gesture_recog_aug_categorical

September 5, 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

# -import os
# -import shutil
```

```
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("[MESSAGE] 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 and type(ty) represents the type of the␣
 ↪above folders
            origcaty_dir = os.path.join(origca_dir, j)
            print("[MESSAGE] 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("[MESSAGE] Done    ", origcaty_dir)

    print("[MESSAGE] All Done!")

if __name__ == '__main__':

    move_data(orig_dir, src_dir)
```

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[MESSAGE]
Category /home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/06 06
[MESSAGE] Type
/home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/06/03_fist
03_fist
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08_palm_moved
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06_index
[MESSAGE] Type
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[MESSAGE] Type
/home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/09/07_ok 07_ok
[MESSAGE] Done
/home/mike/Documents/image_gesture/leapgestrecog/leapGestRecog/09/07_ok
[MESSAGE] All Done!
```

[5]:

```
# Divide the dataset into train, validation and tfile sets.

# -import os
# -import shutil

# 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)


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

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

tfile_dir = os.path.join(dset_dir, 'tfile')
if not os.path.exists(tfile_dir):
    os.mkdir(tfile_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)

    val_idx_dir = os.path.join(val_dir, num)
    if not os.path.exists(val_idx_dir):
        os.mkdir(val_idx_dir)

    tfile_idx_dir = os.path.join(tfile_dir, num)
    if not os.path.exists(tfile_idx_dir):
        os.mkdir(tfile_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(val_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(tfile_idx_dir, fname)
            shutil.copyfile(src, dst)

        j = j + 1

    print("[MESSAGE] Copy completed :", train_idx_dir)
    print("[MESSAGE] Copy completed :", val_idx_dir)
    print("[MESSAGE] Copy completed :", tfile_idx_dir)


print('[MESSAGE] Train folders:', len(os.listdir(train_dir)))
```

```python
print('[MESSAGE] Validation folders:', len(os.listdir(val_dir)))
print('[MESSAGE] Tfile folders:', len(os.listdir(tfile_dir)))

print('[MESSAGE] Train images per folder:', len(os.listdir(train_dir+"/1/")))
print('[MESSAGE] Validation images per folder:', len(os.listdir(val_dir+"/1/")))
print('[MESSAGE] Tfile images per folder:', len(os.listdir(tfile_dir+"/1/")))
```

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[MESSAGE] Copy completed : /home/mike/Documents/image_gesture/dset_data/train/3
[MESSAGE] Copy completed :
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```
[MESSAGE] Train folders: 10
[MESSAGE] Validation folders: 10
[MESSAGE] Tfile folders: 10
[MESSAGE] Train images per folder: 1000
[MESSAGE] Validation images per folder: 500
[MESSAGE] Tfile images per folder: 500
```

[6]:

```
# Shift the dataset from tfile_dir to test_dir with only one subsidiary folder

# -import os
# -import shutil

tfile_dir =  '/home/mike/Documents/image_gesture/dset_data/tfile'
test_dir  =  '/home/mike/Documents/image_gesture/dset_data/test'
if not os.path.exists(test_dir):
    os.makedirs(test_dir)

def shift_data(tfile_dir, test_dir):

    for i in os.listdir(tfile_dir):
        tfca_dir = os.path.join(tfile_dir, i)

        for j in os.listdir(tfca_dir):
            tfcaimg_path = os.path.join(tfca_dir, j)
            tfol_dir = os.path.join(test_dir, 'folder')
            if not os.path.exists(tfol_dir):
                os.makedirs(tfol_dir)
            tfolimg_path = os.path.join(tfol_dir, j)
            shutil.move(tfcaimg_path, tfolimg_path)

if __name__ == '__main__':

    shift_data(tfile_dir, test_dir)
```

[7]:

```
# Assign the global arguments

EPOCHS = 32
BATCH_SIZE = 100
image_width = 227
image_height = 227
channels = 3
num_classes = 10
```

[8]:

```
# Call the AlexNet model

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

[9]:

```
# Compile the Model with RMSprop and categorical_crossentropy for ten classes

model.compile(optimizer=tf.keras.optimizers.Adam(0.001),
              loss='categorical_crossentropy',
              metrics=['acc'])
```

