Geometrical Approach for Face Detection and Recognition

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Abstract

A method for face detection and recognition using geometrical relationships of faces is presented in this paper. A gray level of image which is thresholded to produce a binary, edged image is required for face detection step then finding the head outline and then extracting it to perform the process of recognition. A pre-processing step will occur to remove the noise effect and to produce the accurate outline of head curve. The system is composed of a face detection stage presented previously which provides good results maintaining a low computational cost. After the integration of the two stages, several improvements are proposed which increase the face detection and recognition rate and the overall performance of the system. Application of these techniques has led to measurements of characteristic features of the human face with sufficient accuracy to merit later inclusion in full package for automated facial recognition. Good results have been obtained.

I. Introduction

In order to recognize a person, the person's information such as a PIN and a password, or something he or she has such as an ID card or other tokens are commonly used in contemporary society. However, such software or hardware tokens can be easily lost, forgotten, stolen or duplicated. Biometric indicators are suited for different kinds of identification applications due to their variations in intrusiveness, accuracy, cost, and ease of sensing [1], [2]. Nowadays, there are great expectations from such biometrics authentication in view of increasing vicious crimes and terrorist threats. As before face authentication has interesting characteristics than fingerprint authentication because facial images can be captured from distance, special actions are not always required for capturing, and a crime-deterrent effect can be expected because the captured images can be recorded and we can see who the person is at a glance. Therefore, the face recognition technique is expected to be applied widely not only in security applications but also to image indexing, image retrievals and natural's user interfaces. Among the six biometric indicators considered in [3], facial features scored the highest compatibility. The advantages/disadvantages of different biometrics are described in [4].

Since the early 1990's Face Recognition Technology (FRT) became an active research area. A general statement of the problem of face recognition can be formulated as follows: given still or video images of a scene, identify one or more persons in the scene using stored database of faces [5].

The solution of the problem involves segmentation of faces from cluttered scenes, extraction of features from face region, identification, and matching. The main approaches for face recognition can be classified into two categories: model based and appearance based [6]. The model based method tries to extract geometrical parameters measuring the facial parts while the appearance based approach uses the intensity intensity-derived parameters such as eigenfaces coefficients [7], [8] to recognize faces.

Due to changes of lighting conditions, expression, etc., the human face appearance could change considerably, so that we concern our work in geometrical shapes of face or, in more scientific words, on model based approach. Most of pioneering work in face recognition was done based on the geometric features of human face [9], [10], [11], [12]. This technique involves computation of a set of geometrical features such as nose length, mouth and eyes positions with respect to each other, etc., from the picture of the unknown face we want to recognize. This set of features is compared with the features of known individuals and the closest match is then found. The main disadvantages of geometrical face recognition are that sensitivity to the scaling and rotation of face in the image

plane [6] and therefore would not be as robust as other recognition models. In this paper, we propose a face detection and recognition system which can learn human faces of frontal views within few rotation range if the case needed.

The remainder of the paper is organized as follows. We describe the face detection and recognition techniques in section II, and our techniques for face detection/recognition are described in section III, while the results are discussed in section IV. Finally, we conclude the paper in section V.

II. Face detection/Recognition

A. Face Detection

The face detection problem is to locate and identify a human face in an image. The problem has important applications to automated security systems, lips reading, indexing and retrieval of video images. A general statement of the problem can be defined as follows: Given a still image, detect and localize an unknown number (if any) of faces. The solution to the problem involves segmentation, extraction, and verification of faces and possibly facial features from an uncontrolled background. Early efforts in face detection have been dated back as early as the beginning of the 1970s, where simple heuristic and anthropometric techniques [13] were used. These techniques are largely rigid due to various assumptions such as plain background, frontal face, illumination ... etc. Despite these problems the growth of research interest remained stagnant until the 1990s [14]. Over the past decade there has been a great deal of research interest spanning several important aspects of face detection. More robust segmentation schemes have been presented, particularly those using motion, color, and generalized information. The use of statistics and neural networks has also enabled faces to be detected from cluttered scenes at different distances from the camera. Additionally, there are numerous advances in the design of feature extractors such as the deformable templates and the active contours which can locate and track facial features accurately. Because face detection techniques requires a priori information of the face, they can be effectively organized into two broad categories distinguished by their different approach to utilizing face knowledge. The techniques in the first category make explicit use of face knowledge and follow the classical detection methodology in which low level features are derived prior to knowledge-based analysis [15], [16]. The apparent properties of the face such as skin color and face geometry are exploited at different system levels. Typically, in these techniques face detection tasks are accomplished by manipulating distance, angles, and area measurements of the visual features derived from the scene. Since features are the main ingredients, these techniques are termed as feature-based approach. These approaches have embodied the majority of interest in face detection research starting as early as the 1970's. Taking advantage of the current advances in pattern recognition theory, the techniques in the second group address face detection as a general recognition problem. Image-based [17] representations of faces, for example in 2D intensity arrays, are directly classified into a face group using training algorithms without feature derivation and analysis. Unlike the feature-based approach, these relatively new techniques incorporate face knowledge implicitly into the system through mapping and training schemes [16].

