Face Authentication Based on SIFT Features

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ABSTRACT

There are several ID cards as a method of personal authentication. This method is not always a surefire way in terms of safety, forgery and loss. This is why biometric authentication using physical features is gathering much attention. Face authentication is a part of it. There are, however, some problems when some parts in aface image are hidden by masks and sunglasses. In such case, face authentication could not be necessarily succeeded with conventional authentication methods. SIFT (Scale Invariant Feature Transform) is one of the algorithms that describes features that are brightness, orientation and scale invariant features. We consider SIFT features would be able to solve the problems in face authentication under above conditions. Goal of our study is personally identifiable using face image in some parts, such as eye or nose, are invisible. This paper proposes a face authentication based on SFIT features and show the effectiveness and availability of using SIFT features in face authentication.

Keywords: biometrics, face authentication, key point, scale invariant, rotation invariant, SIFT

1. INTRODUCTION

There are several authentication using biometrics such as vein, fingerprint and face features. Compared with other biometrics, face authentication have a merit that reluctance of users is low because that authentication is non-contact. Face authentication is, therefore, widely used such as security systems for access-controlled rooms. As applications using this merit in airport, face authentication is used to identify terrorists or criminals. We cannot, however, say face authentication were not yet fully reached. Because there are some problems when some parts in face image are hidden by masks and sunglasses. In such case, face authentication could not be always succeeded with conventional authentication methods.

Studies of face authentication had been made from the 1970's. In 1991,and Turk proposed a paper using principal component analysis(PCA) of face images that is called eigen face [1]. An identification method in this paper can achieve without technical ingenuity by fixing lighting condition and pose. From this paper, studies of face authentication has been becoming much active. Until recently, most of face authentication has been adopting algorithms based on PCA. These include dynamic collation eigen face, linear discriminant analysis, elastic graph matching punch or hidden Markov models. These methods could calculate image features including obstacle objects other than face, because of taking features from whole image. This becomes one of the problems in face authentication. So we consider, to solve this problem, an method that describes local features in face image.

SIFT (Scale Invariant Feature Transform) is one of the algorithms that describe local features of brightness, orientation and scale invariant[2]. Now, its main use is object retrieval or object recognition, for example in image database. However, study for face authentication using SIFT is not enough [3-6,8-9]. We consider SIFT features could be able to solve the problem in face authentication as above problem. It is because it robustly retrieves or recognizes target object even when the object is occluded by other objects.

Goal of our study is personally identifiable using face image in some parts, such as eye or nose, are invisible. This paper proposes a face authentication based on SFIT features and shows the effectiveness and availability of SIFT features in face authentication using face database with computer experiments. Organization of this paper is shown as follows. Firstly, the SIFT algorithm is briefly described in chapter 2, and the chapter 3 explains the proposed method. Second is that the chapter 4 shows the experimental results. Finally, the chapter 5 includes conclusion of this paper and some works to be considered in the future.

2. SCALE INVARIANT FEATURE TRANSFORM (SIFT)

Firstly, we review SIFT algorithm. The outline of SIFT is briefly introduced as below. SIFT can be divided into two steps, one is key points detection and, other is feature description.

A. Keypoints Detection

Points of describing features in image are called key points. The first step of SIFT algorithm is to detect key points. Firstly, SIFT detects candidates of key points using DoG (Difference of Gaussian). DoG is given following Eq.(1)-(4) below. Here, $L(x,y,\sigma)$, $G(x,y,\sigma)$, $I(x,y)$, and $D(x,y,\sigma)$ are smoothed image, Gauss function, input image, DoG image, respectively.

$$L(x,y,\sigma) = G(x,y,\sigma) * I(x,y) \quad (1)$$

$$G(x,y,\sigma) = \frac{1}{2\pi\sigma^2} \exp\left(-\frac{x^2+y^2}{2\sigma^2}\right) \quad (2)$$

$$D(x,y,\sigma) = L(x,y,k\sigma) - L(x,y,\sigma) \quad (3)$$

$$2\sigma_1 = \sigma_2 \quad (4)$$

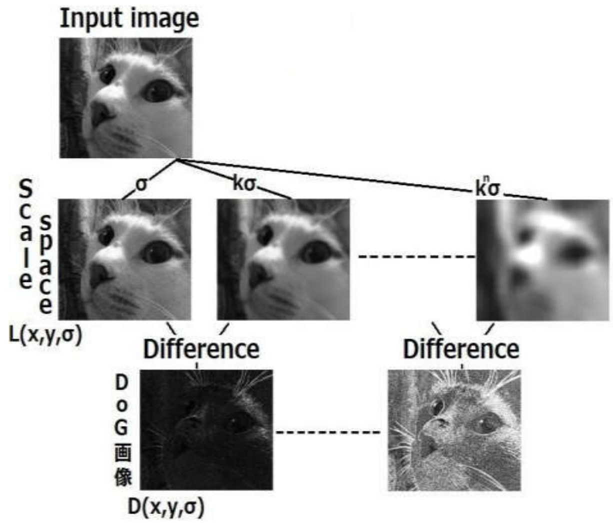


Figure 1: Calculation Flow of DoG Image

Figure 1 shows the flow of DoG processing. Firstly, Gauss function with a standard deviationσinEq.(1) is applied to the input image. This is performed as convolution of Gauss function to input image. The scaled image with a standard deviation σ is given. Secondly, the different scaled image with a standard deviation $k\sigma$ is calculated and the difference between two image is taken as a DoG image.k is called growth rate of scale space.

Because DoG image is the difference of two smoothed images with distinct σ, the some region of the DoG image that includes large value relatively could have a lot of information such as edge. This region could include candidates of key points. Here, the largest value is detected from the DoG images in ascending order withσ, and the position and scale of key points are decided as the candidates. This is shown in Fig.2. The pixel of the noted DoG as shown in Fig.2 is compared its neighboring 26 pixels, and the pixel is detected as a candidate key point, if its value is extreme value. Such extreme value detection is performed from DoG image in the order of a small value ofσ. As shown in Fig. 3, SIFT can describe features that invariant to the scale, because of Eq .(4) characteristic expression. Finally, reduction of key point candidates is performed by using threshold processing and principal curvatures.

B. Feature description

In this step, feature description quantity for each key points that is obtained in previous section is shown. Feature description quantity is defined as 128 dimensional vector based on gradient of pixel value in input image. This is normalized to the orientation with max value of the gradient. The Orientation is representative luminance direction based on value gradient of key points pixel. Therefore, SIFT has feature description invariant to orientation and scale.

Feature description consists of gradient strength and gradient orientation, and they are calculated out on the key points in the smoothed image. $m(u,v)$ is gradient strength, and $\theta(u,v)$ is gradient orientation of each key point. These gradient information can be obtained from the following gEq.(5)-(8) below. The gradient orientation is discredited to 36 orientations, and weighted histogram is created by the gradient strength.

$$f_u(u,v) = L(u+1,v) - L(u-1,v) \quad (5)$$

$$f_v(u,v) = L(u,v+1) - L(u,v-1) \quad (6)$$

$$m(u,v) = \sqrt{f_u(u,v)^2 + f_v(u,v)^2} \quad (7)$$

$$\theta(u,v) = \tan^{-1}\left(\frac{L_v(u,v)}{L_u(u,v)}\right) \quad (8)$$

Gradient information of neighboring region around each key point is obtained. This region is divided into 4x4 blocks. Histogram of orientation that discredited to 8orientation is created in each block. This become feature description of 128 dimensional vector. Figure 2 shows the description flow of feature description.

