Facial Expression Recognition Using Eigenface Method in MATLAB

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Abstract

The eigenface method is a classic method in face recognition. Facial expression recognition, as an extension of face recognition also adopted this method in the beginning. This article is a summary of the project, which used the eigenface method to recognize the facial expression. This project aimed to recognize the facial expression captured from the front camera. It used a set of single static image with different expression labels as the training database, projected the training image to subspaces. And then it calculated out the similar face of the tested expression in the training database, and gave out the label of that face as the recognition result of captured face. The result demonstrated several shortages of this eigenface method in face expression recognition. Due to it depended on the gray level similarity of the training image set and the given test image, it would be influenced greatly while the light, angle, face size and face color were changed in either training database or the captured test image.

1. Introduction

Facial Expression is an important communication channel other than language. The psychologist Russell pointed out that only 7% of information was conveyed through language during people's everyday communication, while the face expression might send out 55% of the communicated information [1]. Along with the development of computer vision, the automatic facial expression recognition has become a hot direction. And it has broad application field, such as security, healthcare, human-computer interface, and robotics.

The facial expression recognition study started at 1978, when Suwa and Sugie tired to recognize the pattern of facial expression from an animation video of face [2]. Since then a serials of algorithms used in facial expression recognition were blooming. In 1971, psychologists Ekman and Friesen identified 6 basic facial expressions: surprise, fear, disgust, anger, happy and sad. Then in 1978, they developed the Facial Action Coding System (FACS) to detect the minor changes in facial expression. This system divided the human face into several action units (AU) which were used to describe the face movement. The 6 basic face expressions and the FACS then became the basis of the study of facial expression recognition [3].

The eigenface method was firstly introduced and evoked broad interest in the field of face recognition, then it became a classic and benchmark method in this field. While the facial expression recognition is considered as an extension and also a branch of face recognition field, the eigenface method was also adopted in facial expression recognition. Then many advanced algorithms has stepped on to the stage, however, the eigenface method is still taught and used in some cases [4].

This project aimed to recognize the face expression captured from the front camera. It used a set of single static images with different expression labels as the training database, projected the expression to different spaces, and calculated out the similar face expression in the training database, thus gave out the label of that face as the recognition result of the captured face. This article reported the project. The article introduced the project briefly and then reviewed the related work in the field of facial expression recognition. Thirdly, it explained in details about the project implementation. After that, it discussed the result and concluded the shortages and advances of using the eigenface method in facial expression recognition.

2. Related Work

Based on the different recognition objects, there are basically two types of facial expression recognition: Single Static Image based facial expression recognition and Dynamic Image Sequence based facial expression recognition. The single static image based facial expression recognition refers to indentifying the expression in one single, non-related and static facial image, while the later one refers to indentifying the expression in a serials of related dynamic images such as a video. These two types of facial expression recognition worked with different strengths and shortages. For the single static image based facial expression recognition, it only extracts the features

from the single image, so the methods were relatively simple and easy to compute. However, it ignored the time information and face movement information. While the dynamic image sequence based face expression recognition considers the time information and face movement information, it extracts the changes of facial expressions in every frame and also the features of face movement, thus it usually leads to heavy computation work. With more information is taking into consideration, the Dynamic Image Sequence based facial expression recognition reached more reliable results, and it also the hot field in facial expression recognition nowadays. It mainly adopted the optical flow method.

The basic working flow of facial expression recognition is 1) face recognition; 2) face feature extraction; 3) expression recognition. Yingli Tian, Takeo Kanade, and Jeffrey F. Cohn illustrated this work flow as in Figure 1.

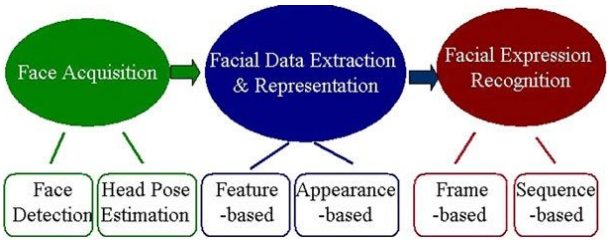

Figure 1: Basic structure of facial expression analysis system [5].

