TUNKU ABDUL RAHMAN UNIVERSITY COLLEGE

BEYOND EDUCATION

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Assignment Documentation_

Full Name: Desmond Lim Chiang Shen
Student ID: 20WMR12176
Programme: RSF2S3
Tutorial Class: G1
Project Title: Face recognition
Module In-Charged: Eigenfaces

Other team members' data

No	Student Name	Module In Charge
1	HII PUONG HOU	Local Binary Patterns Histograms
2	TANG HANG RONG	Scale Invariant Feature Transform
3		

Lecturer: Dr. Goh Ching Pang	**Tutor : Dr. Goh Ching Pang**

1. Introduction

1.1. Problem Background

In the booming era, human beings already have very good basic equipment or relatively complete systems, but in terms of convenience, most of the basics still remain in the need to use fingerprints to unlock the phone or enter a password to log in to the system, which is very time-consuming And it is possible that the user forgets the password or the fingerprint changes, for example, the finger is injured and the mobile phone cannot be unlocked (Malik, D., 2019). And in the era of advanced technology, many hackers will create fake websites to obtain user information such as bank numbers and passwords, which is very dangerous. It is very difficult for people to identify whether a website is genuine or not, and it can endanger personal property. Most of the criminals also choose to cover their crimes considering the underdevelopment of facial recognition, which makes it difficult for the police to find criminals with the naked eye, and can only investigate through the evidence left at the scene, so this is very inefficient for the police (InnefuLabs, n.d.).

1.2. Objectives/Aims

- **increase convenience**
  The actions of users take attendance are reduced, and users only need to perform face recognition to take attendance. For example, when a user takes attendance, he no longer needs to sign by hand or punch a card, he only needs to show his face for the camera to collect data and identify it.

- **Add security features**
  Everyone has different facial features, so we take advantage of this to differentiate the face recognition possibilities for individual people's faces. For example, the system has permission restrictions, and users can only use facial recognition to unlock the use of permissions.

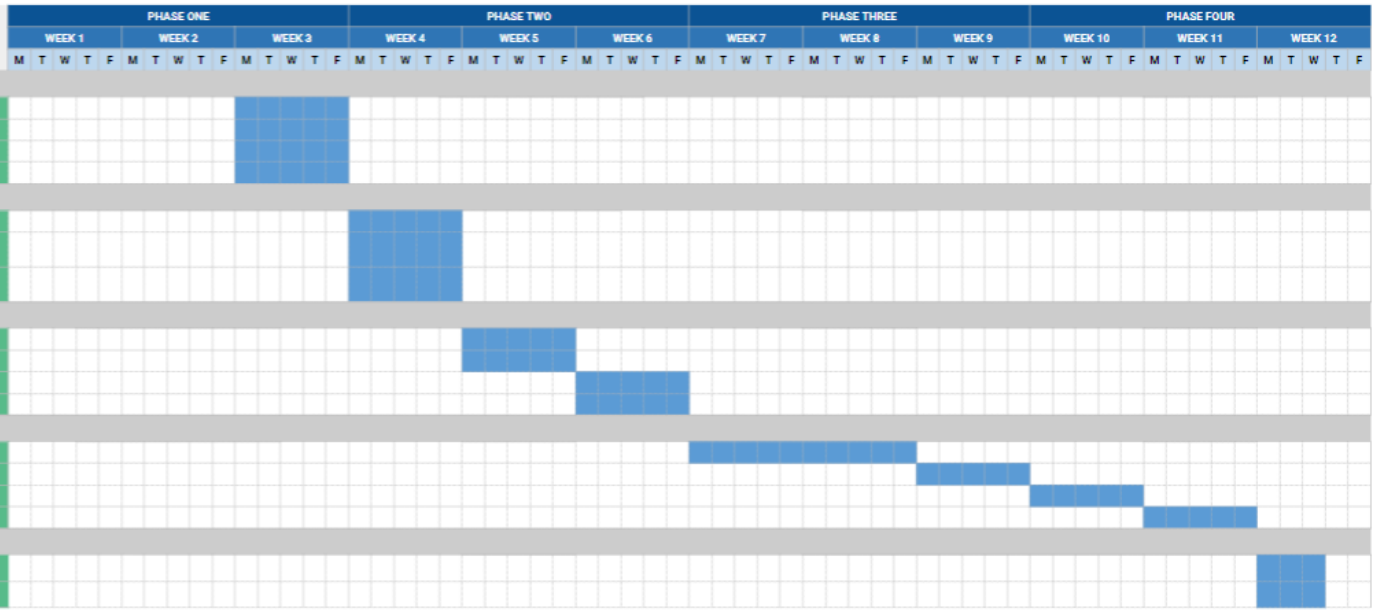
- **reduce crime**
  Facial recognition can reduce criminal incidents, such as thieves stealing bank cards or obtaining user information through some means, but thieves will get stuck at the level of facial recognition, and may store thieves' facial features in a database.