[10]:

```
# 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, 10)                10010
=================================================================
Total params: 62,388,354
Trainable params: 62,388,354
Non-trainable params: 0
```

```
---------------------------------------------------------------
```

[11]:

```
# Preprocess the augumented images

train_datagen = ImageDataGenerator(rescale=1.0/255,
                                   rotation_range=10,
                                   width_shift_range=0.1,
                                   height_shift_range=0.1,
                                   shear_range=0.1,
                                   zoom_range=0.1)

train_generator = train_datagen.flow_from_directory(train_dir,
                                                                ␣
 ↪target_size=(image_width,image_height),
                                                    batch_size=BATCH_SIZE,
                                                    seed=1,
                                                    shuffle=True,
                                                    class_mode='categorical')

train_num = train_generator.samples


test_datagen = ImageDataGenerator(rescale=1.0/255)

val_generator = test_datagen.flow_from_directory(val_dir,
                                                             ␣
 ↪target_size=(image_width,image_height),
                                                 batch_size=BATCH_SIZE,
                                                 class_mode='categorical')

val_num = val_generator.samples
```

```
Found 10000 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("label batch shape:", label_batch)

    break
```

```
data batch shape: (100, 227, 227, 3)
label batch shape: [[0. 0. 0. 0. 0. 0. 0. 0. 0. 1.]
 [0. 0. 0. 1. 0. 0. 0. 0. 0. 0.]
 [0. 0. 0. 0. 1. 0. 0. 0. 0. 0.]
 [0. 0. 0. 1. 0. 0. 0. 0. 0. 0.]
```

```
[0. 0. 0. 0. 0. 1. 0. 0. 0. 0.]
[0. 0. 0. 0. 0. 0. 0. 0. 1. 0.]
[0. 0. 1. 0. 0. 0. 0. 0. 0. 0.]
[0. 1. 0. 0. 0. 0. 0. 0. 0. 0.]
[0. 1. 0. 0. 0. 0. 0. 0. 0. 0.]
[0. 0. 0. 0. 0. 0. 0. 0. 0. 1.]
[0. 0. 0. 0. 0. 0. 0. 0. 1. 0.]
[0. 0. 1. 0. 0. 0. 0. 0. 0. 0.]
[0. 0. 0. 0. 0. 0. 1. 0. 0. 0.]
[0. 1. 0. 0. 0. 0. 0. 0. 0. 0.]
[0. 0. 0. 0. 0. 0. 1. 0. 0. 0.]
[0. 0. 0. 0. 0. 0. 1. 0. 0. 0.]
[0. 0. 0. 0. 0. 0. 0. 1. 0. 0.]
[0. 0. 0. 0. 0. 0. 0. 1. 0. 0.]
[0. 0. 0. 0. 0. 0. 0. 1. 0. 0.]
[0. 0. 0. 0. 0. 0. 0. 1. 0. 0.]
[0. 0. 0. 0. 0. 0. 0. 1. 0. 0.]
[0. 0. 1. 0. 0. 0. 0. 0. 0. 0.]
[0. 1. 0. 0. 0. 0. 0. 0. 0. 0.]
