Facial recognition

July 26, 2020

1 Hochschule Bonn-Rhein-Sieg

2 Mathematics for Robotics and Control

3 Eigenfaces

3.1 Manoj

[1]:
```
try:
    shell = get_ipython()
    shell.enable_pylab("inline")
except NameError:
    pass

import numpy as np
import matplotlib.pyplot as plt

from IPython.display import display
from IPython.core.pylabtools import figsize, getfigs
import IPython
import imageio

from typing import Tuple, Sequence
```

3.2 Eigenfaces

Eigenvectors have many applications which are not limited to obtaining surface normals from a set of point clouds. Writing your own facial recognition library. Take a look at the following image:

[4]:
```
IPython.core.display.Image("images/my.png")
```

[4]:

This is what is called an eigenface. An eigenface really is nothing else than an eigenvector, in this case reshaped for plotting. Eigenfaces can be used in facial recognition, allowing a robot to distinguish between different persons, but can also be applied to other use cases, such as voice or gesture recognition. Your task consists of the following subtasks:

1. Algorithm is based on Scholarpedia article.
2. Implement the eigenface algorithm described in the article. In particular, create a Python class that exposes (at least) two methods:
    1. A method for calculating eigenfaces given two parameters, namely (i) a set of images and (ii) subject ids that uniquely identify the subjects in the images.
    2. A method that takes one parameter - a list of query faces - and, for each face in the input list, finds the subject id of the most similar face.

A dataset for training your recognition algorithm is given in the data/training folder. The images in the data/test folder will be used for testing the algorithm.

[59]:
```
class FaceRecognition(object):
    def __init__(self):
        self.subject_ids = None
        self.faces = None
        self.eigenface_weights = None
        self.mean_image = None
```

```
   def eigenfaces(self, image_filenames: Sequence[str],subject_ids:␣
↪Sequence[int]) -> None:

   #Creating a empty matrix to stack all image vectors
       Matrix_image = []
       for i in image_filenames:
           #Reading all matrix
           matrix = imageio.imread(i)
           #flattening the image for stacking
           vector_image = np.matrix.flatten(matrix)
           #stacking the image
           Matrix_image.append(vector_image)
       # Taking the mean for normalising
       mean = np.mean(Matrix_image,axis=0)
       # Creating empty matrix to stack all normalised value
       Normalised_matrix = []
       for m in range(len(image_filenames)):
           #Appending the image to Normalised Matrix
           Normalised_matrix.append(Matrix_image[m]-mean)
       # Finding the covariance of the normalised matrix
       CV = np.cov(Normalised_matrix)
       # finding the eigen values and eigen vectors
       w, v = np.linalg.eigh(CV)
       # Finding the eigen faces
       print(np.shape(v[:,-4:]))
       faces = np.matmul(np.transpose(v[:,-9:]), Normalised_matrix)
       plt.imshow(np.reshape(faces[0],[231,195]), cmap='gray')
       # Finding the eigen vector weights
       eigenface_weights = np.matmul(Normalised_matrix,np.transpose(faces))

       self.faces = faces
       self.eigenface_weights = eigenface_weights
       self.mean_image = mean
       self.subject_ids = subject_ids

   def recognize_faces(self, image_filenames: Sequence[str]) -> Sequence[int]:
       '''
       Finds the eigenfaces that have the highest similarity
       to the input images and returns a list with their indices.
       Keyword arguments:
       image_filenames -- A list of image filenames
       Returns:
       recognised_ids -- A list of ids that correspond to the classifier
       '''
       eigenface_weights = self.eigenface_weights
       faces = self.faces
       mean = self.mean_image
```