1.3. Motivation

Face recognition technology allows users to have the same authorization function as fingerprints in terms of security, in addition to the hassle of forgetting their passwords or trying to unlock their phones with a finger scan (Kaspersky, 2021). In addition, face recognition can also be used for attendance, office workers or students do not need manual attendance, and it also solves the problem of users forgetting manual attendance (Monika, n.d.). And under the database with facial recognition in full name, people who want to commit crimes will have nothing to hide, because everyone has certain facial features. Using facial recognition technology, the face of the criminal can be easily scanned and reported to the police for investigation, which greatly improves the efficiency of case handling.

1.4. Timeline/Milestone

WBS NUMBER	TASK TITLE	TASK OWNER	START DATE	DUE DATE	DURATION	PCT OF TASK COMPLETE
1	**Introduction**					
1.1	Problem Background	Individual	7/19/22	7/22/22	3	100%
1.2	Objectives/Aims	Individual	7/19/22	7/22/22	3	100%
1.3	Motivation	Individual	7/19/22	7/22/22	3	100%
1.4	Timeline/Milestone	Individual	7/19/22	7/22/22	3	100%
2	**Research Background**					
2.1	Background of the applications	Individual	7/25/22	7/29/22	4	100%
2.2	Analysis of selected tool with any other relevant tools	Individual	7/25/22	7/29/22	4	100%
2.3	Justify why the selected tool is suitable	Individual	7/25/22	7/29/22	4	100%
3	**Methodology**					
3.1	Description of dataset	Individual	8/1/22	8/5/22	4	100%
3.2	Applications of the algorithm(s)	Individual	8/1/22	8/5/22	4	100%
3.3	System flowchart/activity diagram	Individual	8/8/22	8/12/22	4	100%
3.4	Proposed test plan/hypothesis	Individual	8/8/22	8/12/22	4	100%
4	**Result**					
4.1	Results	Individual	8/15/22	8/26/22	11	100%
4.2	Discussion/Interpretation	Individual	8/29/22	9/2/22	3	100%
4.3	Effort and Cost Tracking	Individual	9/5/22	9/9/22	4	100%
4.4	Project Performance	Individual	9/12/22	9/16/22	4	100%
5	**Discussion and Conclusion**					
5.1	Achievements	Individual	9/19/22	9/21/22	2	100%
5.2	Limitations and Future Works	Individual	9/19/22	9/21/22	2	100%



