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A Feature Extraction Method in Face Image for Personal Identification

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Abstract

Recently in the world, many researches of personal identification method using biometrics are widely done. Especially, personal identification using the face is used because of needless for physical contact. In this paper, we propose the new method to identify the personal using the SPCA and the NN. The SPCA has been proposed in order for the PCA to achieve high-speed processing. Moreover, the personal identification system needs to have not only ability to recognize registrant correctly but also ability to reject un-registrant certainly. Therefore, we perform simulation using un-registrant. Furthermore, we analyzed and examined about the individual feature in a face by using the GA and the SPCA. Then, in order to show the effectiveness of the proposed method, we show computer simulations by using the real image. From these results, we show the effectiveness.

1 Introduction

Personal identification is very important, but very difficult. The password and cards are widely used for the technologies that recognize users. Even if it is not a registrant, it may be accepted by the presumption of the password and the acquisition of the card. Furthermore, there are problems on convenience such as memory of a password and carrying of cards[1].

Consequently, many researches of personal identification technique using biometrics are widely done[2]. Biometrics is not in need of memory or carrying of cards, and only registrant is accepted. Altogether, it can be simultaneously improved in safety and convenience. There are fingerprints, an iris, a voice, and a face in the physical feature are used for biometrics. Especially, the face is always opened to society, it has little psychological burden compared with other physical feature. For this reason, faces are used for personal identification in this paper. There are some personal identification methods using the front face image[3, 4]. One is an extraction method of feature points using edge detection and others are template matching, and so on. In the extraction method of the feature points, the form of the portion that constitutes a face and an individual difference of the position are used for recognition. But it is difficult to extract the portion that constitutes with sufficient accuracy from front face image. In pattern matching, a face is regarded as a value pattern of the gray under arrangement of 2-dimensions. However, it becomes redundancy expression by the vector with the huge number of dimensions, and it is influenced by the change of the environment[4].

Therefore, principle component analysis (PCA) is used for yielding a feature vector to discernment[5, 6]. However in PCA, it is not easy to compute eigenvectors with a large matrix when considering the cost of calculation to adapt for time-varying processing. Therefore, the simple principle component analysis (SPCA) method has been proposed in order for PCA to simulate at high-speed. Furthermore, the neural networks (NN) are an advanced parallel system, which is excellent especially in the problem related to pattern recognition. The NN is used in order to avoid the difficulty of the threshold value determination in many dimensions.

In this paper, we reduce the computing time cost by using the SPCA, and get feature vector for identification. Therefore, we calculate the similarity between eigenvector and face pattern, and using the NN does an individual distinction. In addition, by the genetic algorithm (GA), the region where the individual feature has shown up is extracted, and it is used for identification. In order to show the effectiveness of the proposed method, computer simulations are done.

2 SPCA

The SPCA has been proposed in order for the PCA to achieve high-speed processing. It is confirmed that it is effective in information compression at the handwritten digits and dimensionality reduction at a vector space model[7]. The SPCA produces approximate solutions without calculating a variance-covariance matrix. The SPCA algorithm is given as:

1. Collect of a dimensional data set, $V = \{v_1, v_2, ..., v_m\}$
2. $X = \{x_1, x_2, ..., x_m\}$, which are obtained by subtracting which is the average value of form the cen-

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ter of gravity of set of the vectors, is used as input vectors.

3. The column vector is defined as connection weights between the inputs and output. The first weight is used to approximate the first eigenvector. The output function has a value given by:

$$y_1 = a_1^T x_j \tag{1}$$

4. Using the following equation (2) and (3), repetitive calculation of arbitrary vector suitably given as an initial value is carried out. As a result, the vector can approach the same direction as.

$$a_1^{k+1} = \frac{\sum_j \Phi_1(y_1, x_j)}{\| \sum_j \Phi_1(y_1, x_j) \|} \tag{2}$$

$$y_1 = (a_1^k)^T x_j \tag{3}$$

where is the threshold function given as

$$\Phi_1(y_1, x_j) = \begin{cases} +x_j & y_1 \geq 0 \\ -x_j & \text{otherwise} \end{cases} \tag{4}$$

5. Using the following equation (5), we remove the first principal component vector from the dataset in order to find the next principal component.

$$x_i' = x_i - (a_1^T x_i) a_1 \tag{5}$$

We obtain principal components because we substitute with and with in equation (2), (3) and perform repetitive calculation once again.

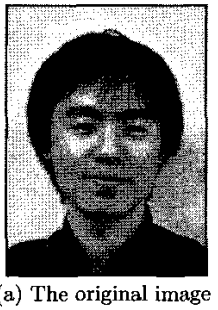
If the same operation is being done enough for the dataset, we obtain the principal component, which is stronger in contribution rate by turns.

