Simple Identification Process Using Vein Pattern

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Abstract

In recent years biometrics security technology, which certify an individual with human characteristics, attracts more and more interest. In this study, we pay attention to vein pattern certification technology. We firstly take photos of a vein pattern of forefinger using a transmitted near-infrared light method with a near-infrared light camera. We then convert them to grayscale images, emphasize the vein part, and get normalized images. Finally, we propose some algorithms to compare two of these images. One of the most important problems that lower the accuracy of recognition is the difficulty of adjusting the location of the two images. We show some experimental results as a basis to solve this problem.

Introduction

People's interest in security for personal information is rising in recent years. The identification methods using memory and knowledge such as passwords have been used earlier as a tool to protect security. Recently, living body authentication system is expected to realize both security and certainty. Living body authentication utilize many parts of our body such as fingerprint, countenances, handwriting, irises, retinas, veins, voiceprint, and DNA. Especially, the identity authentication technology based on vein recognition has been widely utilized in place of conventional password in various places such as ATM (automated teller machine).

This study attempts to manufacture the finger vein authentication system with higher precision at lower cost. First, we manufacture near-infrared LED lighting, and capture veins with a CCD camera. Then, we construct an authentication system by analyzing the pictures of extracted veins.

Vein certification

The vein works to return the blood including unnecessary things such as carbon dioxide or the waste material to the heart. Since the red blood cell of veins shows a characteristic to absorb specific near-infrared light, we can extract the image of the vein pattern. Even if the size of his/her finger changes by growth, the vein pattern itself remain unchanged. The vein patterns differ from person to person, even between twins, and it is hard to be imitated, so it can be used for personal identification.

Features of vein authentication technology

1. Since it is an internal physical information, it is more difficult to counterfeit than other biometrics such as fingerprint, face, irises, etc., and thus reliability is high.
2. Because the penetration light is used to get the vein image of the finger, the influence such as dust and dirt is little.
3. The contact part of the tip of a finger is little, and user's psychological sense of resistance is little.
4. The vein pattern of a finger can be easily memorized to IC card.
5. The attestation speed and the attestation accuracy are high.

Obtaining Vein Images

Near-infrared light

It had been said that the living body is hard to penetrate light until the transmittance of the near-infrared light of wavelength 700-1200nm turned out to be high. The light of this wavelength range penetrates the biotissue such as a muscle and the fat of the human body, but is absorbed by pigments such as the hemoglobin or melanin in blood.

Reduction hemoglobin streams down a vein and is the hemoglobin which lost oxygen. Oxidation hemoglobin and reduction hemoglobin have different absorption coefficients. The reduction hemoglobin of blood was understood that it made the vein pattern visible by absorbing the near-infrared light (Fig. 1).

Making a near-infrared lighting

To make a panel of near-infrared lighting, we prepare the following material;

- a universal base (4.7 cm * 7.2 cm),
- five resistances (100Ω),
- five LEDs.

Against a universal base, I installed five LEDs and five resistances in a line, respectively, and fix them with solder as in Fig.2. We use LEDs of several wavelength; 700nm, 750nm, 780nm, 800nm, 850nm, etc.

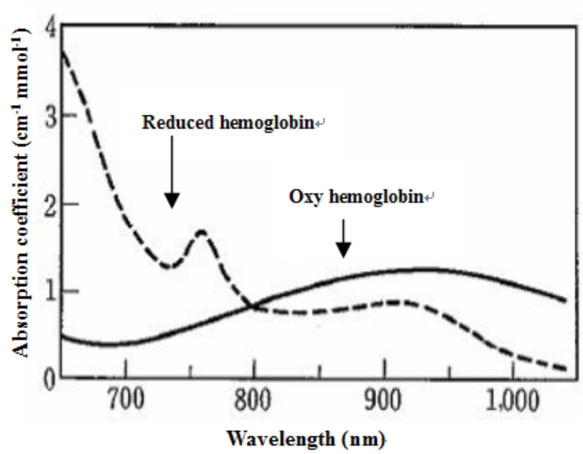

Figure 1. *Hemoglobin absorption spectrum*

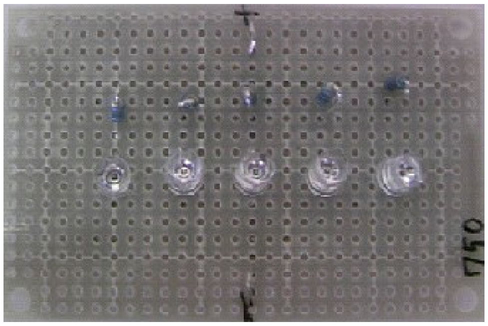

Figure 2. Light source

Taking photos of finger veins

Photographs of the vein image are taken by using a near-infrared light source placed at the back of the finger. The near-infrared light will penetrate the living tissue and transmit a light to the camera, thus the light part should be represented by the white area in the captured images. On the other hand the light will be absorbed by the reduction hemoglobin, thus the blood vessel, especially the vein part should be represented by black area in the captured images. Note that the pattern of a vein in the deep part of the finger and the bone will be represented by white because they are deleted by dynamic scattering. This photographing schema is illustrated in Fig. 3.

