53.3510 - val_acc: 0.1002
Epoch 26/32
156/156 [==============================] - 27s 176ms/step - loss: -53.2573 -
acc: 0.0962 - val_loss: -53.3632 - val_acc: 0.0998
Epoch 27/32
156/156 [==============================] - 27s 175ms/step - loss: -53.3033 -
acc: 0.1041 - val_loss: -53.3540 - val_acc: 0.1002
Epoch 28/32
156/156 [==============================] - 28s 179ms/step - loss: -53.6271 -
acc: 0.0971 - val_loss: -53.3601 - val_acc: 0.1002
Epoch 29/32
156/156 [==============================] - 28s 178ms/step - loss: -52.8567 -
acc: 0.1023 - val_loss: -53.3907 - val_acc: 0.1002
Epoch 30/32
156/156 [==============================] - 27s 176ms/step - loss: -53.5826 -
acc: 0.0992 - val_loss: -53.3693 - val_acc: 0.1000
Epoch 31/32
156/156 [==============================] - 27s 176ms/step - loss: -53.4337 -
acc: 0.0996 - val_loss: -53.3357 - val_acc: 0.1000
Epoch 32/32
156/156 [==============================] - 27s 176ms/step - loss: -53.3248 -
acc: 0.0986 - val_loss: -53.4029 - val_acc: 0.0996
```

[14]:
```
# Save the model

model.save('/home/mike/Documents/image_gesture/leapGestRecog_small_1.h5')
model.save('/home/mike/Documents/image_gesture/leapGestRecog_small_2.h5')
```

[15]:
```
# Evaluate the model with visulizing the result

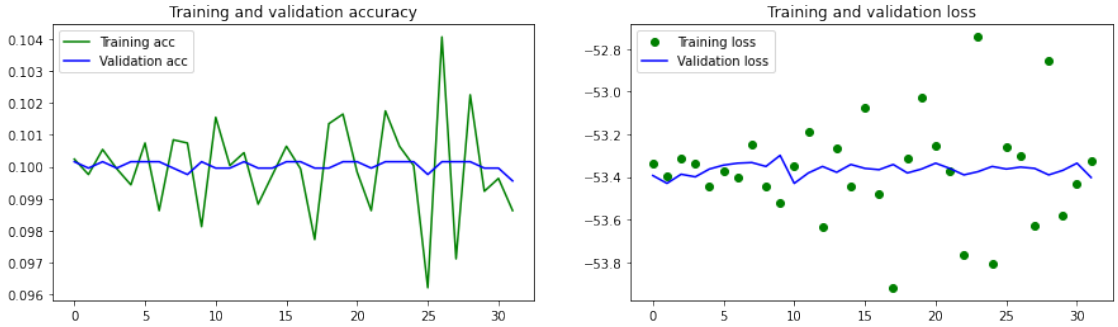
acc = history.history['acc']
val_acc = history.history['val_acc']
loss = history.history['loss']
```

```
val_loss = history.history['val_loss']
epochs = range(len(acc))

plt.figure(figsize=(15,4))
plt.subplot(1,2,1)
plt.plot(epochs, acc, 'b', label='Training acc', color='green')
plt.plot(epochs, val_acc, 'b', label='Validation acc')
plt.title('Training and validation accuracy')
plt.legend()

plt.subplot(1,2,2)
plt.plot(epochs, loss, 'bo', label='Training loss', color='green')
plt.plot(epochs, val_loss, 'b', label='Validation loss')
plt.title('Training and validation loss')
plt.legend()

plt.show()
```



[16]:
```
# Release the GPU memory

cuda.select_device(0)
cuda.close()
```