2. Research Background

2.1. Background of the applications

Face recognition is computer programming studied by American researchers Bledsoe et al in 1964. And in 1977, the system was improved by adding 21 additional marks to the previous facial features, namely lip width, hair color, etc. The theoretical tools used previously were introduced in 1988. The first successful example of facial recognition technology, Eiginface, was proposed in 1991 by Alex Pentland and Matthew Turk of the Massachusetts Institute of Technology (MIT). Eiginface uses the statistical principal component analysis (PCA) method. Then in 1998, to encourage progress in industry and academia, the Defense Advanced Research Projects Agency (DARPA) developed the Face recognition technology (FERET) for face recognition. Project (FERET). Face recognition technology (FERET) provides a large and challenging database containing 2400 personal avatars of 850 people. In 2005, DARPA launched The Face Recognition Grand Challenge (FRGC) competition. In 2011, the industry developed rapidly due to the deep learning of the industry. This is a machine learning method based on artificial neural network. When we feed it more images, it can learn better. In 2014, Facebook claimed to have mastered how to recognize faces. The social network claims that its method, called Deepface, has close to 97% performance close to the human eye. And in recent years, due to the malicious use of people with intentions to steal the faces of celebrities and put them in bad use, more people know that the technology of facial recognition has reached a level that is easy to be faked. Advances in facial recognition have also encouraged multiple investments due to business, industry, law and government (Adjabi, I., Ouahabi, A., Benzaoui, A. and Taleb-Ahmed, A., 2020).

2.2. Analysis of selected tool with any other relevant tools

Tools comparison	**Remark**	**cv2**	**PIL**	**Matplotlib**
Type of license and open source license	State all types of license	Apache 2 license	HPND License	PSF license
Year founded	When is this tool being introduced?	2000	1995	2003
Founding company	Owner	Intel Corporation, Willow Garage, Itseez	Fredrik Lundh	John D. Hunter
License Pricing	Compare the prices if the license is used for development and business/commercialization	Free	Free	MYR 2,868.00
cvs	What features that it offers?	Feature Matching + Homography to find Objects	Can perform various operations on images such as cropping, resizing, adding text, rotating, grayscaling, and so much more using this library.	Setting the aspect ratio of the axes box
Common applications	In what areas this tool is usually used?	huge open-source library for the computer vision, machine learning, and image processing	Powerful library for processing images	cross-platform, data visualization and graphical plotting library for Python and its numerical extension NumPy
Programming language used	`what programming languages can be used ?`	C, C++, Python, Java, Assembly language	Python	Python
Limitations	The drawbacks of the software	does not provide the same ease	Pillow was announced as a replacement for PIL	It wasn't designed for exploratory data analysis and visualization. It is also very unwieldy when dealing with multiple datasets while it is easy to convert a dataset into a long format and plot it. The library is very low-level, which means that one needs to write more code to get the visualization

2.3. Justify why the selected tool is suitable

Compared to the other 2 libraries, cv2 is the most suitable to use in this project because it is free without any cost, the cv2 library is a large open source library for computer vision, machine learning and image processing. The cv2 library can match the school and homography search objects for the characteristics of the people in the photo. In addition, CV2 can support multiple languages such as C, C++, Python, Java, assembly language and other programming languages. The limitation of CV2 is just not convenient, we can only do what we want by programming, such as letting the system detect photos.

3. Methodology

3.1. Description of dataset

Perform face recognition must have a certain number of photos, so that the system can recognize it so that it can accurately identify whether there is a person in the database. Our database is divided into 19 groups in total, each group of photos is divided into training-data and test-data, training-data has a total of 10 photos, to ensure that the system can detect the person in that photo. There are more than 10 photos in test-data, the format of each photo is Jpeg, the size of the photo does not exceed 1900x1080, and the memory does not exceed 1mb.

3.2. Applications of the algorithm(s)

In face recognition, I use Eigenface, a face recognition technology invented in 1991. Eigenface is the name given to a set of features used in the computer vision problem of face recognition. The method of recognition using eigenfaces was invented by Sirovich and Kirby. It was later used for face classification by Matthew Turk and Alex Pentland (Turk, Matthew A; Pentland, Alex P, 1991). Eigenfaces refers to an appearance-based face recognition method designed to capture changes in a collection of face images and use this information to encode and compare images of individual faces as a whole. Eigenface facial recognition technology is also considered the first effective facial recognition technology, and it is the basis for one of the top commercial facial recognition technology products (Kline, C., 2017). Eigenfaces are still often considered a baseline comparison method to demonstrate the lowest expected performance of such systems.