B. Face Recognition

Face recognition is a pattern recognition task performed specifically on faces. It can be described as classifying a face either "known" or "unknown", after comparing it with stored known individuals. It is also desirable to have a system that has the ability of learning to recognize unknown faces. Much of the work in computer recognition of faces has focused on detecting individual features such as the eyes, nose, mouth, and head outline, and defining a face model by the position, size, and relationships among these features. Such approaches have proven difficult to extend to multiple views and have often been quite fragile, requiring a good initial guess to guide them. Research in human strategies of face recognition, moreover, has shown that individual features and their immediate relationships comprise an insufficient representation to account for the performance of adult human face identification [18], [19], [20], [21]. Nonetheless, this approach to face recognition remains the most popular one in the computer vision applications. In Figure 1, the outline of a typical face recognition system is given.

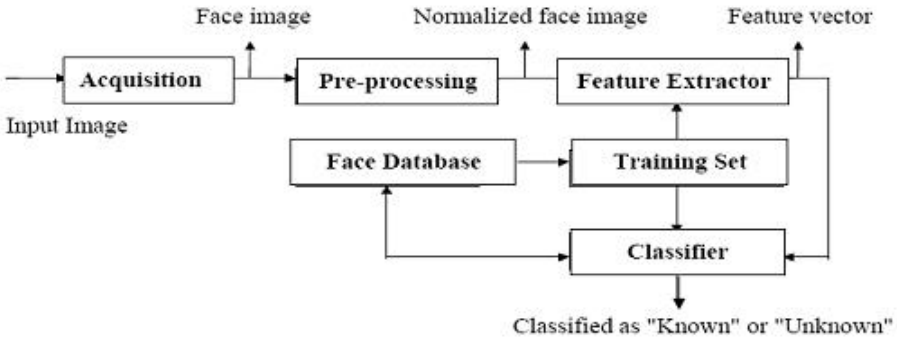


Fig. 1. Typical Face Recognition System

III. The new Proposal

A. Face Detection

We can divide the process of face detection according to the type of background (simple or complex) and the view of person(s) in the image. This classification and associated results was depicted in Figure 2. In our algorithm we trace the edged image, so that we can decide whether the image contains face or not according to the geometric shapes of faces and their angles. Once the face is detected, the coordinates of it are also detected and by subtracting them from the original image, it is then prepared it to the recognition stage.

Case	Image	Needed Background	Edged Image	Result
1- Simple background and not intersected faces		———		
2- Complicated background and not intersected faces				
3- Intersected faces with (without) complicated background		———		

Fig. 2. Various Methods Applied in Face Detection

As depicted in Figure 2 we can use two techniques in the face detection problem in first two cases we use the edged image curve to separate the head outline from the parts of the body then we can determine the coordinates of the head and separate it from the original image to prepare the face to face recognition step. We surrounded the face by a rectangle with size 46x53. Another approach we can use irrespective of the edge of the image, we can use only gray level contrast to find the region of faces by using a specific threshold describe the gray level of skin. Also we can use the coordinates of this skin region to detect it from the original image. The comparison between the two applicable methods in face detection can be summarized as in Figure 3.

Comparison \ Algorithm	Edged technique	Skin technique
Advantages	Cover all images with no intersected faces with 100% percentage of detection.	• Not restricted to orientation, size or grouping candidates. • Can handle a complex background. • Cover all skin colors.
Disadvantages	• The existence of the background is required if it's complicated. • The faces must be separated from each other.	When objects are present with a color similar to skin, since we base the segmentation in color.

Fig. 3. Comparison among different techniques used in Face Detection

B. Face Recognition

After finding the coordinates of head outline then extract it from the full image we can begin the stage of recognition. First we find the edge and compute the x-y coordinates for each pixel and find the slope between any two successive pixels then find the total angles of head by moving around this outline. This process is explained in Figure 4.

