Face Identification Method Using Face Shape Independent of Lighting Conditions

H.Takimoto*, Y.Mitsukura** and N. Akamatsu*

*Department of Information Science and Intelligent Systems, The University of Tokushima, 2-1 Minami-Josanjima, Tokushima 770-8506, Japan

(Tel: +81-88-656-7493; Fax: +81-88-656-7493; Email:{taki, akamatsu}@is.tokushima-u.ac.jp)

**The Okayama University, 3-1-1 Tsushima-Naka, Okayama, 700-8530, Japan

(Tel: +81-86-251-7724; Fax: +81-86-251-7724; Email:mitsue@cc.okayama-u.ac.jp)

Abstract: In this paper, we propose the face identification method which is robust for lighting based on the feature points method. First of all, the proposed method extracts an edge of facial feature. Then, by the hough transform, it determines ellipse parameters of each facial feature from the extracted edge. Finally, proposed method performs the face identification by using parameters. Even if face image is taken under various lighting condition, it is easy to extract the facial feature edge. Moreover, it is possible to extract a subject even if the object has not appeared enough because this method extracts approximately the parameters by the hough transformation. Therefore, proposed method is robust for the lighting condition compared with conventional method. In order to show the effectiveness of the proposed method, computer simulations are done by using the real images.

Keywords: face identification, hough tranceform, face shape independent

1. Introduction

Recently in the world, personal identification has been realized by the advancement of an information technology. In the personal identification method, there are recognition methods by using IC card, password, and biometrics[1], [2]. The biometrics is not in need of memory or carrying of cards, and only registrant is accepted. Especially, the face is always opened to society, it has little psychological burden compared with other physical features.

There are some personal individual identification methods using the front face image[3], [4]. In the personal identification methods using the face, the feature point method and the pattern matching method are general technology. A basic concept of the feature point method is to use knowledge about the structure of the face for recognition. This method extracts the facial feature such as an eye, a nose and a mouth. Then, it calculates feature vectors for recognition which showed a shape and a position of each feature numerically. In the conventional method, there are many researches of having used the feature point method as the based on. However, it is difficult for them to perform robust recognition for lighting even if the data to be used is limited to the front face image. Furthermore, the pattern matching method is used for extraction of facial feature.

In this paper, we propose the face identification method which is robust for lighting based on the feature points method. In the image recognition, the object is often composed of a basic figure element that is a line, a circle, an ellipse and so on. Moreover, it is thought conventionally that facial feature is expressed by using a line and an ellipse. Therefore, the face identification is performed by using a parameter that express contour of facial feature.

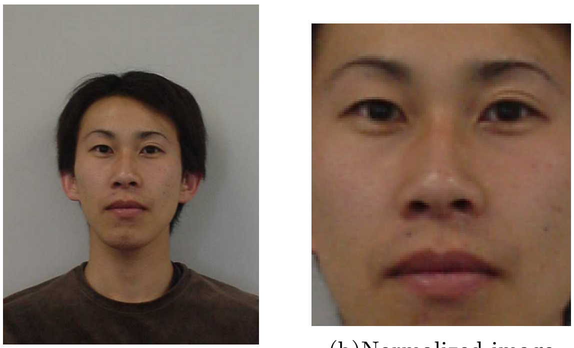
First of all, the proposed method extracts an edge of facial feature which an eye, an eyebrow and a mouth. Then, it determines ellipse parameters of each feature from the extracted edge by the hough transform. It performs the personal identification by using them. The edge extraction is robust for the change of environment, because it is performed on the basis of variance of pixel in locally region. When it is difficult to extract the edge from face image, the hough transform can calculate the parameter of each facial certainly. Because, it perform determination of parameters approximately. Therefore, it is a robust for lighting compared with the conventional methods. Moreover, compared with the conventional method, the extraction of the feature point is certainly and easily detected. In order to show the effectiveness of the proposed method, computer simulations are done by using the real images.

2. Face image data

In this paper, it is necessary to normalize the face image to recognize. The normalization method of face image in the paper is shown. The face image is normalized based on both eyes. The reason for having used the eye for normalization of face image is as follows. The first, eyes are having been easy to perform the normalization about a rotation and a size, compared with a lip, a nose, or an ear. Next, many researches of extracting the region of an eye are proposed[5], [6]. Therefore, to use eye for normalization of face image is efficient.

First of all, an original image (420×560 pixels, 24bit color; Fig. 1(a)) is changed into 8bit into the gray scale image, and median filter is performed in order to remove the noise. Next, center positions of both eyes are extracted. Then, the line segment joining both eyes is rotated so that it matches the horizontal line. Furthermore, the distance between both eyes is made 60 pixels by scale change.

