Facial Expression Recognition System based on Geometric Feature

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Abstract

The facial expression recognition system has been a significant field in human-computer interaction. It is a considerably challenging field to generate an intelligent computer that is able to identify and understand human emotions for various vital purposes. This paper focuses on facial expression to identify five universal human expressions: neutral, happy, anger, sad and surprise. The proposed system uses a technique of image processing consisting of 3 major processes: 1) pre-processing of images, 2) geometric feature extraction of eyes and mouth from images, used for a calculation of Euclidean distances between each feature; and 3) face expression recognition using principal component analysis method. Especially, the movement of the mouth is investigated for expression recognition in this paper. The effectiveness of the proposed system can be confirmed through the experimental results.

Keywords: Expression Recognition, Movement of the mouth, Geometric facial feature, component analysis

1. Introduction

Facial expression recognition plays a principal role in human-computer interaction. In recent years, numerous algorithms for facial expression analysis from static images have been proposed, which are quite different in the facial features. Conventional methods extract facial features and recognize the expressions from changes in their shapes or their geometrical relationships by different facial expressions when we watch two photos of a human face, we can answer which photo shows the facial expression more strongly. Accordingly, as extending the step of facial expression recognition, we think it is important to develop a measurement method of the strength of facial expressions.

A number of methods that have been developed for representing faces for identity recognition may be powerful for expression analysis. These approaches are also included in the present comparison. These include local feature analysis [1], independent component analysis [2], Gabor wavelets [7], [9], and linear discriminant analysis [5]. Previous works on facial recognition systems using the static image have good results recognition [6, 3]. Recognition methods for the image sequence have also emerged [4].

Unlike other existing facial expression recognition systems, the proposed system uses the geometric parameter of human face that mainly emphasize the movement of the mouth from the static image. The contribution of this system is that the percentage of accuracy can improve because the numbers of the extracted facial features have a few parameters; therefore the system can be more important, stronger and more sufficient to facial expression recognition system. In this paper, we use the principal component analysis algorithm for identifying the neutral, happy, anger, sad and surprise expressions from the static image.

The paper is arranged as follows. Section 1 gives introduction, section 2 proposed system design, section 3 shows proposed system architecture, section 4 describe briefly about principal component analysis, section 5 gives results and discussion, and section 6 presents conclusions and future work.

2. Proposed System Architecture

The proposed system can be divided into three main stages: pre-processing, feature extraction and recognition. The first step is face detection that generally enter the image to segment the face image. Then feature extraction process will applied on the face image in order to extract the geometric feature such as eyes and mouth. Finally this feature is recognized with principal component analysis. The overall structure of the proposed facial expression recognition system is shown in figure 1.

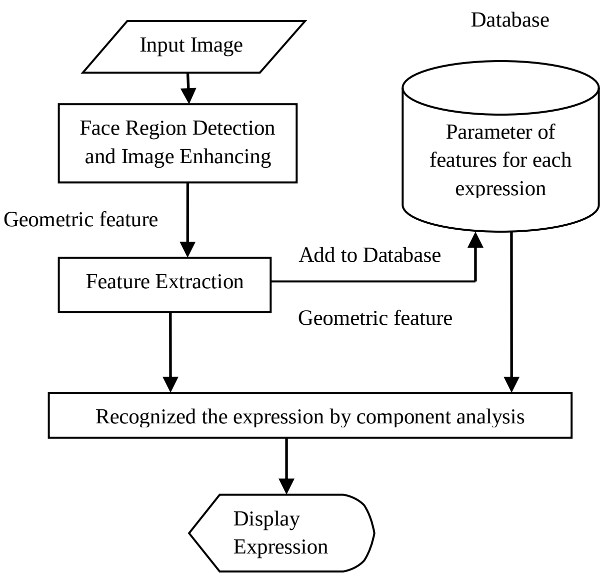
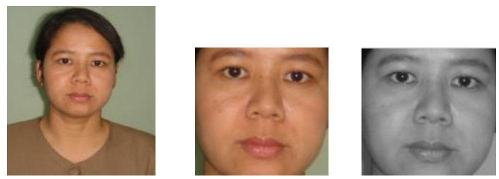


Figure 1. The proposed facial expression recognition structure

2.1 Face Detection

The first step of preprocessing consists of two steps: firstly, the face region is cropped from the input image by using cropping tool; secondly, unifying the properties for lighting the image and removing noise. Grayscale converting, noise filtering is performed. These results are shown in figure 2.