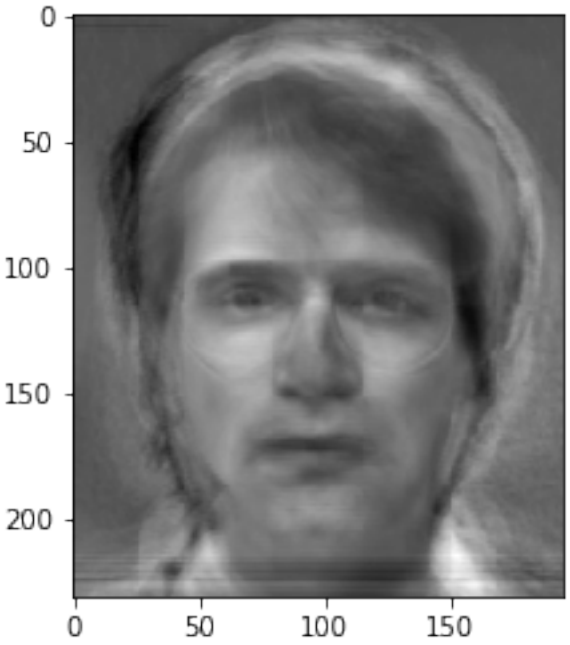
```
        subject_id = self.subject_ids
        projection = []
        prediction_id = []
        for i in image_filenames:
            image = imageio.imread(i)
            # Normalising the image
            Normalised_image = np.matrix.flatten(image) - mean
            # Finding the Eigenface weight of the test image
            eigenface_weights_test = np.matmul(Normalised_image,np.
↪transpose(faces))
            # Appending all the eigenface weight to a projection matrix
            projection.append(eigenface_weights_test)

        for j in range(len(image_filenames)):
            # Taking the individual images eigenface weight
            image_weight_test = projection[j]
            all_weights = []
            for d in range(110):
                # Taking the individual eigenface weight of the model
                image_weight_model = eigenface_weights[d,:]
                # Subtracting the Test image eigenface weight with the␣
↪eigenface weight model
                diff1 = image_weight_test - image_weight_model
                # Finding the sum of difference for comparison
                test_variation_from_original = np.sum(np.absolute(diff1))
                # Appending the value to all_weights for comparison
                all_weights.append(test_variation_from_original)
            # Taking the subject id and finding the index which has minimum␣
↪value which means minimum variation.
            prediction_id.append(subject_id[all_weights.
↪index(min(all_weights))])

        return prediction_id
```

4 Testing the code

[60]:
```
import os
import glob
#loading training images
training_image_filenames = sorted(glob.iglob('training/*.pgm'))

#loading test images
test_image_filenames = sorted(glob.iglob('test/*.pgm'))

#creating a lambda function for extracting filenames;
#the filename of each image is the subject id
```

```
subject_number = lambda filename: int(os.path.basename(filename)[7:9])

#extracting the filename using the lambda function
train_subject_ids = list (map(subject_number, training_image_filenames))
test_subject_ids = list (map(subject_number, test_image_filenames))

print('Test subject ids:', np.array(test_subject_ids))

face_recognition = FaceRecognition()
face_recognition.eigenfaces(training_image_filenames, train_subject_ids)
recognized_ids = face_recognition.recognize_faces(test_image_filenames)
print('Predicted subject ids:', recognized_ids)

different_results = np.array(test_subject_ids) - np.array(recognized_ids)
positives = (different_results == 0).sum()
accuracy = positives / (len(test_subject_ids) * 1.)
print('Number of correct predictions =', positives)
print('Prediction accuracy =', accuracy)
```

```
Test subject ids: [ 1  1  1  1  2  3  3  3  4  4  4  4  5  5  5  5  6  6  6  6
6  7  7  7
  7  8  8  8  9  9  9  9  9 10 10 10 11 11 11 11 11 12 12 12 13 13 14 14
 14 14 15 15 15 15 15]
(110, 4)
Predicted subject ids: [6, 1, 2, 1, 2, 3, 3, 8, 4, 4, 14, 4, 5, 5, 9, 5, 6, 6,
2, 6, 6, 7, 7, 7, 3, 8, 2, 8, 9, 9, 9, 9, 9, 10, 10, 10, 11, 11, 11, 11, 11, 12,
12, 12, 13, 7, 14, 14, 4, 14, 7, 3, 15, 15, 15]
Number of correct predictions = 43
Prediction accuracy = 0.7818181818181819
```


0
50
100
150
200
0
50
100
150

[ ]: