Semi Automatic Process of Feature-Based Approach to Face Recognition by using SVD

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Abstract

Face recognition (FR) is a very challenging problem and up to date. Due to dissimilarity in human pose, facial expressions, hairstyle, image style and lighting condition, the problem is very difficult. This paper proposes the method of the face recognition focus on still image in frontal view. The facial feature is extracted from the face in frontal view or near frontal view. The silent feature region also extract from the two eyes and the mouth. Singular value decomposition approach is applied for detecting the matching point pairs. Some experiments have been done to confirm the effectiveness of our system.

Keywords: Face Recognition, Facial Feature, Frontal View, Singular Value Decomposition (SVD), and Matching Pairs, Euclidean Distance.

1. Introduction

Face recognition is an interesting problem in the computer vision with many commercial and law enforcement applications. User verification and user access control, crowd surveillance, and enhanced human computer interaction all become possible if an effective face recognition system can be implemented. While research into this area dates back to the 1960's, it is only very recently that acceptable results have been obtained. However, face recognition is still an area of active research since a completely successful approach or model has not been proposed to solve the face recognition problem. So there is no technique that provides a robust solution to all situations and applications that face recognition may encounter. Though people are good at face identification, recognition human face by computer is very difficult. So face recognition (FR) is a very challenging problem and up to date, there is no technique that provides a robust solution to all situations and applications that face recognition may encounter. Approaches for face recognition are generally classified as static (processing still images) and dynamic (processing video image sequences).

There are some reports have already been proposed related to the face recognition works [1-6]. B.S. Manjunath, R. Chellappa, C.V.D. Malsburg proposed biologically motivated the feature extraction model and the locations of the features often correspond to silent facial features such as the eyes, nose, etc [3]. Topological graphs were used to represent relations between features, and a simple deterministic graph-matching scheme, which exploits the basic structure, is used to recognize familiar faces from a database. R. Burnelli and T. Poggio presented face recognition study based on geometrical features and template matching [5]. The features based on the facial key points exhibited good recognition rate. Geometrical features based approach can be effectively explored for a course preliminary face recognition stage. E. Hjelmas proposed a face recognition system based on local features. Interesting feature points in the face image were located by Gabor filters, that is not depend on accurate detection of facial features [2]. The feature points were typically located at positions with high information contents (such as facial features). Gabor coefficients were consisting in feature vector. J. Shi and C. Chen Focused the human face recognition using ratios [4]. A semiautomatic method to find which facial points and ratios are presented, these are useful for face recognition. Correct calculation of face ratios might facilitate the face recognition in finding landmarks. V. Starovoitov, and D. Samal proposed two algorithms for computer recognition of human faces, one based on the computation of a set of geometrical features, such as nose width and length and mouth position, and chin shape, and the second based on gray level template matching [1].

This paper proposed face recognition focus on still image in frontal view. A semiautomatic method to find which facial points and ratios are presented, these are useful for face recognition. Correct calculation of face ratios might facilitate the face recognition in finding landmarks. In these systems, the significant facial features are detected and the distances among them as well as other geometric characteristics are combined in a feature vector that is used to present a face. To recognize a face, first the feature vectors of the test image and of the image in the database are obtained. Second, a similarity measure between these vectors most often a minimum distance is used to determine the identity of the face.

2. System Design of Feature-Based Approach to Face Recognition

2.1 Pre-processing

Pre-processing steps are physically motivated and supply the purpose of data reduction, removal of redundancies, and speed-up of parameter searches. The key to the recognition is feature extraction and it reduces redundant information, which is not concern as the attributes of the face. Before computing image-based features, the images are changed to grey scaled and reduce to the same resolution. The input face images pass the preprocessing steps, such as cropping, resizing, normalization, and so on. The system gets the benefit of small memory requirements and a higher recognition speed after passing the preprocessing step.