Moreover, in order to diminish influence of hair and clothes, an image is cut out as shown in Fig. 2. That is, letting the midpoint of the segment joining both eyes be a standard point, the region spreads by 120 pixels (by 60 pixels in right



(a) The original image (b)Normalized image

Fig. 1. Normalization of the face image

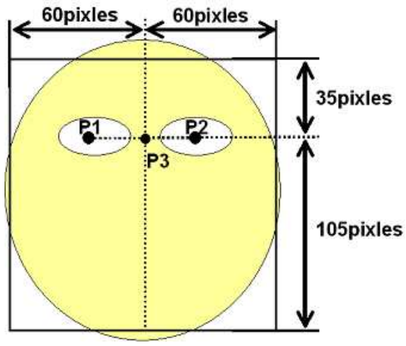


Fig. 2. The outline of the normalization method

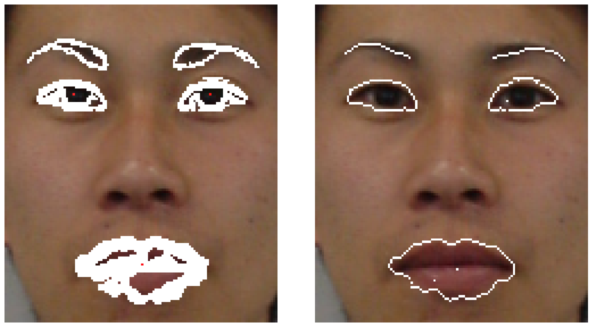
and left direction, respectively) in horizontal direction, and by 80 pixels (by 35 pixels in the upper part and by 105 pixels in the lower part) in the vertical direction. Finally, in order to ease the influence by photometric property, gray scale transformation is performed. The image of the Fig. 1(a) is normalized as the Fig. 1(b).

3. Edge detection

In this paper, the edge image of facial feature is extracted form the face image by using the Sobel operator. Sobel operator is popular method of edge extraction, because it is very simple and calculation cost is few. Then, an eyebrow, an eye and a mouth are targeted in the parameter extraction.

The edge extraction of an eye and eyebrow is performed by using brightness value Y of the YCrCb color space. Because, there is a difference of brightness between targeted object and around them. In the edge extraction of a mouth, difference of brightness is few. Consequently, a product between $a*$ and Y is used. It is color space reflecting the feeling to color of human[7]. The $a*$ value designate intensity of ruddiness, and it is shown in equation (1). The parameters X are Y value of an object in the XYZ color space. Then, the parameters X_0 and Y_0 are value of a standard light source.

However, if the Sobel operator is only used for the edge extraction of each facial feature, then the pupil and the boundary of both lips are extracted as shown in Fig. 3(a). It is difficult to calculate each parameter by the hough transform stably. Thus, the advanced active net is used as solution of them. The advanced active net leaves each pixel which is most away for all directions from center of targeted object. Therefore, as shown in Fig. 3(b), optimal edge image is obtained. The centerline which is horizontal direction is obtained from the edge image as a feature line. Because, an eyebrow is changed easy by influence of front hair and make up.



(a) (b)

Fig. 3. The contour extraction of facial feature

$$a^* = 500\Big\{(\frac{X}{X_0})^{\frac{1}{3}} - (\frac{Y}{Y_0})^{\frac{1}{3}}\Big\} \tag{1}$$

4. Extraction of feature parameters

4.1. Hough transform

Hough transform makes a histogram in parameter space which expresses targeted object, and it searches a peak of them. Hough transform is relatively robust for change of pattern which is a noise and a concealing and so on. In this paper, it determines ellipse parameters of each facial feature from the extracted edge by the hough transform. In the conventional hough transform, only the position information of the edge point which is in image was used. Recently, the hough transform method that used not only position information but also tangent line in edge point was proposed. Accordingly, this method can extract ellipse that shares center and overlaps[8], [9].

In this paper, hough transform is used for extraction of tangent line from a binary image of contour. Next, ellipse is detected by multi-step hough transform which is used tangent line information. In this method, the ellipse parameter is calculated by a mapping array of 2-dimensions. Thus, it is thought that this method is optimal method in environment that resource of hardware is restricted. The process of calculation of tangent line form contour image is as follows[10].

(1) The map space is initialized. It is quantized to interval 1^o in Lift angle of line θ ($[0^o, 180^o)$).

