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Development of Data Fusion Human Identification System Based on Finger-Vein Pattern-Matching Method and photoplethysmography Identification

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Abstract

Biometric techniques for authentication using body parts such as a fingerprint, face, iris, voice, finger-vein and also photoplethysmography have become increasingly important in the personal security field, including door access control, finance security, electronic passport, and mobile device. Finger-vein images are now used to human identification, however, difficulties in recognizing finger-vein images are caused by capturing under various conditions, such as different temperatures and illumination, and noise in the acquisition camera. The human photoplethysmography is also important signal for human identification. In this paper To increase the recognition rate, we develop camera based identification method by combining finger vein image and photoplethysmography signal. We use a compact CMOS camera with a penetrating infrared LED light source to acquire images of finger vein and photoplethysmography signal. In addition, we suggest a simple pattern matching method to reduce the calculation time for embedded environments. The experimental results show that our simple system has good results in terms of speed and accuracy for personal identification compared to the result of only finger vein images.

Keywords: *finger-vein identification, biometric techniques, data fusion pattern matching, photoplethysmography*

1. Introduction

With the rapid development of IT(Internet Technology), there has been an increasing demand for biometric technology to apply the security of information. Biometric recognition systems have been usually applied to many areas such as national ID cards, e-passports, border crossings, access authority, IT equipment login systems, and smart cards. However, although hand-shape-based biometric techniques, such as fingerprints, palm prints, and finger-veins, are very popular, some weaknesses for security still remain and are focused. Hand-based biometric techniques such as finger print identification depend on the surface conditions, as well as the degree of sweat and dryness of the user's body. In addition, these techniques suffer from the threat of easy forgery. The use of finger-veins as accurate and fraud-proof biometrics has drawn

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increasing attention from pattern recognition practitioners in recent years[1]. Even though veins in the body are unique and persistent, and authentication systems can utilize finger-vein patterns, finger-vein recognition system can overcome the weaknesses of other hand-based biometric techniques. The advantages of a finger-vein recognition system were introduced in [2]. A finger-vein patterns are non-contact and internal features, finger-vein recognition allows for a comparatively high level of security. Finally, vein can only can be recognized from a living body, and thus finger-veins can be applied to live-body identification. In this paper, we compare different popular biometric recognition techniques. Table 1 shows the comparison results of various biometric technologies[3]:

Table 1. Comparison results of various major biometric recognition methods[3].

Bio-metrics	Security		Convenience				
	Anti-forgery	Accuracy	Speed	Availability	Acceptable	Cost	Size
Fingerprint	N	N	G	I	I	G	G
Iris	N	G	N	N	G	I	I
Face	N	I	N	N	I	I	I
Voice	N	I	N	N	I	N	N
Finger Vein	G	G	G	G	G	N	N
EGC	G	G	N	G	G	G	G

G: Good N: Normal I: Insufficient

In the above comparison, a finger-vein recognition system shows a comparatively high level of security and convenience. However, authentication using a finger-vein still incur certain problems. The original images of a finger-vein usually have a low contrast. It cause to reduce the success rate of recognition. In this paper, to overcome the problems of finger vein recognition and to increase the level of authentication, we combine the finger vein imaging system to finger based an optical photoplethysmography(PPG)[4] sensor. From a hardware perspective, two sensors are easily combined and measure two signals at a same finger. The image processing algorithm of finger vein pattern matching algorithm and heart wave signal finger vein recognition is based on a simple pattern-matching method for embedded applications that can achieve invariant pattern matching with a limited number of shifts and rotations and identification of photoplethysmography signal. The proposed algorithm allows for the use of a cheap and fast hardware system with high level security.

2. Finger-vein and PPG recognition system

Figure 1 shows our proposed authentication system. Our authentication device for finger vein recognition and PPG pulse, use a low-cost camera, Logitech C920 Camera(1920 x 1080) with a CMOS sensor, for acquiring the finger-vein images, as shown in Figure 1. In our proposed device, we use a penetrating infrared LED with a wavelength of 800 to 950nm as the light source. Because the infrared array LED is unable to penetrate the finger bone, and we must see the vessel beneath the bone, Infrared array LEDs are located along the side of the finger position and illuminate perpendicularly into the finger to collect the best quality finger-vein images. The four finger-vein images captured by our proposed image acquisition system and heartwave are also shown in Figure 1. The method to acquire PPG pulse is based on measurement of the change of brightness in ROI. To acquire high speed frame rate of image capture, the ROI size is reduced.