2.2 System Design

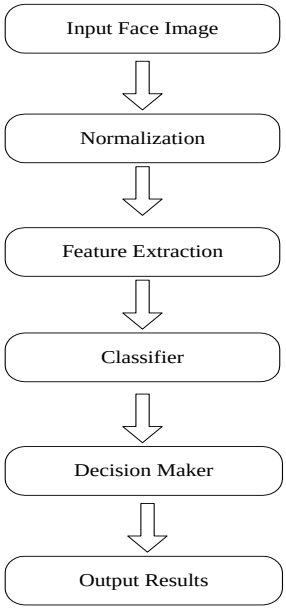


*Figure.*1 *System Design for Feature Based Approach to Face Recognition System*

The first step in face recognition is input the face image, and then preprocesses the face image such as normalization. After passing normalization step, extract the face feature points and classify the features. Decision maker decide whether the face is recognize or not and displaying the out put results. The system design for the face recognition is illustrate in Figure.1.

2.3 Head Pose Definition

There are 3 head pose classes in face recognition. They are

- **Frontal or near frontal view**

  In this view, both eyes and lip corners are visible.

- **Side View or Profile View**

  In this view, at least one eye or one corner of the mouth is visible because of the head turn.

- **Others**

  All other reasons cause more facial features to not be detected such as the back of the head, occluded face, and face with extreme tilt angles.

This paper extract the facial features from the face in frontal view or near frontal view because face recognition systems can get high recognition rate for good quality in frontal view, steady lighting and only slight expression or expressionless face images.

3. The Feature Point on Human Face

3.1 Feature of the Human Face

Due to the human visual property of the recognition of faces, people can identify face from very far distance and even the details are vague. Human face is made up of eyes, nose, chin and mouth. These are differences in shape, size, and structure of the organs, so the faces differ in thousands of ways. One command method is to extract the shape of the eyes, nose and mouth and then distinguish the faces by distance and scale of those organs. It is easily to tell the characteristics of the organ by locating the features points from a face image. By normalizing the characteristics of the face the images which have the properties of scale, translation and rotation invariance of the face image database through pre-treatment, so as to extend the range of the database, reduce the storage and recognize the face more affectively.

Additionally the selection of face feature points is important to the face recognition. In FR system, it needs to extract the feature points, which represent the most important characteristics on the face. The number of feature points should take enough information and not be too many. In this paper, after estimating the head pose, the facial features are extracted only for the face in frontal view. The most facial feature changes that are caused by expression are in the area of eyes, eyes brow and mouth. This paper used the silent facial feature from eyes and mouth.

3.2 Feature Extractions and Classification of the Face

This approach uses only the face in frontal view or near frontal view. The feature points can be extracted from the silent feature region of the face from the two eyes and the mouth. As for features, the six feature points are selected from a gray-scale face image, two feature points from the corner of the two eyes and four feature points from the mouth. Figure.2 shows feature locations. In feature detection step, feature location must be extracted precisely before we can measure the distances and their ratio among different facial points.

After locating the feature points first it need find the distance between the two points of the mouth corners and the height of the mouth by using line equation. After that the system need to find the center points of the mouth by using four feature points from the mouth. And then fix the intersection points of the two lines joining the feature points from the mouth corner and the mouth height as the center points of the mouth. After that connect the feature points of the two eyes corner and also connect each of the eyes corner with the center points of the mouth as shown in Figure 3.

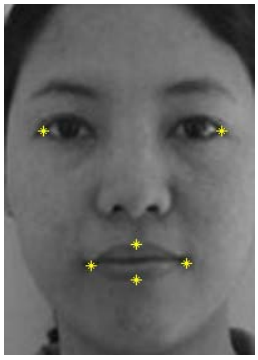


Figure 2. *Locating of Features in Face Image*

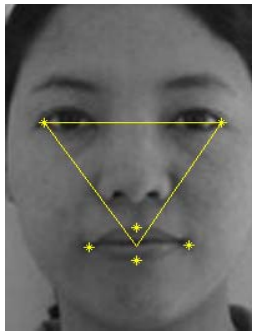


Figure 3. *Distance between Feature Points*

In face classification stage, the two faces are math or not by using the distance between the two eyes corner and the width of the angle appearing at the center points of the mouth. The preliminary experiments are test with the distance between the two eyes corner and the width of the mouth.