(2) There is window (11×11) which center is targeted edge point $P_i(x_i, y_i)$. If other edge point $P_j(x_j, y_j)$ exist in window region, gradient of line is calculated by equation (2). If it is included within the range ($\theta_1 \leq \theta < \theta_2$), it has the possibility of passing by two points (P_i, P_j). Then, the cell within this range is done projection.

$$tan\theta_1 = \frac{y_j - y_i - 0.5}{x_j - x_i}, \quad tan\theta_2 = \frac{y_j - y_i + 0.5}{x_j - x_i} \tag{2}$$

Fig. 4. The detection of ellipse

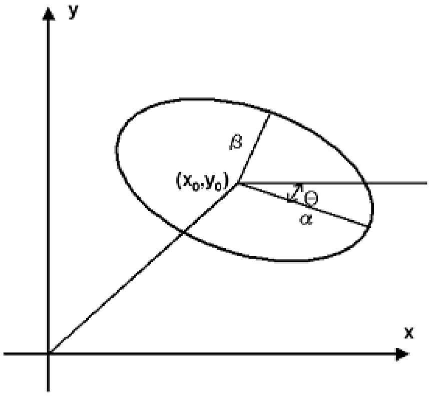


Fig. 5. The parameter of ellipse

(3) After all the edge points within the range are done projection, the maximum projection cell that exceeds the threshold is chosen by operating the map space. Finally, angle θ_i corresponding to the maximum projection cell is chosen as a tangent line information in targeted edge point P_i.

The ellipse has 5 parameters. They are center coordinates (x_c, y_c), Length of axis $(2\alpha,\ 2\beta)$, rotating angle θ. Firstly, the center coordinates is detected by using the ellipse extraction method which is based on the hough transform. Then, the length of axis is detected. Finally, rotating angle is detected. These operations are done by using the map space two dimension or less, because it is calculated stepwise. Therefore, it is efficient algorithm. A result of ellipse which was detected for an eye and a mouth is shown in Fig. 4.

4.2. The calculation of ellipse parameters

In this paper, the face identification is performed by the parameters (ellipse, line) that express contour of facial features. The number of the parameters which is shown in ellipse is 5, and it is shown details in Fig. 4. The parameter that is obtained from both eyes and a mouth is shown in Table 1. The rotating angle θ is not used, because angle of face image is normalized in preprocessing.

Moreover, eyebrow parameters are calculated from center coordinates of eye ellipses and mouth ellipse. The detail of the eyebrow parameters are shown in Fig. 6. First of all, a line lm and rm are obtained from coordinates of an eyes and a mouth. 6 parameters of both eyebrows are calculated based on them. Therefore, by calculating the parameters of each facial feature, The face of one person is expressed by the parameter space of 30 dimensions.

1)Position of X axis : x
2)Position of Y axis : y
3)Length of major axis : a
4)Length of minor axis : b
5)Ratio of Minor axis by Major axis : r
6)Length of the contour : *perimeter*

Table 1. The parameters of the eye and the mouth

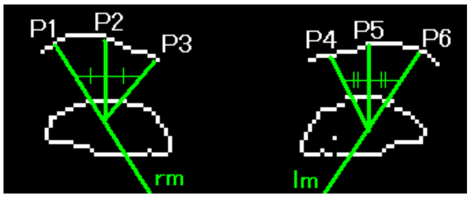


Fig. 6. The parameters of the eyebrow

5. Face identification

For the purpose of showing the effectiveness of the proposed method, computer simulations are done by using the real images. In this simulation, we used 72 adult men's, 28 adult women's in total 100 people images for registrant, and they are 6-face images par person (total 600 face images). The sample of registrants is shown in the Fig. 7. Even if it is a same person, there are normal lightning image, blue lightning image and dark image. In the data of registrant, 5 images are used for training data, and an image is used for test data. Moreover, the Leave-one-out cross-validation method is used for evaluation experiment.

6. Conclusions

Finally in this paper, conclusions are shown in this section. In this paper, face identification method which is robust for lighting based on the feature points method are proposed. In this method, parameters of faces are extracted by the edge

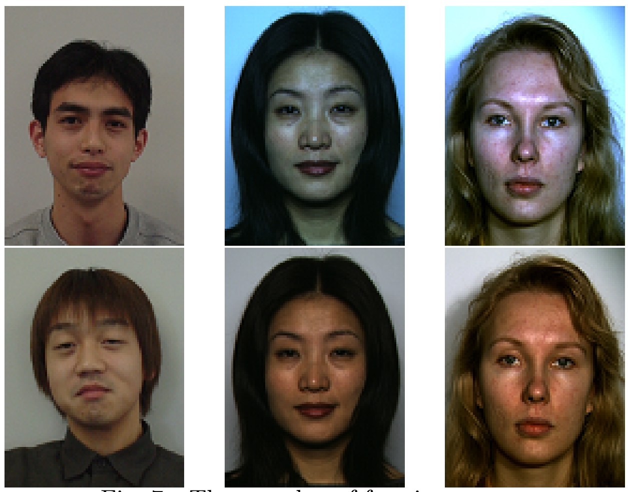


Fig. 7. The sample pof face images

which is detected by the hough transform. By using these parameters, face identification are done in this paper. It is a robust for lighting compared with the conventional methods. These simulations are shown in that day.

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