(a) (b) (c)

Figure 2. (a) input image (b) face region (c) gray scale converting and noise filtering

2.2 Facial Features Extraction

Generally the most important step in the field of facial expression recognition is the facial feature extraction which based on finding a set of features that conveying the facial expression information. This problem can be viewed as a dimensionality reduction problem (transforming the input data into a reduced representation set of features which encode the relevant information from the input data). This paper uses geometric features such as eyes and mouth.

This system can extract these features using the training positions that train from the train images. The mouth region and eye region can get using the canny edge detection with threshold value 0.6. So, this system is more accurate by using canny edge detection. This system emphasizes mainly the mouth region. In extraordinary case, the eyes can be considered. This feature points use for a calculation of Euclidean distances between these features.

2.3 DISTANCE BASED FEATURES

The proposed system evaluates the mouth and eyes features and they consist of distances between certain points as described below. The features (*F1 – F16*) are obtained from the geometric features (see Figure 3). This system calculates Euclidean distance. This is probably the most commonly chosen type of distance. It simply is the geometric distance in the multidimensional space. It is computed as:

$$distance(x,y)=\sqrt{\sum_i (x_i - y_i)^2}$$

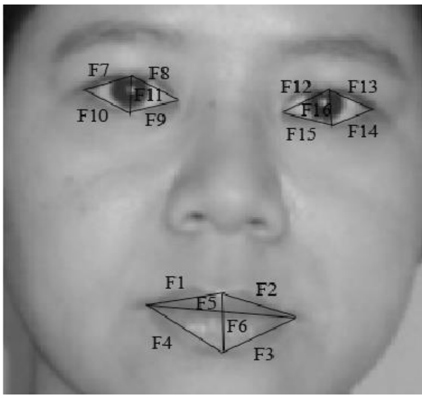


Figure 3. The 16 distance based geometrical features of a face

Mouth: *F1, F2:* distance between the upper lip and the left/right mouth corner. *F3, F4*: distance between the lower lip and left/right mouth corner. *F5*: vertical distance between the left and right mouth corner. *F6*: horizontal distance between the upper and the lower lip. In addition, Distance ratio is considered between the vertical distance and horizontal distance *(F6/F5).* In addition, Distance-ratio is considered between the horizontal distance1 and vertical distance2.

The facial feature vector is then:

V = [*F1; F2; F3; F4; F5; F6; Distance-ratio*]

This vector represents each person by a unique way. These parameters will be stored in database. And then it will be used for the recognition step. In extraordinary case, this system can consider the eye regions as follows:

Eyes: *F7, F8, F12, F13*: distance between the outer eye (right/left) corner and the upper eyelid. *F*9, *F*10: distance between the lower eyelid and the outer eye (right/left) corner. *F11, F16*: distance between the upper eyelid and lower eyelid. *F9, F10, F14, F15*: distance between outer eye corner and the lower eyelid.

2.4 Facial Expression Recognition

The last stage in this system is the recognition of the facial expressions. This system recognizes principal component analysis with the parameter of the training expression. A text file is generated which shows recognized expression. This system can execute online or offline.

3. Principal Component Analysis

Principal Component Analysis is a main technique used for data reduction and feature extraction in the appearance-based approaches. Eigenfaces built based on these technique, has been proved to be very successful [8].

Principal Component Analysis (PCA) is a statistical used for dimension reduction and recognition, and widely used for facial feature extraction and recognition. PCA is known as Eigen space Projection which is based on linearly Projection the image space to a low dimension feature space that is known as Eigen space. A 2-D facial image can be represented as 1-D vector by concatenating each row (or column) into a long thin vector. Let's suppose we have M vectors of size N (=rows of image × columns of image) representing a set of sampled images. Pj's represent the pixel values.

$$x_i = (p_1, ..., p_N)^T \quad (1)$$

where i=1,……,M

The images are mean centered by subtracting the mean image from each image vector. Let m represent the mean image.

$$m = \frac{1}{M}\sum_{i=1}^{M} x_i \qquad (2)$$

Calculate the Covariance matrix to represent the scatter degree of all feature vectors related to the average vector. The Covariance matrix C is defined by

$$C = \frac{1}{N}\sum_{i=1}^{N}\left(X_i - \overline{X}\right)\left(X_i - \overline{X}\right)^T \qquad (3)$$

The Eigenvectors and corresponding eigenvalues are computed by using

$$CV = \lambda V \qquad (4)$$

where V is the set of eigenvectors associated with its eigenvalue λ.