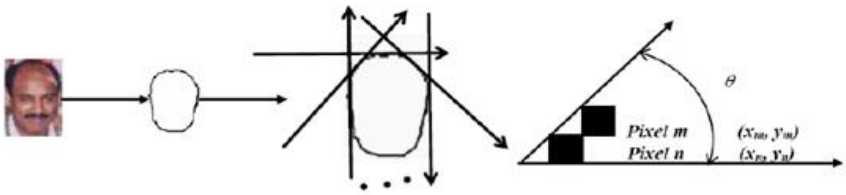


Fig. 4. Process of recognition: face from detection, Edged Face, and Find the angles of Face's edge

To find the angles of pixels, we must first find the slope between successive pixels by the equation 1.

$$M_i = \frac{Y_m - Y_n}{X_m - X_n} \tag{1}$$

Where M_i = slope of the curve between each two successive pixels((X_m, Y_m), (X_n, Y_n)) in the edge.

$$Angle = \theta i = tan^{-1}(M_i) \tag{2}$$

After calculating the angle vector of the unknown person we compare it with angle vectors existing in training set by aid of neural network to identify the person. Also we can find the eigenfeatures for the edged faces which are more useful for increasing the rate of recognition respect to the whole number of faces [22].

We can summarize the steps of the training and recognition in the Figures 5, 6, 7, and 8. These steps are described as follows:

Fig. 5. Training set used in recognition Algorithm

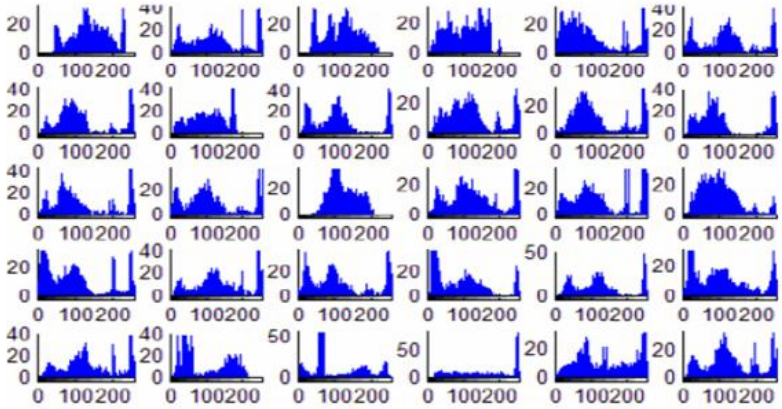


Fig. 6. The Histogram of the Images

- **Step 1:** The first step is to obtain a training set with M face images. In our example M = 30 as shown in Figure 5.
- **Step 2:** After we obtained our set, we will obtain the histogram of images to detect the limit (gray scale of skin) of skin region and reject other region.
- **Step 3:** After some processing (erosion, dilation, and filtering) we can find the skin region of the face which will describe the geometric shape of a face.
- **Step 4:** Then we will find the edges of the head, to enter them to the process of finding angle, described before.
- **Step 5:** To make the recognition step we find the angles of unknown person and compare it with the angles in our training set by aid of neural network, so that we use the ANN as a classifier [23].

Fig. 7. Skin Region

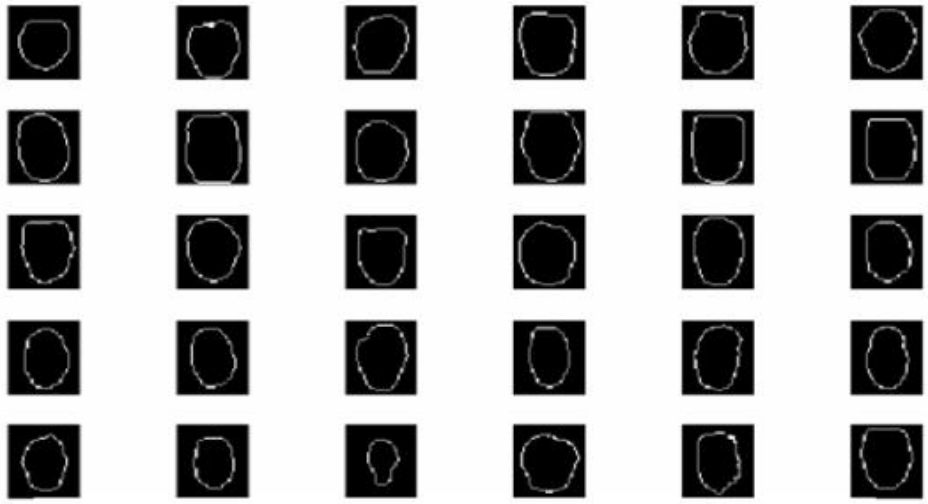
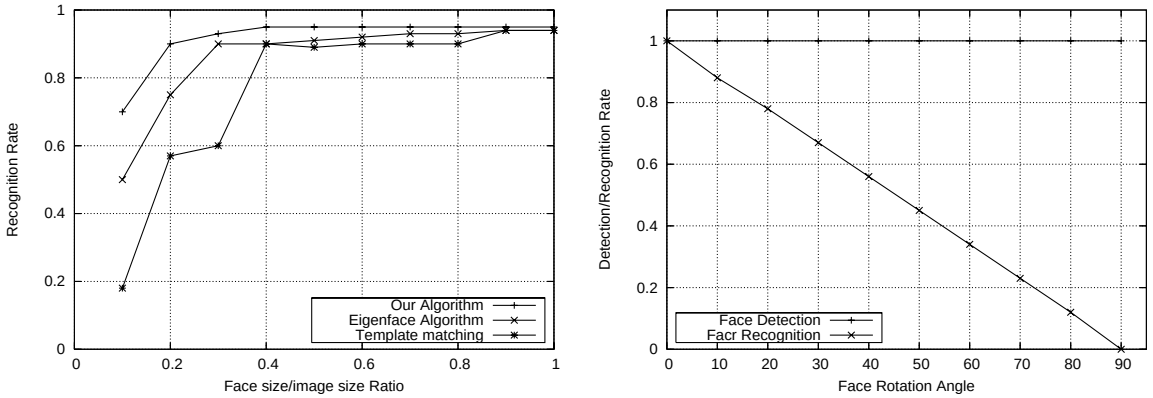