3 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, eye is 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[8, 9]. 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 gray scale image, and median filter is performed in order to remove 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 40 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 80 pixels (by 40 pixels in right and left direction, respectively) in horizontal direction, and by 80 pixels (by 20 pixels in the upper part and by 60 pixels in the lower part) in the vertical direction. Finally, in order to ease the influence by photometric property, gray scale transformation is performed. Therefore, the image of the Fig. 1(a) is normalized as the Fig. 1(b).



(a) The original image

(b)The normalized image

Figure 1: The normalization of a face image

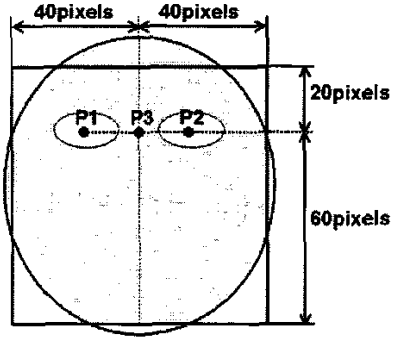


Figure 2: The outline of the normalization

4 Individual Feature Extraction

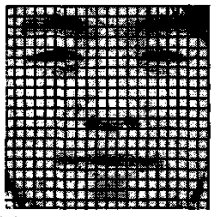
In this paper, the regional segmentation where the individual feature has shown up is extracted by using the GA and the SPCA. Moreover it is used for recognition. Recognition is obtained the good accuracy by removing the region which is not valuable for it. Furthermore, it is considered that it can mitigate calculation cost required for recognition.

4.1 Regional Segmentation and Genetic Coding

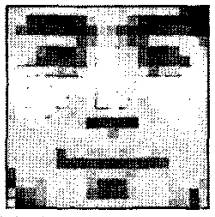
As shown in Fig. 3(a), the region is segmented. One block size is a square (4×4 pixel). In the case of using the Fig.3(b), when performing SPCA for fitness function of the GA. This figure is performed sampling by average gray-scale value in segmented region, in order to purpose of high-speed processing and dimensionality reduction. The chromosomes of GA are binary coding, and they are expressed in 2-dimensional arrangement. Each gene is one-to-one correspondence with the segmented region. When chromosome value is 1, the related region is used for recognition.

4.2 Fitness Function

The fitness function is shown in equation (6). The numerator means that the fitness value becomes high, if the difference of individual in the selected region becomes large. "Sab" means total of variance in the selected regions. "Dim" means total of rate of contribution to the 5th, when performing the SPCA to the selected regions. Then, This denominator means that the fitness value



(a)The region segment



(b)The mosaic pattern

Figure 3: The region segment and mosaic pattern

Table 1: The experimental conditions of GA

Generation	500
Individual	50
Bit of gene	400
Mutation rate	0.05

becomes high, if number of selected region becomes a few. By using this fitness function, we can obtain the small-sized inputs and high recognition accuracy.

In this paper, the elite preservation method and the roulette selection method was adopted as the selection method of the individual. The rate of the individual who reserves as the elite is about 10%. Moreover, creation of a new individual chooses 40% with good fitness value from the whole, and is performed using the GA operations (selection, crossover, mutation).

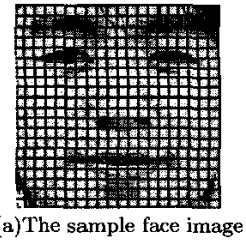
$$Fitness = \left\{ \frac{\mathrm{Sab} \cdot (1 - \mathrm{Dim})}{\frac{\mathrm{Pix}}{\mathrm{Pix}_{max}}} \right\} \tag{6}$$

4.3 Feature Extraction Simulation

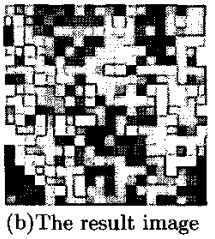
The individual feature extraction is performed to 100 registrants. The experimental conditions are shown in Table 2.

In the result, average of ten individuals with good fitness value is shown in Fig. 4(b). This figure means that the more blackish region was chosen by many individuals. In this paper, because face image is normalized based on both eyes, the selected region has more eye's region than mouth's region.

From these results, it was confirmed that the proposed method by using the GA gets characteristics of faces. Therefore, the GA is effective for the getting individual characteristics.



(a)The sample face image



(b)The result image

Figure 4: The result of feature extraction

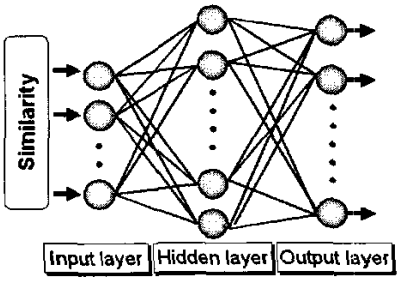


Figure 5: The neural network model

5 Personal Identification Simulation

In order to show the effectiveness of proposed method, we show computer simulations by using real image. Recognition process is as follows, and we show each details of process.