We asked 20 people, from 17 to 50 of age, to be experimental subjects and took some photos of each subject's forefinger. Fig.4 shows four transmission images of the fingers of three of the subjects for this experiment. Let us denote their names as 'A', 'B', and 'C'. In Fig.4, (a) and (a') are the images of subject A, (b) and (c) are the images of subject B and C, respectively.

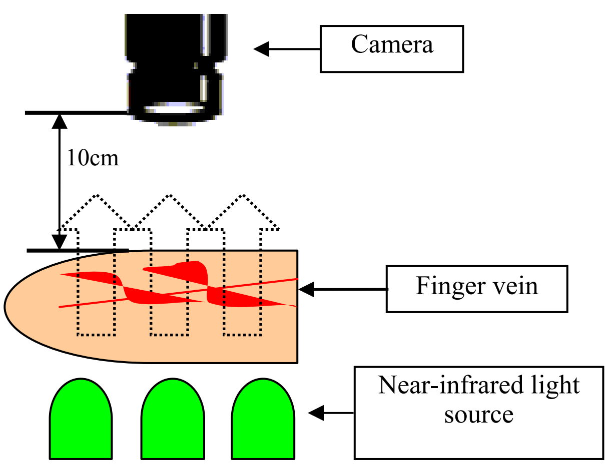

Figure 3. Transmitted light method

Image Processing

The emphasis process of a blood vessel picture is performed in the order as shown in Fig.5. First, ROI of the image which size is 205 pixels in width and 141 pixels in length is trimmed. Second we converted the density of the trimmed image. Finally we apply the line thinning method to this density converted image. The trimmed images obtained from Fig.4 are shown in Fig.6, the density converted images obtained from Fig.6 are shown in Fig.7, and the line thinning processed images obtained from Fig.7 are shown in Fig.8.

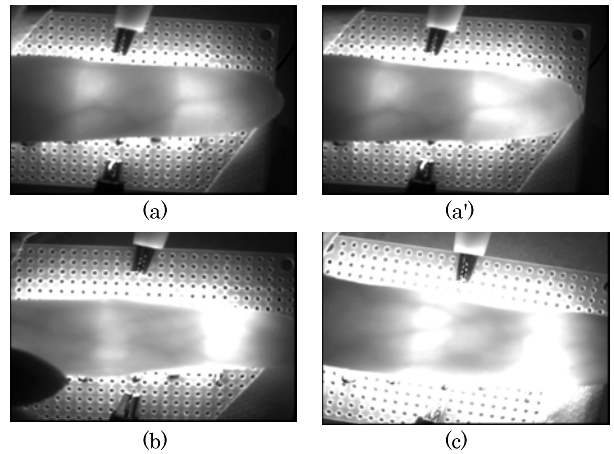

Figure 4. Raw images of forefingers of three subjects; (a) and (a') subject A, (b) subject B, and (c) subject C.

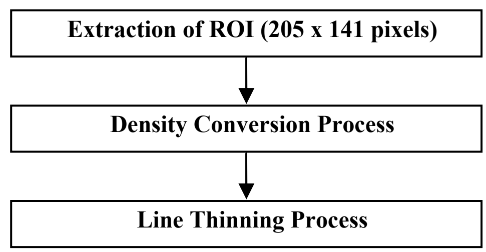

Figure 5. Processing order of a raw image.

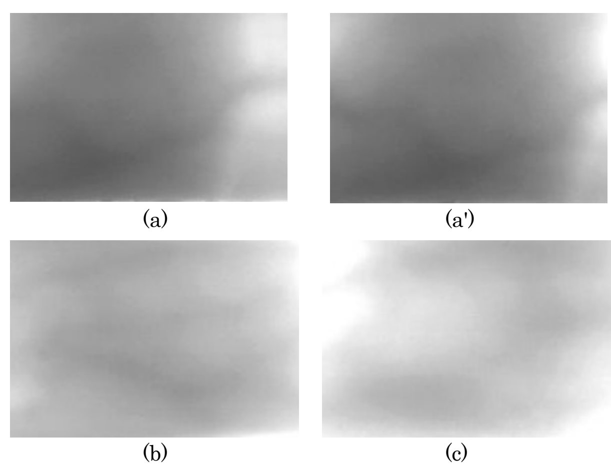

Figure 6. Trimmed images of raw images of forefingers of three subjects; (a) and (a') subject A, (b) subject B, and (c) subject C.

Certification experiment

Pairwise comparison

We developed a software which could compare two images pixel by pixel and calculate the 'match rate'. The match rate is defined as a ratio of the number of the pixels having the same brightness value in common for the numbers of all the pixels, that is,

Match rate of image A and image B

$$= \frac{\#\text{pixels having the same position and value}}{\#\text{ pixels of image A}} \text{ x } 100 \qquad (1)$$

where the number of pixels of image A should be the same as that of image B.

