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A Personal Identification Method using the Face Information from a Tracking Image

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Abstract: The biometric recognition using the feature of individuals, such as a fingerprint, a hand, and face recognition, is atracting attention. In this paper, the identification method which can be performed without the need of special operation for recognition to a user are proposed. The proposed method will be used at a person tracking system. We focus on face information, as the information available for tracking a person. The validity of this proposal method was confirmed in indoor environment with simulation results.

Keywords: face information, person identification, eigenface, KL deployment, principal-component analysis, biometrics.

1. Introduction

In recent years, research on the monitoring system of recognizing and tracking using images from cameras in moving objects, such as a person and vehicles, has been advanced frequently. As the backgroud, the throughput of a computer has been improving and image processing including the object extraction can be done in real time.

It has realized by mobile device, such as GPS, a cellular phone, as a moving object tracking system in the outdoors. Person's position acquirement is also possible by the downsizing these devices. On the other hand, the monitoring system in indoors environment is realized when people is monitoring through invasion detection systems which are composed of sensors, such as infrared rays, and the image of a monitoring camera.

One of Characteristics of using camera in access control system is there is no need to carry any devices for identifing/verifing a person.

From a viewpoint of a security system, research of the high convenient authentication technology using biometrics attracted attention. However, users are often forced to authenticate each time before entering the secure area, this causes users feel stress. In this paper, we aims identifying a person using the image (tracking image) from a camera in person tracking system. By identifying a person using tracking images, users are free from special operation for authentication, or contacting device. Moreover, an identification using tracking images can select candidates ofthe right persons, so combination of other identification facilities will speed up the total process to identify the person.

Images captured from a camera in a tracking system, sizes and directions of faces area always changing. Additionally, there is a case that a part of body is hidden by some objects. However, even if a person's lower half of the body is hidden, a person's face can be captured in many cases. In this paper, we focus on using the face information in a tracking image , and carryed out person identification.

2. The person identification method using face information

The face recognition system using the geometric feature have been proposed so far. The domain of face part is small in tracking image. And when the angle and altitude of a face changes variously, it becomes very difficult

to extract parts, such as eye, nose, and mouth. Moreover, problem occurs when the template matching method is applied to the face recognition. It is mentioned that calculation load cannot be devoted so much to identification process, since extraction of a face domain and tracking process of a person are also needed.

By applying the eigenface method, we carried out performing person identification of the face image in a tracking image.

In this method, reduction of the amount of calculation is expectable ,by carrying out information compression of the pattern of a face image, because matching process is performed using the pattern vector of a low dimension.

2.1 The feature and flow of the proposal method

The feature of this proposal method is shown below.

When a person in the distance from a camera , face image is small, and when a person is in near, it is large. Moreover, the direction of face may change when a person walk. Because the direction of person's walking is not fixed. But the system can be necessary to correspond also to such a situation.

object image

Expansion or reduction are carried out for the face images of many sizes, and these images is made the same size. The face images of various angles are prepared for enrolment process, and it corresponds to direction change of a face.

Feature vector

Even when the size of a person's face changes, the pixel value of a person's face itself is used as a feature vector so that the information on a face can be expressed.

The identification method

The pixel value of the face image contains high order feature vector. But high order vectors are compressed to the low dimensions using Principal-component analysis.

The flow of the proposal method is shown in Fig.1.

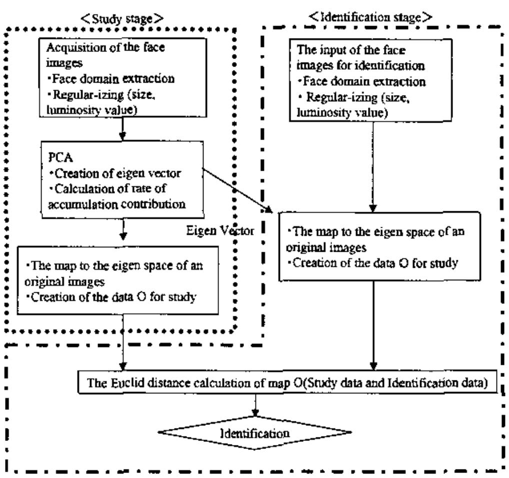

Fig.1: The flow of the proposal method

2.2 Pretreatment

Using face images captured by camera, it is assumed that change of the image size, and change of the luminosity value of the face images will occur by the conditions of indoor lighting.

Luminosity value

A face image contains $n \times n$(pixels). When the image is captured, there are also the so-called background image which doesn't contain face information. Since this background domain is same (background is covered with white cloth in this experiment environment), the luminosity value of this domain is unified into the average value of all the data for enrolment process, and the luminosity value is changed so that the luminosity value of a face image may distribute to 0-255.

Size

All images are changed into the same size by carrying out expansion-reduction of the face image obtained from the camera.

3. Principal-component analysis

As mentioned above, the pixel value of a person's face image is used as a feature vector. Since the size of a image is made into $n \times n$ pixels, one vector has n^2-dimensions [per image of one sheet]. When a face image is scanned horizontally, the upper left corner of a image is the start coordinates point, and it expresses x(1) and n^2 coordinates points $x(j)(j=1,...,n^2)$.

KL-deployment is used in order to cut down the number of dimensions of the feature $\boldsymbol{x}$. The $\boldsymbol{x}$ of I(persons)×J(fames) is prepared as data for enrolment, and the matrix $\boldsymbol{X}$ which is made by arranging them in a line.

$$\boldsymbol{X} = [\boldsymbol{x}_{1,1}, \boldsymbol{x}_{1,2}, ...\boldsymbol{x}_{1,J}, ..., \boldsymbol{x}_{i,j}, ..., \boldsymbol{x}_{I,J}] \qquad (1)$$

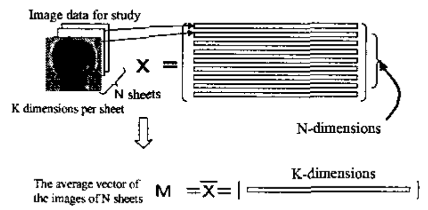

Fig.2: The acquisition method of the feature vector

The vector $\boldsymbol{m}$ is made as the average vector of the whole $\boldsymbol{X}$, and the covariance matrix $\boldsymbol{\Sigma}$ of matrix $\boldsymbol{X}$ is calculated as shown in (3).

$$\boldsymbol{m} = \frac{1}{N}\sum_{k=1}^{N} x^{(j)} \qquad (2)$$

$$\boldsymbol{\Sigma} = \frac{1}{N}\sum_{i=1}^{I}\sum_{j=1}^{J}(\boldsymbol{x}_{i,j} - \boldsymbol{m})(\boldsymbol{x}_{i,j} - \boldsymbol{m})^T \qquad (3)$$

N: Number of sheets of a registered image. (I(persons)×J(fames))

$$\boldsymbol{\Sigma}\boldsymbol{v}_k = \lambda_k \boldsymbol{v}_k \qquad (4)$$

About the covariance matrix $\boldsymbol{\Sigma}$, the eigen value $\boldsymbol{\lambda_k}$ and the eigen vector $\boldsymbol{v_k}$ are calculated. The rate $\boldsymbol{r}$ of accumulation contribution shown by the following formula is calculated in the large order of $\boldsymbol{\lambda}$.

$$\boldsymbol{r} = \frac{\sum_{i=1}^{R}\lambda_i}{\sum_{i=1}^{N}\lambda_i}, (k < N) \qquad (5)$$

$\boldsymbol{k}$ is calculated by the rate $\boldsymbol{r}$ of accumulation contribution, and the set $\boldsymbol{v}$ of $\boldsymbol{k}$ eigen vector $(\boldsymbol{v}_1, \boldsymbol{v}_2, ..., \boldsymbol{v}_k)$ corresponding to the higher rank accmulation contribution of $\boldsymbol{k}$ pieces are registered into a database as individual registration data.