⟨ **step 1**⟩ Normalization face image

⟨ **step 2**⟩ Dimensionality reduction of image pattern by SPCA

⟨ **step 3**⟩ Calculation of similarity between eigenface and face image

⟨ **step 4**⟩ Learning and recognition by NN

5.1 Similarity

In this paper, we calculate the similarity. That is, the similarity is calculated using eigenvectors and gray scale image vectors of each image pattern. It is made by two vectors. We use $\cos\theta$ for similarity.

$$cos\theta = \frac{(a_k, x_n)}{\| a_k \| \cdot \| x_n \|} \tag{7}$$

5.2 Neural Networks

In this paper, the NN is used for a classification and is a three-layered type (Fig. 5). It is learned by using the Back-Propagation (BP) method. The number of input layer units is same as the number of similarity (between each eigenvectors from which the total of rate of contribution becomes 90% or more). The number of output layer units is same as the registrant of the system.

If the output of an output unit exceeds a threshold, then it accept as a registrant corresponding to the unit. If the output of two or more units exceeds a threshold or no output of a unit exceeds a threshold, then it is rejected.

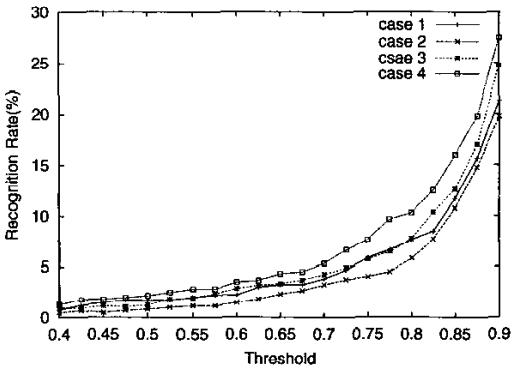
5.3 Evaluation Simulation

In this paper, we perform the simulation of six patterns which is shown in Table 3. This table shows the number of used pixels, used rate, and calculated principal component by SPCA for simulation. The case 1 is used the whole face image which was normalized. The regions of the case 2-4 are determined by result of GA.

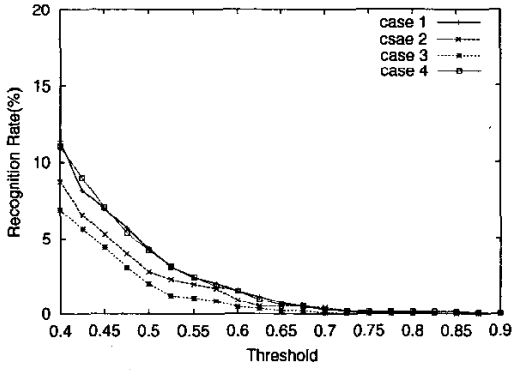
In the result, False Rejection Rate (FRR) and False Acceptance Rate (FAR) are shown in Fig. 6. From the result of FRR, a difference of each result is not seen when

Table 2: The simulation pattern

	Used pixels	Used rate(%)	Input
case 1	6400	100.0	50
case 2	4528	70.7	50
case 3	3552	55.5	49
case 4	2672	41.7	47



(a)The false rejection rate



(b)The false acceptance rate

Figure 6: The simulation result of recognition

the threshold is comparatively low. But, if the threshold is comparatively large, it is found that the case 2, 3 accuracys are better than the case 1. Therefore, the proposed method is effective in the condition where a threshold is large, and the situation that a un-registrant is not allowed. However, the case 4 accuracy is bad than the case 1. It suggests that there is a bad influence, when the amount of information is reduced too much.

Moreover, Equal Error Rate (EER) and threshold are shown in Table 3. EER is the error rate in the threshold that FAR and FRR cross, and it is used often for verification of recognition system effectiveness[11]. In the result of EER, the case 2 accuracy is the best in four patterns. Then, the threshold of case 2 is the highest. Thus, the proposed method is effective in the severe situation of security environment such as high threshold. In coclusions, the proposed method is effective, and obtained the individual characteristics for recognition.

Table 3: The EER and threshold

	EER(%)	θ_0
case 1	2.15	0.57
case 2	1.33	0.58
case 3	1.55	0.52
case 4	2.75	0.54

6 Summary

In this paper, the feature extraction method for personal identification was proposed be using the SPCA and the GA. Furthermore, effectiveness of proposed method was checked, as compared with the case which was used the whole face image. In the result, we obtained EER is 1.33%.

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