Eigenfaces facial recognition technology is to extract relevant facial information such as basic facial features such as eyes, nose and lips. One approach is to capture statistical changes between facial images. Efficiently represent face images. To reduce computation and space complexity, a small number of picture parameters can be used to represent each face image. Eigenfaces can be thought of as a set of features that characterize the global variation between face images. Each face image is then approximated using a subset of eigenfaces that are associated with the largest eigenvalue. These features explain the largest variance in the training set (Chen, L.-W., Ho, Y.-F. and Tsai, M.-F., 2018). And a set of eigenfaces can be generated by performing a mathematical process called principal component analysis (PCA) on a large number of images depicting different faces, any face can be thought of as a combination of these standard faces. For example, a person's face might consist of the average face plus 10% of eigenface 1, 55% of eigenface 2, or even -3% of eigenface 3. And it is not necessary to combine many eigenfaces together to achieve a fair approximation of most faces. Also, because faces are not recorded by digital photos, but only as lists of values, each person's face takes up much less space. (Kline, C., 2009).

When Eigenfaces face recognition technology reads pictures, it obtains the face images in the database, and uses the function read_images to read all the images in the specified directory. The images are divided into subcategories, and these subcategories are the names of people. For example Lebron_James_1. These nouns will be kept in a separate array as a reference between the image and the person's name.

In this project, I built the order in the python programming language as Import libraries, face detection, prepare training dataset, initialize a face recognizer, train the face recognizer model, and predict output on test data.