[0. 0. 1. 0. 0. 0. 0. 0. 0. 0.]
[0. 0. 0. 1. 0. 0. 0. 0. 0. 0.]
[1. 0. 0. 0. 0. 0. 0. 0. 0. 0.]
[0. 1. 0. 0. 0. 0. 0. 0. 0. 0.]
[0. 0. 0. 0. 0. 0. 0. 1. 0. 0.]
[0. 0. 0. 0. 0. 0. 1. 0. 0. 0.]
[0. 0. 0. 0. 0. 0. 1. 0. 0. 0.]
[0. 1. 0. 0. 0. 0. 0. 0. 0. 0.]
[0. 0. 0. 0. 0. 0. 0. 0. 0. 1.]
[0. 0. 0. 0. 0. 1. 0. 0. 0. 0.]
[0. 0. 0. 0. 0. 0. 1. 0. 0. 0.]
[0. 0. 0. 0. 0. 0. 1. 0. 0. 0.]
[1. 0. 0. 0. 0. 0. 0. 0. 0. 0.]
[0. 0. 0. 0. 0. 0. 1. 0. 0. 0.]
[0. 1. 0. 0. 0. 0. 0. 0. 0. 0.]
[0. 0. 0. 0. 0. 0. 0. 0. 0. 1.]
[0. 1. 0. 0. 0. 0. 0. 0. 0. 0.]
[0. 0. 0. 0. 1. 0. 0. 0. 0. 0.]
[1. 0. 0. 0. 0. 0. 0. 0. 0. 0.]
[0. 0. 1. 0. 0. 0. 0. 0. 0. 0.]
[0. 0. 0. 0. 0. 0. 0. 0. 1. 0.]
[0. 0. 0. 0. 0. 0. 0. 0. 0. 1.]
[0. 0. 0. 1. 0. 0. 0. 0. 0. 0.]
[0. 0. 0. 1. 0. 0. 0. 0. 0. 0.]
[0. 0. 0. 0. 0. 0. 0. 0. 1. 0.]
[0. 0. 0. 0. 1. 0. 0. 0. 0. 0.]
[0. 0. 0. 1. 0. 0. 0. 0. 0. 0.]
[0. 0. 0. 0. 0. 0. 0. 0. 1. 0.]
[0. 0. 0. 0. 0. 0. 0. 0. 1. 0.]
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[0. 0. 0. 1. 0. 0. 0. 0. 0. 0.]
[0. 1. 0. 0. 0. 0. 0. 0. 0. 0.]
[0. 0. 0. 0. 0. 0. 0. 1. 0. 0.]
[0. 0. 0. 0. 1. 0. 0. 0. 0. 0.]
[0. 0. 0. 0. 0. 0. 0. 0. 0. 1.]
[0. 0. 0. 0. 1. 0. 0. 0. 0. 0.]
[1. 0. 0. 0. 0. 0. 0. 0. 0. 0.]
[0. 0. 0. 0. 0. 0. 0. 0. 1. 0.]
[1. 0. 0. 0. 0. 0. 0. 0. 0. 0.]
[0. 0. 0. 0. 0. 1. 0. 0. 0. 0.]
[0. 0. 0. 0. 0. 0. 0. 1. 0. 0.]
[0. 0. 1. 0. 0. 0. 0. 0. 0. 0.]
[0. 0. 0. 0. 1. 0. 0. 0. 0. 0.]
[0. 0. 0. 0. 1. 0. 0. 0. 0. 0.]
[0. 0. 0. 0. 0. 0. 1. 0. 0. 0.]
[0. 0. 0. 0. 0. 1. 0. 0. 0. 0.]
[0. 0. 1. 0. 0. 0. 0. 0. 0. 0.]
[0. 0. 0. 1. 0. 0. 0. 0. 0. 0.]
[1. 0. 0. 0. 0. 0. 0. 0. 0. 0.]
[0. 0. 0. 0. 1. 0. 0. 0. 0. 0.]
[0. 0. 0. 0. 0. 1. 0. 0. 0. 0.]
[0. 0. 0. 0. 0. 0. 0. 0. 1. 0.]
[0. 1. 0. 0. 0. 0. 0. 0. 0. 0.]
[0. 0. 0. 0. 0. 0. 0. 0. 0. 1.]
[0. 1. 0. 0. 0. 0. 0. 0. 0. 0.]
[0. 0. 0. 0. 1. 0. 0. 0. 0. 0.]
[0. 0. 0. 0. 0. 0. 0. 0. 0. 1.]
[0. 0. 0. 0. 1. 0. 0. 0. 0. 0.]
[0. 0. 0. 0. 0. 1. 0. 0. 0. 0.]
[0. 0. 0. 0. 0. 1. 0. 0. 0. 0.]
[0. 0. 0. 0. 0. 0. 0. 1. 0. 0.]
[0. 0. 0. 0. 0. 0. 0. 1. 0. 0.]
[0. 0. 0. 0. 0. 1. 0. 0. 0. 0.]
[0. 0. 1. 0. 0. 0. 0. 0. 0. 0.]
[0. 0. 1. 0. 0. 0. 0. 0. 0. 0.]
[0. 0. 0. 0. 0. 0. 0. 0. 0. 1.]
[0. 0. 0. 0. 0. 0. 0. 1. 0. 0.]
[0. 0. 0. 0. 0. 0. 0. 1. 0. 0.]
[1. 0. 0. 0. 0. 0. 0. 0. 0. 0.]
[1. 0. 0. 0. 0. 0. 0. 0. 0. 0.]
[0. 0. 0. 0. 0. 0. 1. 0. 0. 0.]
[1. 0. 0. 0. 0. 0. 0. 0. 0. 0.]
[0. 0. 0. 0. 1. 0. 0. 0. 0. 0.]
[0. 0. 0. 0. 1. 0. 0. 0. 0. 0.]
[0. 0. 0. 1. 0. 0. 0. 0. 0. 0.]
[0. 1. 0. 0. 0. 0. 0. 0. 0. 0.]
[0. 0. 0. 1. 0. 0. 0. 0. 0. 0.]
[0. 0. 0. 0. 0. 0. 0. 0. 0. 1.]]
```

[13]:

```
# 8.Tain the model
history = model.fit(train_generator,
                    steps_per_epoch=train_num//BATCH_SIZE,
                    epochs=EPOCHS,
                    validation_data=val_generator,
                    validation_steps=val_num//BATCH_SIZE)
```

```
Epoch 1/32
100/100 [==============================] - 82s 820ms/step - loss: 2.4491 - acc:
0.2609 - val_loss: 0.8546 - val_acc: 0.6616
Epoch 2/32
100/100 [==============================] - 81s 814ms/step - loss: 0.4741 - acc:
0.8207 - val_loss: 0.0756 - val_acc: 0.9808
Epoch 3/32
100/100 [==============================] - 81s 812ms/step - loss: 0.1768 - acc:
0.9430 - val_loss: 0.0621 - val_acc: 0.9818
Epoch 4/32
100/100 [==============================] - 81s 813ms/step - loss: 0.0966 - acc:
0.9682 - val_loss: 0.0251 - val_acc: 0.9946
Epoch 5/32
100/100 [==============================] - 81s 814ms/step - loss: 0.0727 - acc:
0.9779 - val_loss: 0.0149 - val_acc: 0.9974
Epoch 6/32
100/100 [==============================] - 81s 812ms/step - loss: 0.0502 - acc:
0.9868 - val_loss: 0.0334 - val_acc: 0.9896
Epoch 7/32
100/100 [==============================] - 81s 812ms/step - loss: 0.0518 - acc:
0.9853 - val_loss: 0.0151 - val_acc: 0.9978
Epoch 8/32
100/100 [==============================] - 81s 813ms/step - loss: 0.0601 - acc:
0.9827 - val_loss: 0.0541 - val_acc: 0.9850
Epoch 9/32
100/100 [==============================] - 81s 813ms/step - loss: 0.0519 - acc:
0.9847 - val_loss: 0.0520 - val_acc: 0.9804
Epoch 10/32
100/100 [==============================] - 81s 811ms/step - loss: 0.0353 - acc:
0.9895 - val_loss: 0.0348 - val_acc: 0.9906
Epoch 11/32
100/100 [==============================] - 81s 812ms/step - loss: 0.0596 - acc:
0.9831 - val_loss: 0.0090 - val_acc: 0.9982
Epoch 12/32
100/100 [==============================] - 82s 820ms/step - loss: 0.0495 - acc:
0.9864 - val_loss: 0.0059 - val_acc: 0.9988
Epoch 13/32
100/100 [==============================] - 84s 839ms/step - loss: 0.0277 - acc:
0.9919 - val_loss: 0.0106 - val_acc: 0.9976
Epoch 14/32
```

```
100/100 [==============================] - 84s 842ms/step - loss: 0.0305 - acc:
0.9928 - val_loss: 0.0134 - val_acc: 0.9946
Epoch 15/32
100/100 [==============================] - 83s 832ms/step - loss: 0.0175 - acc:
0.9948 - val_loss: 0.0079 - val_acc: 0.9976
Epoch 16/32
100/100 [==============================] - 83s 829ms/step - loss: 0.0480 - acc:
0.9881 - val_loss: 0.0330 - val_acc: 0.9904
Epoch 17/32
100/100 [==============================] - 85s 847ms/step - loss: 0.0352 - acc:
0.9894 - val_loss: 0.0119 - val_acc: 0.9976
Epoch 18/32
100/100 [==============================] - 84s 837ms/step - loss: 0.0524 - acc:
0.9863 - val_loss: 0.0231 - val_acc: 0.9934
Epoch 19/32
100/100 [==============================] - 85s 847ms/step - loss: 0.0225 - acc:
0.9944 - val_loss: 0.0108 - val_acc: 0.9976
Epoch 20/32
100/100 [==============================] - 83s 835ms/step - loss: 0.0398 - acc:
0.9898 - val_loss: 0.0539 - val_acc: 0.9806
Epoch 21/32
100/100 [==============================] - 83s 828ms/step - loss: 0.0250 - acc:
0.9942 - val_loss: 0.0097 - val_acc: 0.9974
Epoch 22/32
100/100 [==============================] - 82s 820ms/step - loss: 0.0419 - acc:
0.9900 - val_loss: 0.0336 - val_acc: 0.9824
Epoch 23/32
100/100 [==============================] - 82s 823ms/step - loss: 0.0614 - acc:
0.9845 - val_loss: 0.0164 - val_acc: 0.9962
Epoch 24/32
100/100 [==============================] - 82s 824ms/step - loss: 0.0283 - acc:
0.9921 - val_loss: 0.0064 - val_acc: 0.9992
Epoch 25/32
100/100 [==============================] - 82s 817ms/step - loss: 0.0188 - acc:
0.9956 - val_loss: 0.0037 - val_acc: 0.9996
Epoch 26/32
100/100 [==============================] - 82s 815ms/step - loss: 0.0088 - acc:
0.9977 - val_loss: 0.0095 - val_acc: 0.9992
Epoch 27/32
100/100 [==============================] - 81s 814ms/step - loss: 0.0254 - acc:
0.9937 - val_loss: 0.0488 - val_acc: 0.9912
Epoch 28/32
100/100 [==============================] - 81s 814ms/step - loss: 0.0209 - acc:
0.9952 - val_loss: 0.0019 - val_acc: 0.9994
Epoch 29/32
100/100 [==============================] - 81s 814ms/step - loss: 0.0303 - acc:
0.9928 - val_loss: 0.0109 - val_acc: 0.9972
Epoch 30/32
```

```
100/100 [==============================] - 81s 812ms/step - loss: 0.0354 - acc:
0.9913 - val_loss: 0.0127 - val_acc: 0.9982
Epoch 31/32
100/100 [==============================] - 81s 812ms/step - loss: 0.0416 - acc:
0.9896 - val_loss: 0.0048 - val_acc: 0.9992
Epoch 32/32
100/100 [==============================] - 81s 812ms/step - loss: 0.0190 - acc:
0.9951 - val_loss: 0.0087 - val_acc: 0.9980
```