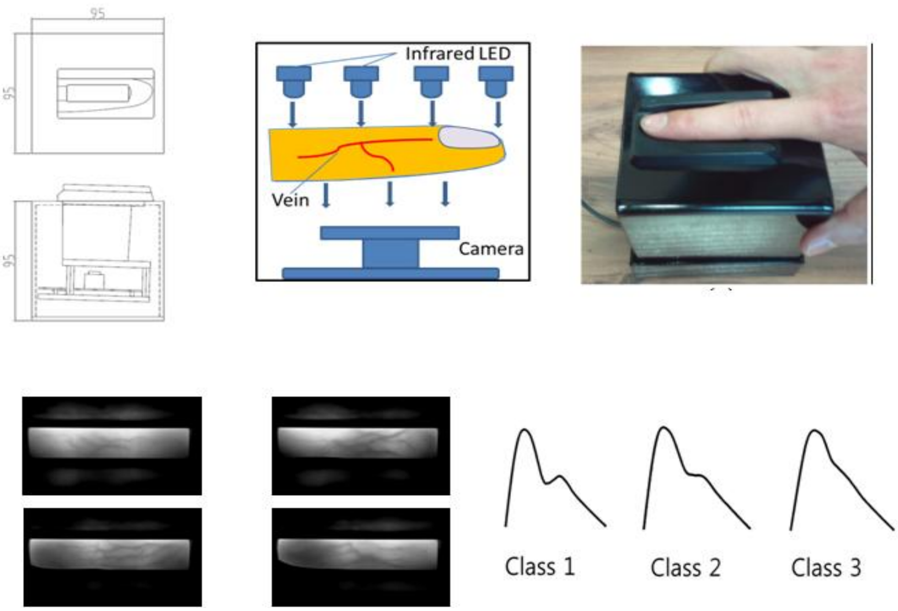

Figure 1. The finger-vein and PPG pulse authentication system [4,5]

3. Image processing algorithms

Captured finger-vein images are usually blurry and suffer from low contrast. The main reason for such blur and low image quality is that the light must penetrate the human body, and the human finger acts as a blurring filter. Image deblurring is therefore an inevitable step in an optical system to enhance the quality of an image. We choose a spatially invariant Gaussian distribution blur model, because, spatially invariant Gaussian blur usually occurs during the digital image processing in an optical system. In this paper, we use the following:

$$X_{i,j} = \frac{1}{\omega} e^{-\frac{(i^2+j^2)}{2\sigma^2}} \qquad \omega = \sum_{i=-M}^{M} \sum_{j=-M}^{M} e^{-\frac{(i^2+j^2)}{2\sigma^2}} \tag{1}$$

Here, $X_{i,j}$ is the gray value in the i^{th} column and j^{th} row of image X, *Row* and *col* are the height and width of image X,$\sigma$is the unit pixel length, and$M$is the size of the mask. We chose M to be 5 and σ to be 3.7.

PPG is measured by CMOS camera through measurement of the change of brightness in each frame of the images taken by the camera. Each pixel of an image is composed of a total of 24-Bit (R, G, B) color images, and the color images are re-configured into gray scale images in order to improve the change of brightness and the image processing velocity. The methods for conversion to gray scale is selected to HSV method, which expresses the brightness most effectively. The evaluation of the PPG signal efficacy through the representative gray scale conversion method is explained and discussed in Fig. 2. After acquiring images for 2 seconds(300frame) , calculation of the mean value of gralvel in each sector in the present frame and the previous frame. The mean gray value is PPG singal

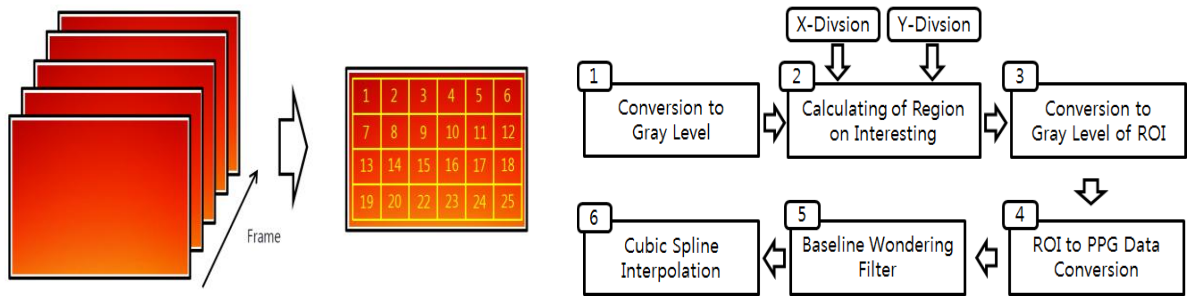

Figure 2. Calculation of a PPG pulse

4. Recognition Algorithm

Our proposed finger-vein recognition algorithm has three main steps, as shown in Figure 3. The first step is capturing images using the finger-vein image acquisition system. The second step is matching between the model and input images. In the second step, three important sub-steps, shown in Figure 3, are applied. The first sub- step is an image enhancement and, normalization after deblurring, the second sub-step is calculating the matching error, and the last sub-step is returning the matching error.

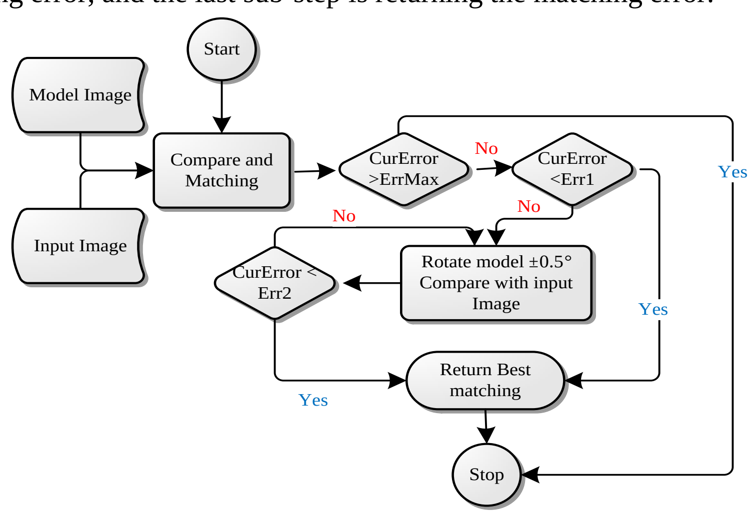

Figure 3. Schematic of the finger vein recognition algorithm

In the first step, the input images are captured twice by the evaluated image acquisition system. The histograms of two images are compared with each other. When they are similarly correlated, we choose one of the two images arbitrarily as an input image. While capturing a finger-vein image, the finger of the user will usually shift or rotate in position. Our algorithm can solve the rotation pattern-matching problem by generating 20 rotation model images from -5° to +5°in±0.05° steps. The rotated model images are generated using binary pixel interpolation. These rotated model images are stored in the database in advance.

The second step of our algorithm is a comparison and matching of the model images and with the test images. The next step is to calculate the correlation value between the model and test images. If the model and test images are of different fingers, the correlation value will be lower than when they are of the same finger.

At the end of this process, the matching error value is returned. This value is used in the next step of our algorithm and calculated through (2):

$$Error_{Matching} = \frac{\sum_{u}^{v} abs(I_{row-u,col-v} - M_{u,v})}{Area_M} \tag{2}$$

where, M is a model image, I is an input image, Error Matching is a matching error between input image I and model image *M*, *Xi,j* is the gray value in the ith column and jth row of image *X*, *u* and *v* are chosen such that all points of the template will be reached, row and col are the height and width of image *I*, Area *M* is the area of image *M*. The values of u and v are the limits of the image shift are set to -5 to 5.

In the last step of the calculation, the correlation returns the best matching error. Our proposed algorithm uses 21 model rotated from -5° to +5°in±0.05° step to resolve the rotational image-matching problem, and applies pixel shifts of -5 to 5 to resolve the shift image problem. The minimum matching error chosen.

The value of the correlation is calculated to return the minimum matching error (as shown in Figure 5). Values such as ErrMax, Err1, and Err2are determined based on the system testing using image data. Our proposed algorithm shows a higher accuracy and speed.