3.3. System flowchart/activity diagram

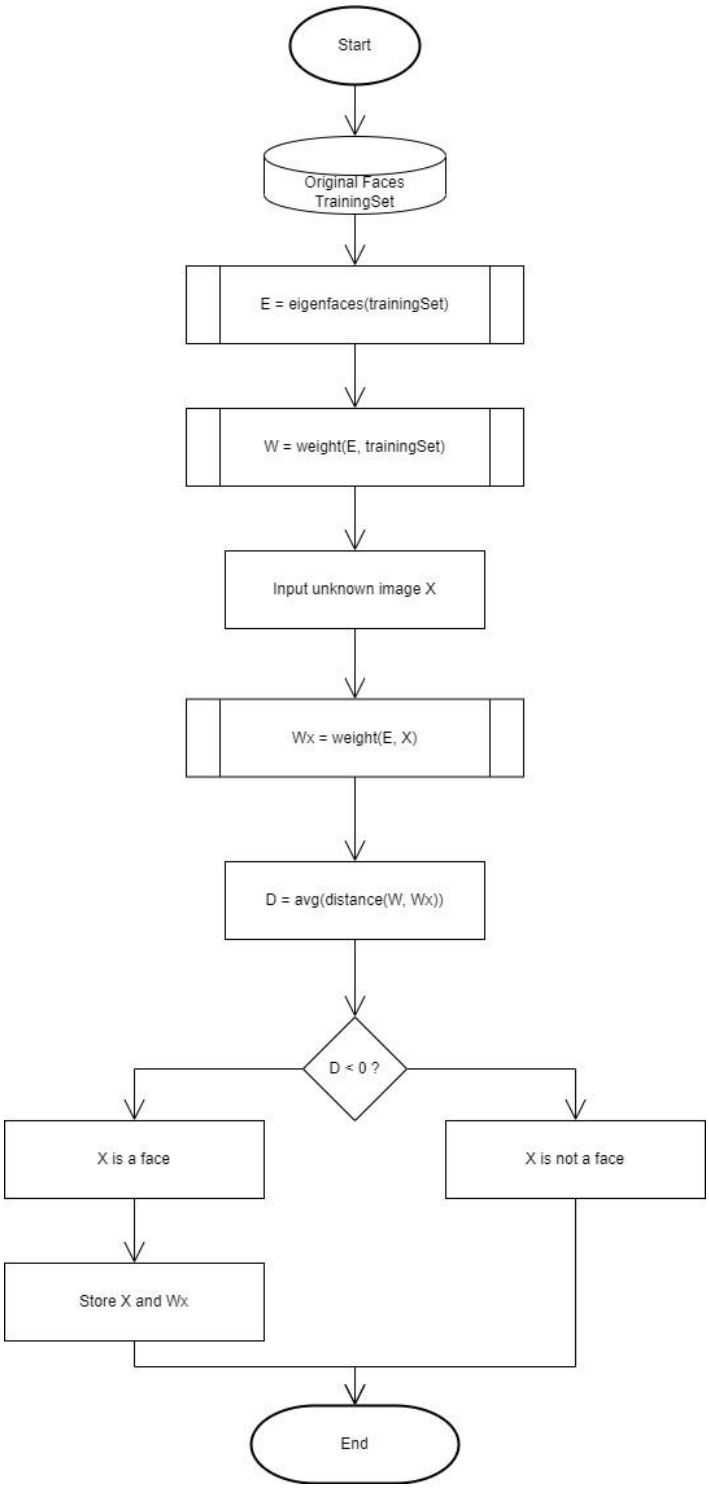


Figure1: Eigenfaces Algorithm for Face Recognition Flowchart

3.4. Proposed test plan/hypothesis

Project assumptions:
H1: Results with preprocessed data are more accurate than results without data preprocessing

In order to implement this hypothesis, I previously prepared a set of 20 photos of the training-data and prepared 2 identical test-data photos, one photo with facial features filled with blue dots, the other photo is There are no photos of the blue dots. And through the function predicted_image, label = predict(test_image), to check the face recognition.

4. Result

4.1. Results

4.1.1 Without pre-processing

Figure 2: Picture with blue dots

```
In [16]: test_image = cv2.imread("dataset/test-data/1/LeBron_James_22.jpg")

In [17]: predicted_image, label = predict(test_image)

---------------------------------------------------------------------------
TypeError                                 Traceback (most recent call last)
Input In [17], in <cell line: 1>()
----> 1 predicted_image, label = predict(test_image)

Input In [12], in predict(test_image)
      4 label= eigenfaces_recognizer.predict(resized_test_image)
      5 label_text = tags[label[0]]
----> 6 draw_rectangle(test_image, rect)
      7 draw_text(test_image, label_text, rect[0], rect[1]-5)
      8 return test_image, label_text

Input In [11], in draw_rectangle(test_image, rect)
      1 def draw_rectangle(test_image, rect):
----> 2     (x, y, w, h) = rect
      3     cv2.rectangle(test_image, (x, y), (x+w, y+h), (0, 255, 0), 2)

TypeError: cannot unpack non-iterable int object
```

Figure 3: Result

According to the results, if the number of blue dots is large enough, it will affect the system's recognition of photos and if the database does not have other people's photos, it will not recognize other people's faces but will indicate errors.

```
In [19]: test_image = cv2.imread("dataset/test-data/1/LeBron_James_21.jpg")

In [20]: predicted_image, label = predict(test_image)

In [21]: fig = plt.figure()
         ax1 = fig.add_axes((0.1, 0.2, 0.8, 0.7))
         ax1.set_title('actual class: ' + tags[1]+ ' | ' + 'predicted class: ' + label)
         plt.axis("off")
         plt.imshow(cv2.cvtColor(predicted_image, cv2.COLOR_BGR2RGB))
         plt.show()
```

Figure 4 : Picture in Original and the Result

If there is no blue dot interference, it can be recognized normally. So based on this result, I can be sure that this hypothesis is accepted.

4.2. Discussion/Interpretatio

From the results obtained above, if the photo is preprocessed, it may affect the system's recognition of the photo, or increase the difficulty of the system's recognition, and the recognition result may be wrong. If there are preprocessed photos and original photos, it will be easier to recognize, but compared with other technologies, Eigenface pays more attention to changes in facial angle and ambient light, which will affect the recognition success rate.