3.3 Singular Value Decomposition (SVD)

In this Section, the correspondence between two images is estimated based on the singular value decomposition (SVD). The algorithms exploit some properties of SVD to satisfy both the exclusion and proximity principles. A remarkable feature of the algorithm is its straightforward implementation founded on a well-conditioned eigenvector solution, which involves no explicit iterations. The parameter σ controls the degree of intersection between the two sets of feature points. The correlation relation S_{ij} is defined for the $W \times W$ area which centered on features I_i and J_j as [6]:

$$S_{ij} = \sum_{u}^{W}\sum_{v}^{W}(A_{uv} - \overline{A})(B_{uv} - \overline{B}) / W^2\sigma(A)\sigma(B), \quad (1)$$

Where $\overline{A}, \overline{B}$ be the average and $\sigma(A), \sigma(B)$ be the standard deviation of all the element of A and B. According to this, the proximity matrix $\boldsymbol{G}$ is defined with the Gaussian weighted distance between two features I_i and J_j.

$$\mathbf{G}_{ij} = Ke^{-d_{ij}^2/2\sigma^2}, \quad (i = 1..m, j = 1..n) \qquad (2)$$

where $d_{ij} = \|I_i - J_j\|$ is Euclidean distance. And K is the Gaussian weighted function of the correlation S_{ij}.

$$K = \exp(-1)((S_{ij} - 1)/2d^2). \qquad (3)$$

Then the value of $(\boldsymbol{G})_{m\times n}$ varies from 1 to 0 with correspondence measurement. Then the SVD of the matrix $\boldsymbol{G}$ is

$$G = TDU^T \qquad (4)$$

The diagonal matrix $(D)_{m\times n}$ contains the positive singular values along its diagonal elements D_{ii} in descending numerical order. By replacing every diagonal element the D_{ii} with 1, a new matrix E is generated from matrix D. Then the new matrix P is obtained by using the matrix E as following,

$$P = TEU^T. \qquad (5)$$

This new matrix $P \in M_{m,n}$ has the same shape as the proximity matrix G and has the interesting property of sort of "amplifying" good pairings and "attenuating" bad ones: "if P_{ij} is both the greatest element in its row and the greatest element in its column, then we regard those two different features I_i and J_j as being in 1:1 correspondence with one another; if this is not the case, its means that feature I_i competes unsuccessfully with other features for partnership with J_j.

4. Experimental Results

To develop the face recognition system, we construct our own face database. Slight face rotation is allowed. The angle of acquisition is not known exactly.

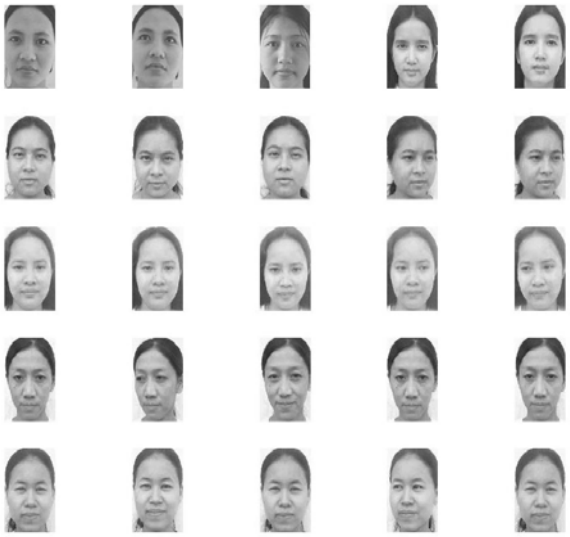
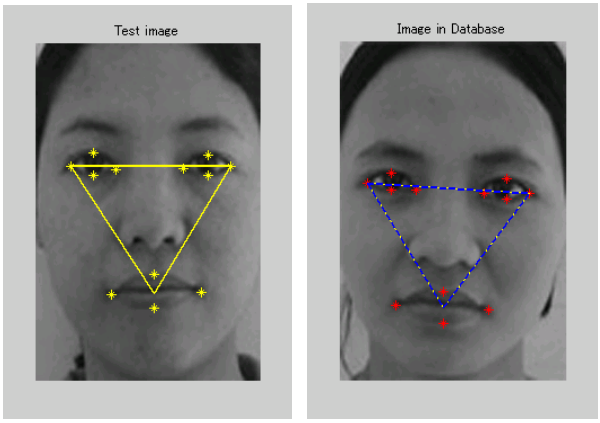
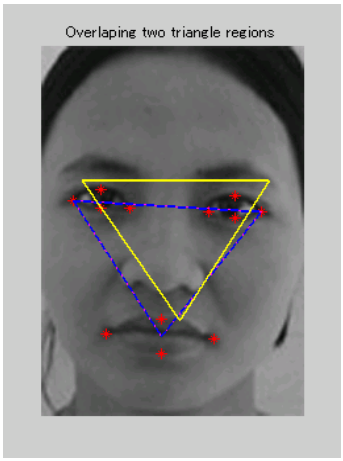