The vector $\boldsymbol{o}$ is calculated for the feature vectors $\boldsymbol{x}$ by the following formula .

$$\boldsymbol{o} = [\boldsymbol{v}_1, \boldsymbol{v}_2, \boldsymbol{v}_3, ..., \boldsymbol{v}_k]^T(\boldsymbol{x} - \boldsymbol{m}) \qquad (6)$$

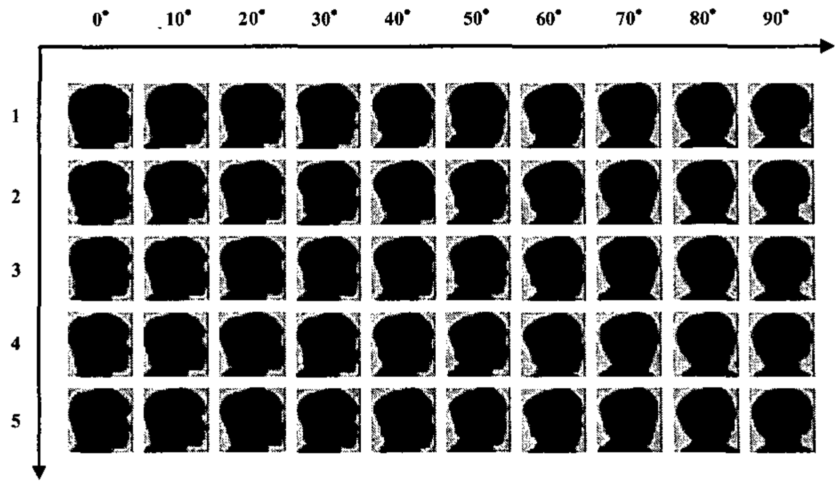

Fig.3: An example of an acquisition image

3.1 Acquisition of face images

First, a subject's face is captured and the image data used for enrolment is collected. The angle of a face changes variously in tracking images, so a subject rotates in advance. Images are captured under a white background so that it may be easy to carry out extraction process.

Moreover, while the person is walking, person's face is not always facing front side. That is, even if he is conscious of facing front, it is possible to change to the upper or lower sides a bit. Moreover, image data was acquired by having a person rotate by 10-degree unit this time. Multi datas of the same angle are acquired, but it might not become 10 degree correctly.

The example of the face images acquired per person is shown in Fig. 3. This time, a image is simultaneously taken for enrolment process and identification process. There are five patterns by the sum total per one angle, and pattern 1-2-3 is used for enrolment and pattern 4-5 is used for identification .

3.2 Registration of the data for enrolment

The eigenface method is applied and eigen space are created by performing principal component analysis. By the repeating method of approximation, a eigen value and a eigen vector are calculable one by one using Power-law-distribution which can improve the solution. The number of dimensions compressed based on the rate of accumulation contribution is decided, and the map o which compressed the original image to eigen space is calculated. When mapped to eigen space, the face image of one sheet will correspond to one point. Here, it is mentioned as character of eigen space that the correlation value between original images is equivalent to the distance value on eigen space. It becomes high correlation between the faces of adjoining angle and it may be understood also from Fig. 3 The distance of the map o which is a point on the eigen space corresponding to the image becomes small, and the sequence of points draw a smooth series.

4. Evaluation experiment

4.1 Influence by the difference in the number of input data

As a stage before mapping a original image to eigen space, principal component analysis by the eigenface method is performed. And there are calculation of eigen vector and a stage which calculates the rate of accumulation contribution. We have investigated what kind of influence in eigen vectors and the rate of accumulation contributions occurs by the change of the number of datas. The word, pattern, used here means how to combine, two or more data used for enrolment in the same person and the same angle acquired as shown in Fig. 3.