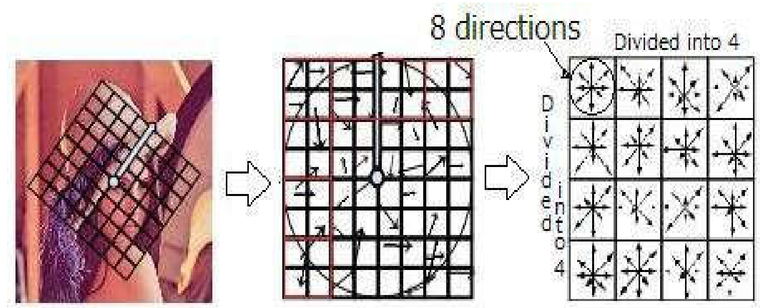


Figure 5: Description Region and Feature Description with Each Block[7]

3. FACE AUTHENTICATION USING SIFT FEATURE

We examine that whether SIFT feature is effective in face authentication in this chapter, and describe our proposed method and the evaluation.

A. Basic Experiments

In section 2, it is shown that key points detection of SIFT depends on the DoG image, so that key points are detected automatically. However, the goal of our study is personal identification using face image whose parts is occluded by something or missing. In that case, SIFT features in originally the unnecessary key points for the feature matching process may be used, and is not sufficient in face identification and results in wrong authentication. So, we manually select the key points from input image. In this way, we can make use of valid feature description, and examine that which key points are important. We do not know where key points are suitable or effective in face authentication. So, we performed experiment that attempts the relationship between the position of the key points and the matching accuracy. In our studies, we assume the image with occlusion such as wear a mask and sunglasses. Therefore, we firstly focus on four parts, eye, nose, mouse and cheek. The results are shown in the Fig.6. Color lines show the matching results between two key points.

(a) Eye **(b) Cheek**

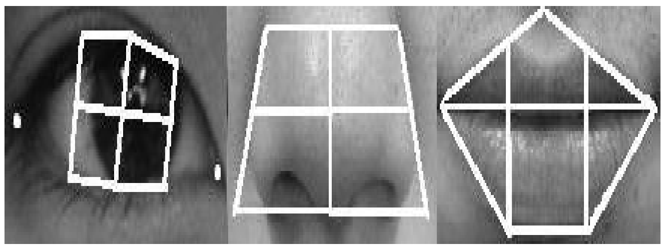
(c) Noise **(d) Mouse**

Figure 6: Matching Results for Four Parts in Face (Eye, Cheek, Noise, and Mouse)

From these results, it is understood that our experiment using SIFT shows the correct matching in eye, nose, and mouse area. But, in cheek area, accuracy is low because false matching and no matching is conspicuous. It was judged that the eye, nose, and mouse area were suitable and effective for feature description matching.

B. Creationof Grid Shape

It was decided to perform experiment with the eye, nose, and mouse area. However, there are many candidate points for key point selection, for example, the feature points such as in the corner of the eye or on the corner of the eye might be candidates. So, we created a grid for each area in order to perform quantitative experiments. These grids are shown in the Fig.7. It was performed experiment to increase the number of key points on the grid, and examined whether changes in identification rate.



(a) Eye **(b) Noise** **(c) Mouse**

Figure 7: Grid Shape for eye, nose, cheek, and Mouse Area

Grid shape is composed by several points that should be easy to extract manually. How to create the grids for each part is as below. Figure 8(a),(b),(c) shows the grids of eye, nose, and mouse area, respectively.

(1) Grid of Eye Area

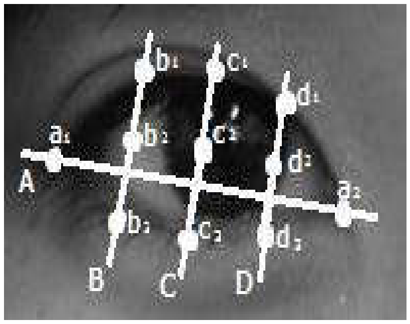
- Put two points; a1 and a2 each corner of eye.
- Draw a straight line from a1 to a2. Then, call this line A.
- Draw three lines at right angles to the each point divided in four on A line.
- Assume the junction of above three lines and the corner of eye to b1, b3, c1, c3, d1, d3.
- Assume the middle point between b1 and b3, c1 and c3, d1 and d3 as b2, c2 and d2.