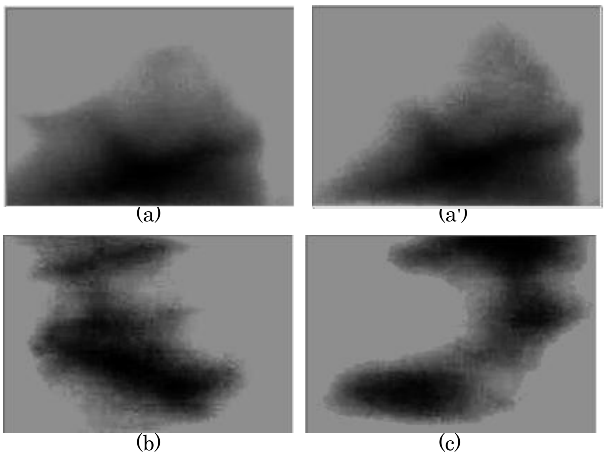

Figure 7. Processing order of a raw image.

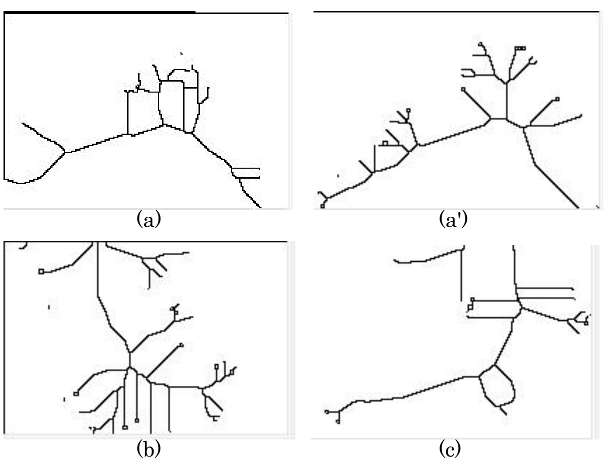

Figure 8. Processing order of a raw image.

Let $P_A(x,y)$ and $P_B(x,y)$ be two brightness values of pixels at the position of (x,y) of image A and B, respectively. Then we can say the number of pixels having the same position and the same value is $|\{(x,y)|P_A(x,y)=P_B(x,y)\}|$. However, we can not always extract the same position of a finger because the position of a finger changes every time we take photos. Therefore we define the modified match rate of image A and B as the following;

Modified match rate of image A and image B

$$= \frac{\max_{0\le s\le i, 0\le t\le j} |\{(x,y)|P_A(x,y)=P_B(x+s,y+t)\}|}{\#\text{ pixels of image A}} \text{ x } 100 \qquad (2)$$

where i and j are the expected range of location difference in the x and y direction, respectively.

Let us denote the nth image of subject A as An. Then we have A1, A2, B1, B2, ..., T1, and T2, that is, 40 images in all. Now we do two kinds of pairwise comparison; "same person" and "different persons". In the former comparison, the match rate of 20 pairs (A1, A2), (B1, B2), ..., (T1, T2) are calculated, and in the latter comparison, the match rate of 760 pairs (A1, B1), (A1, B2), (A1, C1), ..., (S2, T1), (S2, T2) are calculated.

Result

The results of pairwise comparison are shown in Table 1 through to Table 3, where two kinds of LEDs with different wavelength, 750nm and 780nm,.are used as lightings.

Table1: Match rates of raw images

	same person		diff. persons	
Wavelength of LEDs (nm)	750	780	750	780
Match rate average (%)	4.0	3.7	2.4	2.6
Standard deviation (%)	4.7	4.5	2.5	3.1

Table 2: Match rates of density converted images

	same person		diff. persons	
Wavelength of LEDs (nm)	750	780	750	780
Match rate average (%)	29.6	30.5	20.7	27.6
Standard deviation (%)	6.1	5.6	7.0	6.1

Table 3: Match rates of line thinning processed images

	same person		diff. persons	
Wavelength of LEDs (nm)	750	780	750	780
Match rate average (%)	8.6	20.7	6.4	4.1
Standard deviation (%)	10.7	7.0	5.1	4.0

Discussion and future tasks

From the experimental results, the images processed only by density conversion method are most suitable for pairwise comparison, that is, high match rate between images of a same person, low match rate between images of different persons, and low standard deviation. In the case of density converted images, however, there are not enough difference between the two match rates. This occurs because of the influence of the light from other light source, and of the unstable location of photographed fingers.

When we take photos of a finger, we cover it with a simple enclosure made of cardboard to shut out outside light such as sunlight or a light from fluorescent lights. We think this is not enough and we have to adjust quantity and dynamic scattering of the light source. Moreover, as a future task, we should take not only the parallel translation but also rotary motion into consideration.

References

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Author Biography

Kitakubo Shigeru is Assistant Professor of Nippon Institute of Technology. He received his Bs., Ms. and Dr. degrees in Science from Tokyo Institute of Technology in 1986, 1988, and 1992, respectively. He participates in most of NIP conferences since 1995. He is now interested in digital processing theory, especially in halftoning. He is a member of ISJ.