Compared with The Local Binary Patterns Histograms (LBPH) method, LBPH has a higher more stable success rate. As long as the database provided by the user has enough face samples and the number of face samples is greater than 7, the success rate of face recognition will be higher and more stable. And the LBPH method is simple to implement and fast to calculate, LBPH is feasible for real-time systems, but its recognition success rate may decrease when it recognizes images with pixels with similar color values.

Compared with the Scale Invariant Feature Transform (SIFT) method, the SIFT method can match the pictures of people with different background changes. Eigenface can only recognize the monotonous background picture or the blurred background. If there are multiple people Avatars may be identified incorrectly. The SIFT method does not have this concern, because SIFT is a method for extracting unique invariant features from an image, which is invariant in image scale and rotation, and is invariant in affine distortion, 3D viewpoint change, noise addition and lighting. Provides robust matching over a considerable range of variation. Features are highly unique, i.e. a single feature can also be correctly matched with a high probability, and recognition is obtained by matching a single feature with a database of features of known objects using a fast nearest neighbor algorithm.

Compared with the three face recognition technologies, Eigenface is the first face recognition technology discovered, so most of the technologies are derived from the Eigenface algorithm or invented as a base. Eigenface uses Principal Component Analysis (PCA) method for face recognition. The Local Binary Pattern Histogram (LBPH) method compares each pixel in an image with its surrounding pixels, and each pixel can be represented by a binary value, called the Local Binary Pattern (LBP). It is more efficient than Eigenface because the requirements for the angle of the photo and the background are not as high. The Scale Invariant Feature Transform (SIFT) method is to use the fast nearest neighbor algorithm to match each single feature, then perform Hough transform to identify clusters belonging to a single object, and finally obtain the matching object through the least squares solution of the consistent pose parameters . Comparing the three techniques, the Scale Invariant Feature Transform (SIFT) method has the smallest

effect on light and shadow, influence, and the number of faces , and it does not need to be learned by the system, but only needs to be compared directly.

From the results the correct result obtained in Eigenface face recognition was only successful 2 times out of 10, and the remaining 8 times were name mismatches. The LBPH algorithm of facial recognition technology can get the answer correctly 5 times out of 10 times, and the remaining 5 times are name mismatches. In the SIFT method, we compare each set of photos, and occasionally the matching is not accurate. Scale Invariant Feature Transform (SIFT) has been shown to be very powerful for general object detection/recognition. More recently, it has been applied to face recognition. However, the original SIFT algorithm may not be optimal for analyzing face images. The optimal solution is Local Binary Pattern Histogram (LBPH). It's the best match.

5. Discussion and Conclusion

5.1. Achievements

In this project, we have successfully performed face recognition on the photos, compared with the photos in the database and successfully recognized. According to the performance of the Eigenface algorithm I used in this project, it can be used as face recognition. The basis of the technology, even if there are other people next to the recognized object, it will not recognize errors, so it has a certain accuracy and precision. And completed the three goals mentioned above. And I believe that it can be fully applied to increase the convenience of the attendance system. Facial recognition can also add authorization, because the database is compared with the recognized facial features, and authorization is granted if correct. The last goal is to reduce crime. Through face recognition technology, as long as the criminals have not completely changed their faces, they can be successfully identified by eyes, nose, lips or other facial features.

5.2. Limitations and Future Works

The limitation of the project is that the angle of the photo is very strict, because the system will completely focus on the front face when learning the photo, and ignore the side face. Therefore, the eigenface is not accurate when dealing with the avatars of people whose expressions and emotions change greatly. , such as a picture of mouth is open and angry shout, or a sideways smile. As a result, the identification is unsuccessful, Or such photos in the database will also be ignored. And if there are many other faces in the background, it may be wrongly recognized, so a cleaner background may be required, which is difficult to achieve in a real environment. Eigenfaces have been replaced by better techniques, so it can only be used as a basis for comparison. Personal factors, the time we spend in the project is very short, so in the future we can use better algorithms to increase the success rate of face recognition and can be added to the attendance system to allow workers or students to increase the number of times work efficiency.

Reference & Source

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