(2) Grid of Nose Area

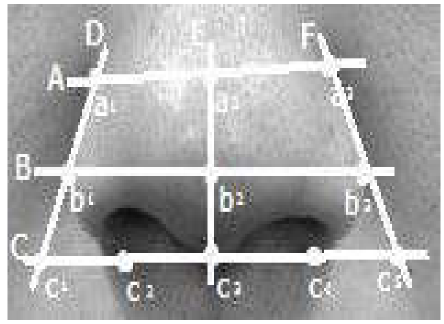
- Assume the above break points of sidewall to a1 and a3.
- Assume the width break points of sidewall to b1 and b3.
- Draw two lines from a1 to a3, from b1 to b3. Then call each line A and B.
- Assume the middle point between a1 and a3 on line A, b1 and b3 on line B as a2 and b2.
- Draw a straight line from a2 to b2. Then, call this line E.
- Assume the junction of line E and supari to c3.
- Draw a parallel line with line B on c3. Then call this line C.
- Draw a straight line from a1 to b1, from c3 to b3. Then, call each line D and F.
- Assume the point of junction of the line D and line C, and junction of the line F and line C as c1 and c5.
- Assume the middle point between c1 and c3, c3 and c5 as c2 and c4.

(3) Grid of Mouse Area

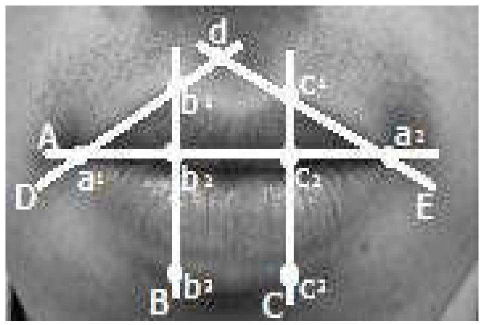
1. Put two points; a1 and a2 each corner of mouse.
2. Assume two points that dented on upper lip as b1 and c1.
3. Draw a straight line from a1 to a2. Then, call this line A.
4. Draw two lines at right angles from line A to the each point b1 and c1. Then, call each line B and C.
5. Assume the point of junction of each line B, C and the bottom of the mouse as b3 and c3.
6. Draw straight line from a1 to b1, from a2 to c1. Then, call each line D and E.
7. Assume the point of junction of line D and line E as d.



(a) Eye Area



(b) Noise Area



(c) Mouse Area

Figure 8: Grid Area for Eye, Noise, and Mouse

C. Proposed Method

We examined using these grid created in above. This is in order to acquire necessary feature value by increase the number of key points. When the number of key points increasing up to 11 from 1, we examine the identification rate of 10 persons. The key points from the input images were compared to ten face images, which we took beforehand, one by one using SIFT matching as shown in Fig.9. In cooperation on members of our laboratory, we took 10 face images that used in the experiments. Further, we divided the shooting date. Imaging conditions were aligned size and direction of faces.

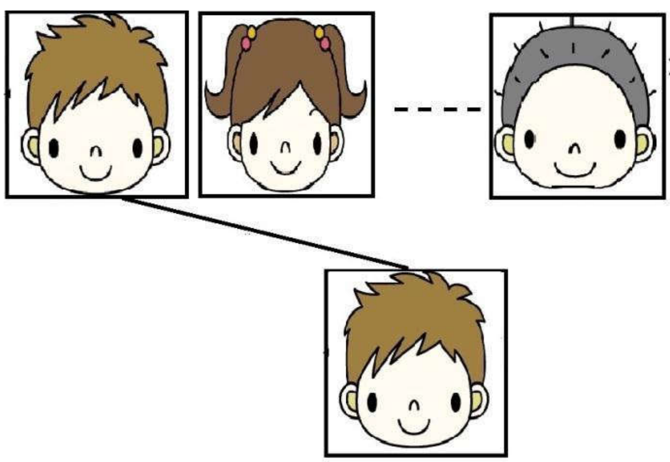


Figure 9: SIFT Matching with One by One.