Sort the eigenvector according to their corresponding eigenvalues from high to low. Each of the mean centered image project into eigenspace using

$$W_i = V_i^T\,(Xi - \overline{X}) \qquad (5)$$

In the testing phase each test image should be mean centered, now project the test image into the same eigenspace as defined during the training phase.

This projected image is now compared with projected training image in eigenspace. Input images are compared with similarity measures. The minimum difference between any pair would symbolize the best possible matched facial Expression.

Euclidean distance is the most common use of distance. Euclidean distance, or simply 'distance', examines the root of square differences between the coordinates of a pair of objects. This is most generally known as the Pythagorean Theorem. Let an arbitrary instance x be described by the feature vector

$$x = [a_1(x), a_2(x), \ldots, a_n(x)] \qquad (6)$$

where $a_r(x)$ denotes the value of the r^{th} attribute of instance x. Then the distance between two instances x_i and x_j is defined to be d (x_i, x_j):

$$d(x_i, x_j) = \sqrt{\sum_{r=1}^{n}\left(\left(a_r(x_i) - a_r(x_j)\right)\right)^2} \qquad (10)$$

For testing we used the Euclidean distance classifier, for calculating the minimum distance between the test image and image expression to be recognized from the database. If the distance is small, we say the images are similar and we can decide which the most similar image in the database is. We can see a text file that shows the recognized expression.

4. Experimental Results

In this experimental results, this system use images from 8 subjects that are selected from Japanese Females Facial Expression (JAFFE) and our database. The proposed system tested all five universal expressions: namely happy, angry, sad, surprise and natural. The portion of data are made by choosing about 65% training data and 35% test data from the total number of data in each set of subject.

The input image may be the color image or gray image. The graphic user interface is applied for developed system implementation. The emotion recognition menu of the developed program is described in figure 4.

The image selection box can be seen by clicking ‘select image’ as shown in figure 5. After loading the input image, this image is manually selected in order to get the face image. So, the system can get only the face image. The third choice of the main menu is that the image feature will be extracted depending on the training data. And the extracted image can be stored in database by clicking ‘Add to Database’. The image can be deleted the whole database by clicking ‘Delete Database’.

The user can show the number of face stored in database by clicking ‘Info database’. Therefore, the extracted feature of one image will be detected on the bases of the extracted feature Database of the training data. The major process of this paper is expression recognition by clicking ‘Facial Expression Recognition’ button. Euclidean classifier will be applied to the image feature to identify its expression. Our database and JAFFE database is shown in figure 5 and 6.

To try PCA on the face images, we need to find the mean face. Mean face for each expression is stored in our database as shown in figure 7 (a to e).

An important observation suggests that the best-recognized category is Surprise 98 % followed by Happy 95% even though Happy and Surprise were often confused for each other as shown in table 1. Possible reason might be, in both cases the mouth is widely opened.