[14]:

```
# Save the model

model.save('/home/mike/Documents/image_gesture/
 ↪leapGestRecog_small_aug_categorical.h5')
```

[15]:

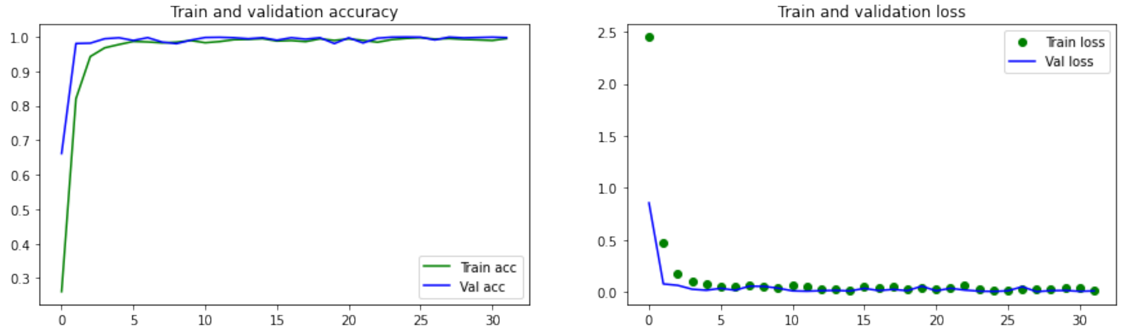
```
# Evaluate the model with visulizing the result

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='Train acc', color='green')
plt.plot(epochs, val_acc, 'b', label='Val acc')
plt.title('Train and validation accuracy')
plt.legend()

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

plt.show()
```



[16]:

```
# Release the GPU memory

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