Fig. 8. The edge detection of our training set

IV. Results Evaluation

We gathered face images from 30 individuals to test the fully automated frontal view face detection and recognition system. Face images were in 46 x 53, jpg format. Face images were intentionally taken under varying lighting conditions with the face being at different positions (frontal view, right view, and left view) and scales in the image. After the step of detection which illustrated in Figure 2, we now ready to the recognition step. Figure 5 illustrated the faces taken as a training set (i.e. faces which already known). Then arrangement the training set as matrix by small program implemented by Matlab software. After this step we must separated the skin region from non-skin (i.e. almost hair, and background). We can do that by find the histogram (see figure 6) for each face then find the threshold values for the skin region, find them then subtracted it from the original face yields the faces in Figure 7. The outline of head is being ready for the process of detection to find the angles of the periphery for each face according to the process illustrated in Figure 4, and put each a group of angles -related to each face- into a vector used as input of the ANN which used it as classifier, Figure **??** illustrated the face images after the process of detection. Successful results were obtained for automated face detection with a



(a) Recognition Rate (b) Detection/Recognition Rates

Fig. 9. Detection and Recognition Rates

frontal view face detection rate nearly of 100% being achieved using fully automated face detection.

The complete fully automated face detection and recognition system with a recognition rate nearly of 100% on test face images. In cases of rotated faces the rate of face detection remains constant at 100% but the percentage of recognition inversely proportionally with increase in this rotation angles (see Figure 10). It may therefore be concluded that automated frontal view face detection has been very successful.

The recognition rate also increase dramatically, by training the neural network on a different view of angles for same face resulting in higher face recognition accuracy. Since this study increase the time of recognition with how many angles required to recognize the faces on it. Therefore by increasing the number of subjects in the study the recognition performance of the overall system will increase. This is in contrast to traditional neural network based techniques, where recognition accuracy would be adversely affected as the number of known subjects' increases.

In order to test the viability of this approach to face detection/recognition, a sample set of face images were created under known variations of lighting and orientation. Besides, some of these original face images were manually decorated to add facial details such as glasses or beards. See Figure 10.

Fig. 10. manually decorated face used to test the viability of our approach

Because our approach not depended on the facial details but depended only the outline of face at all our approach give a very good result over any last approaches [22],[23],and[24]. For the variations occurred in face image.

V. Conclusion

In this paper, a new approach for face detection and recognition is proposed. The method is based on the geometric shape of the head. This method over any other method in detection point is well qualified because we the most feature known in the person is his head over his eyes , mouth or other small feature comparison with head in total. Our method does not affect by the resolution of the image or illumination or other drawbacks associated with the past face detection and recognition methods. In order to minimize the effects of face background and head orientation on the recognition performance, background of face images should be removed and heads should be normalized both in scale and orientation. The current recognition system has been designed for frontal views of face images (or rotation to left or t right by small angles). A neural network architecture be implemented

in which the orientation of the face is first determined, and then applied the recognition method. The current recognition system acquires face images not only from face files located on magnetic mediums but also from camera and scanner for greater flexibility.

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