The following identification experiments were carried out by the proposal method.
Experiment 1 The images photoed at the equal distance from the camera.
Experiment 2 The images whose sizes are differ (zoom function of a DV camera).

4.2 eigen vector

In order to examine what change occurs to eigen vectors with the increase of the number of patterns, the following formula estimated the degree of similar of eigen

Fig.4: eigen vectori1st'5th-principal componentj

vectors between using 5 patterns and 1-4 patterns.

$$r_{k,j} = \frac{1}{I}\sum_{i=1}^{I}(100 - \frac{|v_{i,j} - v_{i,5}|}{|v_{max,5} - v_{min,5}|} \times 100) \quad (7)$$

$$R_j = 100 - \frac{|\sum_{k=1}^{K} c_{k,j} r_{k,j} - \sum_{i=1}^{I} c_{k,5} r_{k,5}|}{\sum_{i=1}^{I} c_{k,5} r_{k,5}} \times 100 \quad (8)$$

Here, R_j expresses that the degree of similar between the eigen vector $v_{(i,5)}$ using 5 patterns and $v_{(i,j)}$ using the number of patterns used as the candidate for comparison , which equivalent to the j-th principal components. $v_{max,5}$ and $v_{min,5}$ show the maximum and the minimum value in the element of $v_{i,5}$.

Fig. 6 shows that The degree of similar of the rate of accumulation contribution of the eigen vector $(v_1, v_2, ..., v_k)$ in consideration created in the experiment 1. However, x of data x-y in Fig. 4 is the number of patterns of the data for enrolment shown in Table 1, and there are 100 sheets at data 1-5, and 200 sheets at data 2-5, ..., 500 sheets at data 5-5 are learned. Fig. 6 shows the degree of similar as the base of the pattern 5 ($=y$) with most enrolment data.

4.3 The rate of accumulation contribution

We have calculated accumulation contribution from the formula (5) when the number of data of the face images used for principal component analysis is increased from one pattern to five patterns. By calculating the rate of accumulation contribution, it can measure how much information on the pattern vectors of original images does eigen vector includes. That is, if the rate of accumulation contribution is high in a low dimension, since the data for enrolment can be registered with the fewer number of dimensions, reduction of the amount of calculation is also expectable. You can understand from Fig. 5 that the more the number of dimensions are increased, the more the rate of accumulation contribution changes.

Fig. 5 shows that the rate of increase of the rate of contribution becomes low, when the number of patterns (the number of data) of the face images used for Principal component analysis increases. Moreover, if the number of data is small as used in this experiment, it reaches even to 70% in about 10 dimensions, and even to 80% in about 18 dimensions, and even to 90% in about 40 dimensions.

By this experiment, the pattern vectors of the 4096-dimensional original face images is compressed to the partial sapce of low dimensions which vectors maintain the amount of information , the rate of accumulation contribution indicate. Moreover, although the increase in the rate of contribution is intense in a low dimension, the rate of accumulation contribution is hard to go up as it becomes the component of high order. . This shows that the eigen vector of a low dimension can express more amount of information of a original image.

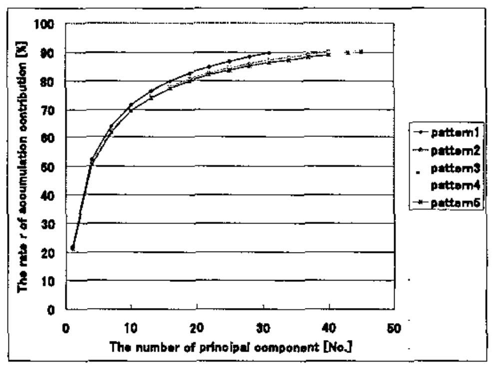

Fig.5: Change of the rate of accumulation contribution

4.4 Evaluation result

In experiment 1, it was discriminated that all 10 out of 10 subject persons are identity. Furthermore, in it, the number of sheets of the image judged to be the same angle (the number of correct answers) is shown in Table 2. Moreover, Fig. 6 indicates that almost same eigen vector (eigen space by principal conponent analysis) as the pattern 5 using many enrolment data has been created, even when there are few patterns of enrolment data (data 1-5, 2-5), almost same eigen vector (eigen