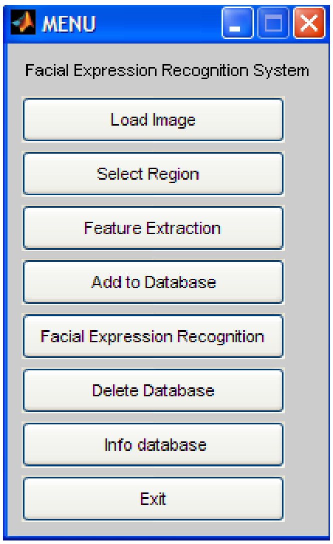


Figure 4. Main menu of the facial expression recognition system

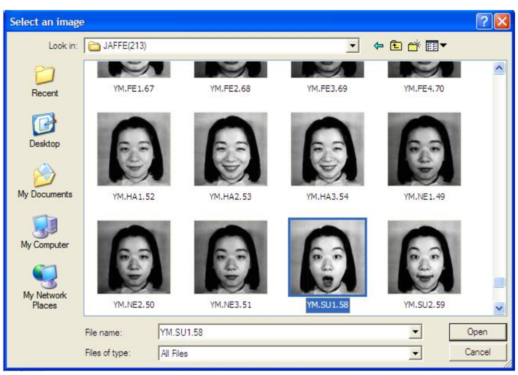


Figure 5. Some images in JAFFE database

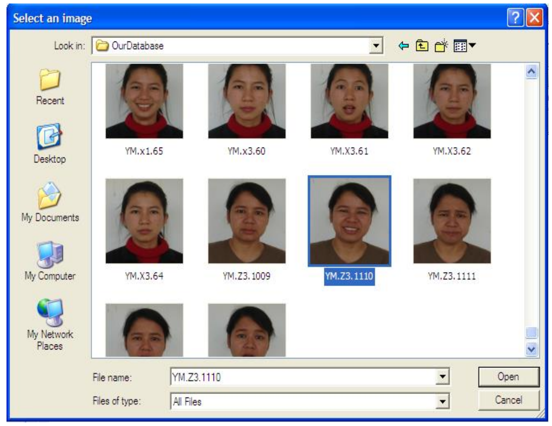


Figure 6. Some images in our database

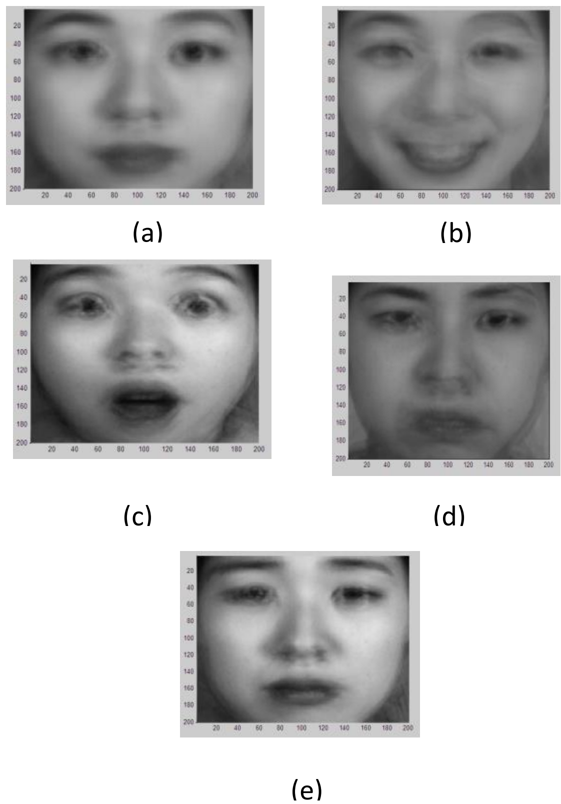


Figure 7. Mean Face for each expression (a) neutral, (b) happy, (c) surprise, (d) anger, (e) sad

Table 1. Recognition Rate of Facial Expressions of JAFFE and our Database

Expression \ Database	Our Database	JAFFE Database
Natural	93	95
Happy	95	96
Surprise	98	99
Anger	93	92
Sad	90	89

When we compare the performance of the facial expression recognition system that is based on principal component analysis with the two used database, the two recognition rates are almost equally recognized.

In the supposed usage (JAFFE) database, there were ten different form faces that represent the expressions. At this stage, eight forms have been chosen with examples representing different expressions of the training system. In contrast, for the supposed usage (our) database, the training data and testing data are not divided because of the age of people. And then we considered real time applications.

5. Conclusion

This paper presents expression recognition system based on geometric feature. It addressed the problems of how to detect a human face in static images and how to recognize facial expressions presented in those faces. Experimental results show that the proposed system using PCA outperforms others. The recognition rate of the system obtained 93.8%. It takes only 0.0346 second to process one input image of size 200 × 200. In this work the proposed system deals with the static images. The future work will be the dealing with other types of images such as image sequence and 3D images.

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