D. Evaluation Method

In SIFT matching experiments; a person in most high percentage of correct corresponding key points is decided as identified person. This is shown in Fig.10. Experimental evaluation is performed by visual, and we show the percentage that identified how many people out of ten people. From the result of this, we evaluate whether face authentication using SIFT feature can be used.

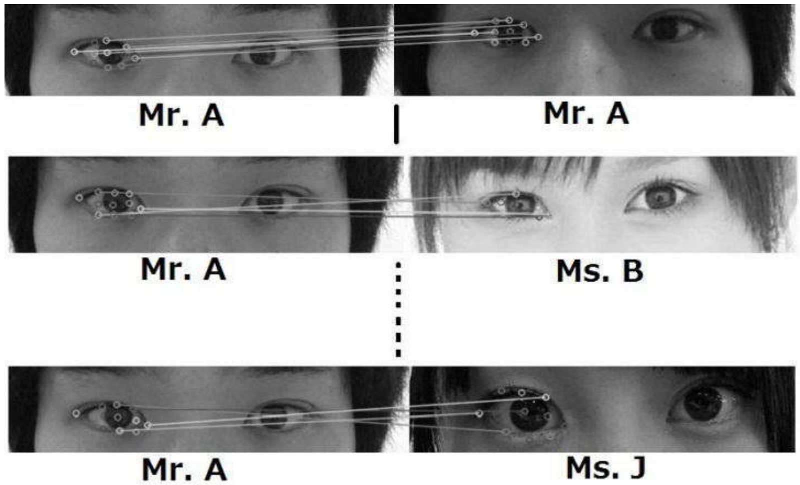


Figure 10: Matching in Eye Area

4. COMPUTER SIMULATION

A. Experimentals Results

We performed experiment and obtained its results. These results are shown in Table 1. This table shows the percentage in the number of key points established. This percentage is that how many people out of 10 persons are identified. From this table, it was found that the identification rate has risen from 4, 5 or 6points.

Table 1: Experimental Results

Number of Key points	Eye (%)	Noise (%)	Mouse (%)
1	0	0	0
2	0	0	0
3	0	0	20
4	0	0	20
5	10	0	70
6	20	10	90
7	20	60	100
8	50	30	100
9	50	80	
10	70	80	
11	80	100	

B. Consideration

We considered the experimental results in each eye, nose, and mouse area. The results of eye, nose, and mouse area are shown in Figure 11. These are identification rate for the change in the number of key points.

(1) Eye

It was found that the identification rate was raised in increasing the number of key points, and however the identification rate did not reach 100%. It is considered to this result as aperture problem. This is likely to be happened and increases the false matching. Therefore, we understand that the identification rate is lower by increasing false matching.

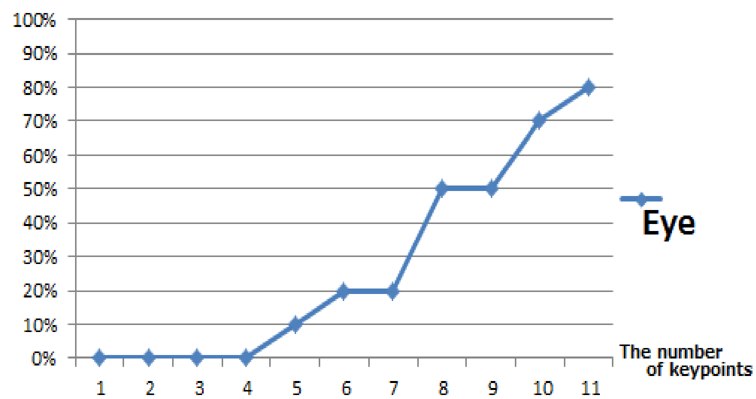
(2) Nose

Similarly, in the nose area, itwas found that the identification rate was raised in increasing the number of key points. When there are 8keypoints, identification rate decreased. This is because that key points selection is carried out manually. It result in deciding the unintended position of keypoints. This feature description is false and effects on matching results.