2.1. Face Acquisition

Face detection is the major problem in this step. It refers to recognizing and localizing the human faces from the given images or videos. The major challenges of this step were: 1) different skin color, face shapes, view angles; 2) occultation by glasses, hair or hat; 3) light condition.

There are two major methods of face detection: global consideration and feature analysis. The global consideration methods include template and skin color based. While the feature analysis refers to detecting important features such as eyes and mouth and then calculating the face area.

2.2. Facial Data Extraction

Facial feature extraction is the major problem in this step. It refers to extracting the information of face movement or face feature deformation. And in most cases, these feature extraction would generate giant data and request further dimension reduction.

Major methods in this step include: geometric feature extraction, statistical feature extraction, frequency domain feature extraction and movement feature extraction.

The geometric feature extraction extracts face features based on the knowledge of face structure. It extracts the eyes, nose and mouth to represent the whole face. In this way, the data size would be compressed. However, it also may lose some important facial expression changing features.

The statistical feature extraction requires large size of sample training. The eigenface method belongs to this category, and used to be the most common method in face recognition. The statistical feature is based on the whole grey level characteristics, and it reserved the original face expression information as much as possible. However, the quality of the training sample would greatly affect the final result.

The representing of frequency domain feature extraction is the Gabor filter, which is now broadly adopted in the facial expression recognition [6]. It could reduce the influence of lighting.

The movement feature extraction differed much from the methods above. It is mainly adopted in the dynamic image sequence based facial expression recognition. It mainly includes feature points tracking [7] and optical flow [8].

2.3. Facial Expression Recognition

Facial Expression Recognition mainly involves two types of problems: one is the expression type and the other is the recognition method. As introduced previously, the 6 types of expression were broadly accepted. While the recognition methods contains: expert rules, neural network, support vector machines (SVM) and hidden Markov model (HMM).

3. Implementation

This project aimed to recognize the face expression captured from the front camera. For the face acquisition step, it used skin color based face detection method. For the face feature extraction and expression recognition step, it used the eigenface method, which utilized a set of single static image with different expression labels as the training database, projected the expression to subspaces, and calculated out the similar face expression in the training database, thus gave out the label of that face as the recognition result of captured face. Figure 2 below demonstrated the major steps of this project followed detailed implementation explanation.

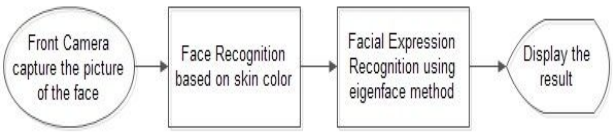

Figure 2: the major steps of this project

3.1. Capturing the image from the front camera

The objective of this step is to capture a static image of the user face with certain expression. The captured image was served as the test picture to be recognized later.

In this step, the front camera would be open, and the user could left click the mouse while he/she was making certain face expression to it.

The captured picture was suggested to be saved to the test image file for further use.

Figure 3 below showed the interface of this step.

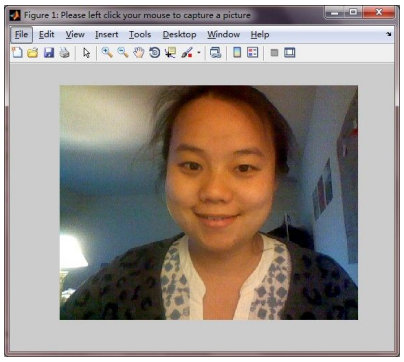

Figure 3: The step of capturing picture of certain face expression.

3.2. Face detection in the given image

Considering that the captured picture was from the front camera, there would mainly be one face sitting in the center of the picture. So a relatively simple face detection method would work here.

The skin color based face detection is based on the study that in the YCbCr color space, the skin color of human is concentrated distribution [9]. So we read in the captured picture, turned it to YCbCr color and detected the Cr color in the following range: 10<Cr & Cr<255. Thus we get the skin area.

As there has already been toolbox for this function, Tolga Birdal's code was cited and used in this step [10].

Figure 4 below showed the interface of this step.