Figure 4 shows the waveform when blood is circulated through the aorta and capillaries and flows into the vein, and the ratio of a to b is called the RI (reflection index). The feature points of PPG include the onset point, peak point, dicrotic notch point, and peak-reflection point. Even though the measurement is done by one person, the dicrotic notch point and peak-reflection point may not appear depending on the surrounding environment and the state of the person who performs the measurement.

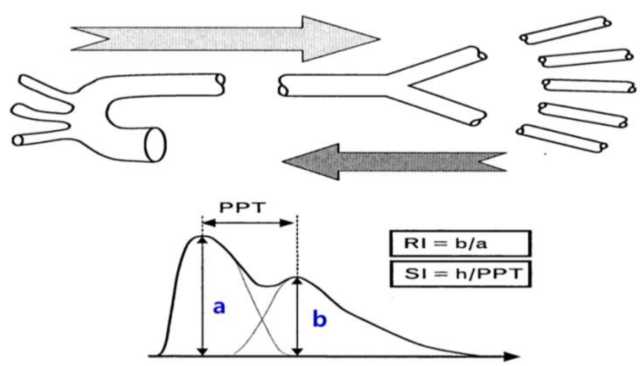

Figure 4. Principal of the photoplethysmography(PPG)

5. Experimental Result

The finger-vein and PPG datasets for our experiments were generated by collecting finger-vein images from 100 individuals. Each data of an individual was captured five different times. In total, the database contains 500 x 21 finger-vein model images because each model image was rotated 21 times and PPGs. Our proposed method is 99.20% compared with 97.60%(only finger vein) and 98.20%(only PPG) success rate. Table 2shows the results of our classification. When finger-vein pattern matching is failed, the PPG matching is applied. When the PPG matching is failed, the finger-vein is used in other direction. However, when the matching rate of both PPG and finger vein method is lower than threshold values, the matching is defined to fail

Table 2. Comparison results of the proposed method.

Authentication System		*Number of Total Trials*	*Number of Successes*	*Number of Fails*	*Ratio(%)*
Reference System		500	451	49	90.20
Proposed method	Finger Vein	500	488	12	97.60
	PPG	500	491	9	98.20
	Data Fusion	500	496	4	99.20

6. Conclusion

The greatest difficulty in a finger-vein recognition system is that the original finger-vein images have a low contrast and are blurry. To recognize the finger-vein images with a high success rate, a complex shift-invariant pattern-matching algorithm is needed for noise reduction, image re-construction, and rotation. However, we use PPG signal to increase success rate. we used a simple identification device for acquiring the finger-vein images and PPG with a conventional CCD and lens at once, and proposed a simple pattern-matching algorithm for finger-vein and also PPG signal, with low computational complexity. Our experimental results show that our proposed identification methods using finger- vein images and PPG has good results with an accuracy of 99.20%. In the future, our study will concentrate on developing image acquisition system to obtain better quality finger-vein images and PPG signals and new fusion algorithms for high success rate and fast identification

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References

[1] Y.Shi, J. Yang, J. Yang, “A New Algorithm for Finger-Vein Image Enhancement and Segmentation,” *Information Science and Industrial Applications*, Vol. 4, No. 22, pp. 139-144, 2012.

[2] S. Zhao, W. Yiding, and W. Yunhong, “Extracting hand vein patterns from low-quality images a new biometric technique using low-cost,” *International Conference On Image and Graphic*, pp. 667-671, 22-24 August 2007.
DOI: 10.1109/ICIG.2007.97

[3] Ephin M, Sherya Mohan, N.A. Vasanthi, “Survey on Multimodal Biometric Using Palm print and Fingerprint,” *Amrita International Conference of Women in Computing*, pp. 36-41, 2013.

[4] Dawber, T.R., H.E. Thomas, Jr., and P.M. McNamara, “Characteristics of the dicrotic notch of the arterial pulse wave in coronary heart disease,” *Angiology*, Vol. 24, No. 4 , pp. 244-55, 1973.

[5] Ko, Kuk Won, et al., “Development of Human Identification System Based on Simple Finger-Vein Pattern-Matching Method for Embedded Environments,” *International Journal of Security & Its Applications*, Vol. 9, No. 5, pp. 297-306, 2015.
DOI: http://dx.doi.org/10.14257/ijsia.2015.9.5.29