Figure 4. *Some Images in Database*

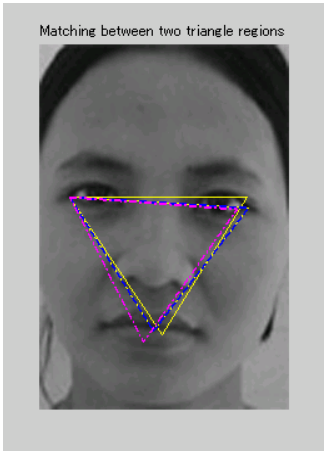


(*a*) (*b*)

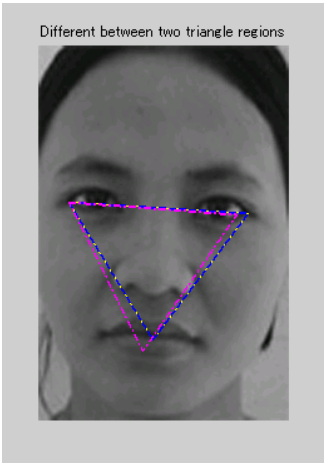
Figure 5.(*a*) *Feature Points of Testing Image and* (*b*) *Feature Point of Trainging Image*



(*a*) *Overlapped triangles*



(*b*) *Matching between two triangles*



(*c*) *Different between two triangles*

Figure 6. *Matching the Feature of Two Faces for Classification*

To ensure that the location of the features can be detected precisely, the FR system needs some limited constraint such as not wearing glasses, without beards, etc. The resolution of the images is 200x300 pixels. There are 50 training face images use in the preliminary experiment. Figure 4 shows the some images in the database. The feature points of the corner of the eyes and lip are detected from each image and connect to them. Figure 5 (a) and (b) show the feature points and drawing triangles of the training and testing face image, respectively.

The overlapped triangles on the training image are illustrated in figure 6(a); translation of a triangle of testing image is shown in figure 6(b), respectively. And, after rotating the edges of the triangle, the different between two triangles can be measured (see in figure 6(c)). Several experiments have been done using the multi face images to confirm the effectiveness of our proposed method. The accuracy rate of the system is getting around ninety percent when using with frontal face image. The recognition errors about ten percent were caused due to the variation of pose.

Table 1. *Accuracy Rate of Face Recognition in Preliminary Experiment*

Person	Accuracy Rate (Percentage)
Person 1	98.25
Person 2	92.54
Person 3	90.01
Person 4	89.36
Person 5	87.89

5. Conclusions and Future Work

Face recognition is a very attractive research area. This paper includes translation, small rotation and small illumination changes. The experiment showed that geometric feature provides an excellent basic for face classification with image in low intensity. Some errors were caused due to the large changes of facial position.

So as in future work, face features are extracted by mean of singular value decomposition. The SVD based method get good outcome because the training and testing images have been normalized.

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