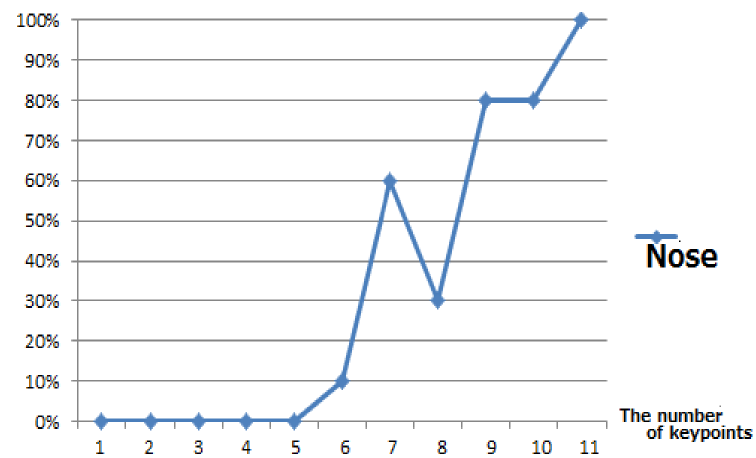
(3) Mouse

Similarly in the mouse area, it was found that the identification rate was raised in increasing the number of key points. The identifying rate is better than other area. SIFT features in mouse area is well suited compared with other area.

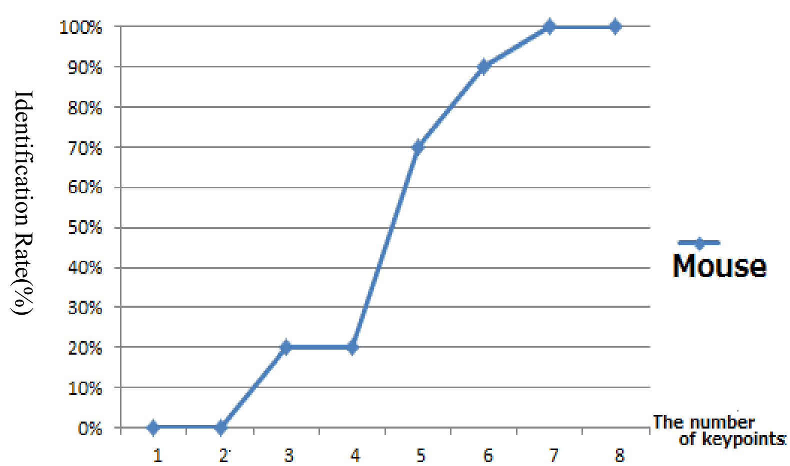
Finally, it could be concluded that SIFT features are effective and available in face authentication.



(a) Eye



(b) Noise



(c) Mouse

Figure 11: Identification Rate

CONCLUSION

In this paper, we have proposed a face authentication method based on SIFT feature, and showed the effectiveness and availability of SIFT features in face authentication using face images with computer experiments. However, it did not work in all area of face, especially in the eye area. Further improvement is needed. It is also important to reduce false matching that caused by the aperture problem. So, it must be needed to create the shape of the grid that is less susceptible to the aperture problem.

In this time, it was carried selecting the key points manually. However, to complete face authentication method, these key points such as representing eye, nose, and mouth should be choose automatically. As this key point select in method must be different to the method described in original SFIT paper [1].

Future work is to complete our method includes above improvement, especially automatically key points selection.

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