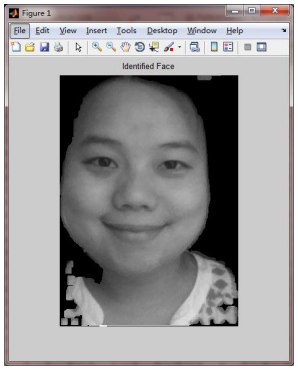

Figure 4: The step of face recognition.

3.3. Compute the eigen subspace

The training images and the captured images were all preprocessed by the load image function (loadImage.m): resize and generate the matrix as the input for the PCA (Principal Component Analysis) function (princomp from the MATLab toolbox). Then the training images were loaded to generated a low dimensional face space and also the projected versions of all these training images. The captured image was also projected onto the face space, which means that the captured image was represented by the selected principal components [11] [12].

3.4. Recognition

The Euclidian distance of the projected test image from each projected training image was calculated. The minimum Euclidian distance represented that the right training image was the most similar one to the captured image, which means they were considered to be sharing the same label of the face expression on that training image [11] [12].

4. Results

When the training images and the captured images were from the same face, and with good light condition, the recognition result was optimized. However, if the training images and the captured image were from different faces, it would influence the recognition rate.

Also, the size of face in the image would affect the result. If the face was smaller in the training images (captured at further distance), while the captured face was much larger, it would also lead to the failure of recognition.

5. Conclusion

The eigenface method is a classical method in the field of face recognition. And it also could be used in the field of facial expression recognition. The basic concept of the eigenface method is Principal Component Analysis and distance calculation. It is a simple but important method and its basic concept influenced numerous advanced algorithms in this filed.

The facial expression recognition using eigenface method worked well while the training image and the to-be-recognized image were the face of the same person in good lighting condition. However, it also demonstrated its limitation. Due to it depended on the gray level similarity of the training image set and the given test image, so it would be influenced greatly while the light, angle, face size and face color were changed in either training database or the captured test image.

References

[1] Mehrabian, A. (1968). Communication without Words. , 4. Retrieved , from http://www.skillschannel.tv/Communication%20-%20WithoutWords%20-%20A.%20Mehrabian.pdf

[2] S Suwa, M., Sugie, N., & Fujimora, K. (1978). A Preliminary Note On Pattern Recognition of Human Emotional Expression. International Joint Conference of Pattern Recognition, , 3. 408--410

[3] Ekman P,Friesen W V，Hager J C.(l978). Facial Action Coding System：Consulting Psychologists Press Palo Alto，CA，

[4] TURK, M. (2013). Over Twenty Years of Eigenfaces. ACM Trans. Multimedia Comput. Commun., , 5..

[5] Stan Z., L., & Jain, A.K. (2011). Chapter 19 Facial Expression Recognition. Handbook of Face Recognition (2nd ed., p. 3). New York: Springer.

[6] Tian Y, Kanade T, Cohn J F.(2002). Evaluation of Gabor Wavelet. Based Facial Action Unit Recognition in Image Sequences of Increasing Complexity: IEEE Computer， 229-234.

[7] Otsuka T， Ohya J.(1999). Extracting Facial Motion Parameters by Tracking Feature Points，Lect Notes Comput Sci, 433-444.

[8] Mase K.(1991). Recognition of Facial Expression From Optical Flow, IEICE transactions, 74(10)：3473-3483.

[9] Pai Y, Ruan S, Shie M, Liu Y, (2006). A simple and accurate face detection algorithm in complex background. IEEE International Conference on Multimedia and Expo.

[10] Tolga Birdal, Simple Face Detection, retrieved from: http://www.mathworks.com/matlabcentral/fileexchange/23382

[11] Turk M ,Pentland A.(1991). Eigenfaces for Recognition.Journal of Cognitive Neuroscience ,3(1) .

[12] Peter N. Belhumeur, Joao P. Hespanha, and David J.(1997). Kriegman Eigenfaces vs. Fisherfaces: Recognition Using Class Specific Linear Projection。 IEEE Transactions on pattern analysis and machine intelligence, vol.19, No.7, July 1997.