Table. 1: Experiment element

	Data for enrolment			
	Angle	Pattern	Number of people	Number of sheets
Experiment P	0‘90iEvery 10j	1‘5	10	100‘500
Experiment Q	0‘90iEvery 10j	1‘5	5	50‘250

Table. 2: The number of correct answers of the angle in experiment 1(10 persons) i20 data per individualj

person	A	B	C	D	E	F	G	H	I	J
The number of correct answers	20	13	18	16	18	18	17	20	16	15

space by principal conponent analysis) as the pattern 5. using many enrolment data has been created. However, since the identification result may be influenced if the vertical direction of a face is changed, these two factars are considered a trade-off relation.

FIg. 7, based on person A in experiment 2, shows the result of the degree of similarity regarding the rate of accumulation contribution of the vectors between any other person and person A. In this figure, B-A in Fig. 7 shows that the degree of similarity of the data of the person B based on the data of Person A. The results of experiment 2 lead us to think that the almost same mapping vectors were able to be obtained by inputting the data after normalization of face images of different sizes.

Fig. 7 shows that there is little influence even when the image size of input data changes. Moreover, since there is a clear difference between comparison A-A(between individual) and any other data, it can be said that identification of individual and any others is possible.

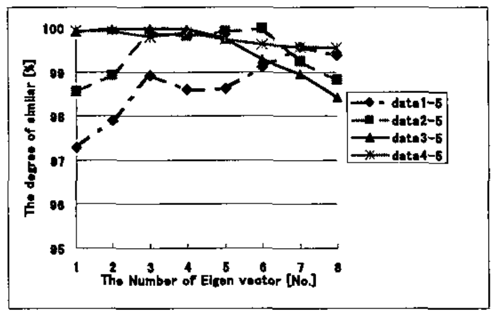

Fig.6: Experiment. 1 The degree of similar

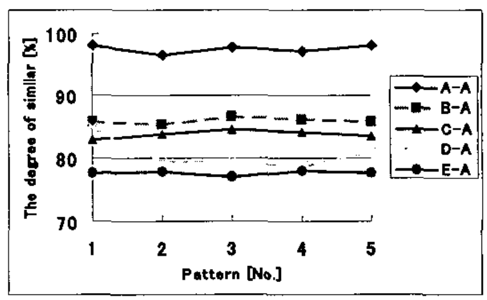

Fig.7: Experiment. 2 The degree of similar [between individual's Map vector O]

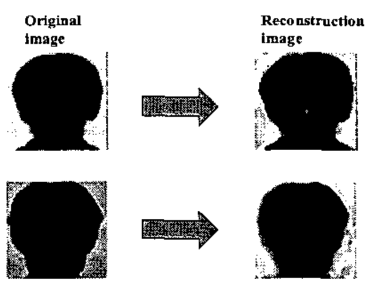

Fig.8: Reconstruction of a face

5. Conclusion

In the environment where a person's whole body is captured, we proposed for applying the eigenface method which is a 2-dimensional collation model , we applied this by using the images of various angles and sizes in the enrolment process. There are the following characteristics in a Tracking image. In an environment where the face domain occupied in the image captured is small, it is hard to extract the features as eyes, nose and mouth, and the direction and size of the face is not consistent. The evaluation experiment proved the adaptability to the tracking image. Moreover, since it is effective also from the regarding the speed of the calculation process, it is thought that it is effective also in identification process in real time.

In the future, We will focus on the following terms.

- Increase the number of people for enrolment.
- The method with which data is compensated focusing on the correlation between angles.
- Direction presumption processing of the face obtained from tracking system.
- Improvement in accuracy by integrating the identification result of multiple frames acquired during tracking.

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