FINGER VEIN VERIFICATION TECHNOLOGY FOR MOBILE APPARATUS

Hideo Sato
FVA Business Department, Sony Corporation, Japan

Keywords: Biometrics, Finger vein, Authentication, Mobile devices, Forge resistance.

Abstract: In this paper we present a new finger vein authentication technology for consumer mobile products. The finger vein patterns are unique for each individual and do not change over a long time. Since finger veins exist inside of the body, it is extremely hard to be forged. Very short response time while keeping high-level security authentication is achieved by the new compact-fast-matching scheme and small-size template. The data size is nearly as small as the one of the minutiae-based fingerprint authentication systems. The compact sensor size is realized by the method of reflecting scattering light. These technologies enable the use of finger vein authentication to the mobile devices and smart cards.

1 INTRODUCTION

Biometrics is expected to become more important as the core technology for mobile network security. In spite of such expectations, a lot of issues on the biometrics are pointed out (Virginia Ruiz-Albacete et al., 2008, Tsutomu Matsumoto et al., 2002). It is also standardized for example in ISO and JIS (ISO-standard on vein, JIS (JP) standard on vein).
Especially following issues need to be improved for mobile usage of biometrics.

•Forge resistance
The fake physical biometric is serious problem. Actually fake fingerprint was used to trick biometric airport fingerprint scan. Latent fingerprint is another issue (Tsutomu Matsumoto et al., 2002). When you lost your mobile phone, your fingerprint patterns remain on the surface and it can be used for forge.

•Disability to enrol some users
All the people should be able to use the biometrics system. About 4% of the population have poor quality of fingerprint, especially the elder people and manual worker (Privacy International, 2005). For these cases one need to consider other biometrics or password service.

•Environmentally free
Finger print authentication is affected by skin condition (dry or wet). Dry skin cause the increase of the false rejection rate in winter season.

•Limited resource environments
The authentication algorithm should be designed to be small, efficient, and use resources efficiently for operating on the resource-limited devices. A very good performance is necessary to achieve a comfortable authentication. Of course, small size low cost sensor is must issue for mobile use.

Finger vein authentication technology is expected to be more secure, reliable than current biometric systems. However, the usage has been still limited due to the above issues to be cleared. The purpose of our development is to improve the actual performance of the finger vein authentication for mobile usage. It is necessary to resolve the following two major issues for wider and practical use.

The first issue is the improvement of the sensor size. This is a problem concerning the biometric sensor device and the image processing.

The second issue is the efficient authentication scheme for mobile usage. This needs improvements the authentication algorithm. It is also related to the data size of the biometric template.

Sato H. (2009).
FINGER VEIN VERIFICATION TECHNOLOGY FOR MOBILE APPARATUS.
In *Proceedings of the International Conference on Security and Cryptography*, pages 37-41
DOI: 10.5220/0002231300370041

2 VEIN PATTERN AUTHENTICATION

Finger vein authentication is expected to be a new technology that replaces the fingerprint. Like irises and fingerprints, a person's veins are completely unique. Even twins don't have identical veins, and each person's veins differ between their left and right sides. Furthermore veins are not visible usually since they are covered by the skin, making them extremely difficult to be counterfeited or tampered. The pattern also changes very little as a person ages.

The advantages on finger vein authentication in comparison with other biometrics and listed as follows;

•Advantages

(1) Robustness
As veins are hidden inside the body, there is little risk of forgery or theft.

(2) High accuracy
The authentication accuracy is less than 0.1% for the FRR (False Rejection Rate), less than 0.0001% for the FAR (False Acceptance Rate).

(3) Very good performance on Failure to Enrol Rate (FTE)
FTE of the finger vein authentication is nearly equal to 0%. All the people can use this method.
(*Finger Print = 4%)

(4) Dependence of the surface conditions of the fingers
The surface conditions of the hands have no effect on authentication.

It is already used for biometrics ATM cards in Japan. This shows the trust to vein authentication technologies by banking field.

•Issues in the past technologies
On the other hand, some weak points of a past vein technology still remain to be resolved compared with the fingerprint.

(1) Size of device
It is too large for mobile apparatus.

(2) Authentication speed
It is slower than a general fingerprint authentication.

(3) Need the guide to fix hand or finger
All of vein sensors used the assistance of finger or hand guide. Steady and stable operations are difficult without it. This is not practical for the use of mobile environment.

(4) High cost of sensor
It is too expensive for the cellular phone.

(5) Data size
The data size of the template needs to make is very small.

It is necessary to improve these issues for vein technologies to be used widely in the mobile area.

3 THE PROPOSED FINGER VEIN TECHNOLOGY

3.1 Biometric sensor

The first issue is the improvement of the sensor size.

•Open Type Capability
Generally other vein authentication systems such as palms and back of the hands use the reflection of the body. On the other hand, as near-infrared light is transmitted through the finger, and strongly scattered in the inside of the body, it is difficult to capture the finger vein image by this method. Small finger veins are masked by the reflection light of the epidermis.

Finger vein are much smaller than other vein such as palms and back of the hands. It is more difficult to forge the finger vein patterns than other portions. This is a big advantage of finger vein. On the other hand, we had to use the transmission type optical system for the finger vein image usually. This is the reason why the size of sensor device is large.

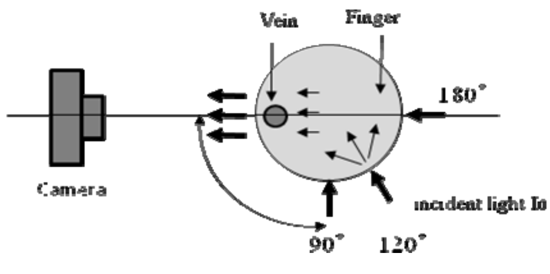

Figure 1: The reflecting scattering light method.

•The reflecting scattering light method
We developed a new finger vein sensor by the reflecting scattering light method as shown in Figure 1. This uses the scattering light in the inside of finger. The LED array emits near-infrared light, and it is strongly diffused. By the deep investigation of these characteristics we developed a new structure of

the vein scanner for finger. This method can be achieved only by lighting from the direction of single side, which enabled open type's sensor.

It shows the relation between the sensor and LED unit. For transmission type, the angle is 180 degrees. The angle between camera and incident light affect the image quality of vein. The maximum efficiency and the image quality are obtained by about 120 degrees through investigation. The influence of the image of the dermis and the epidermis appears by about 90 degrees, and the vein image quality is deteriorated. It increases the failure to enrol rate (FTE).This method (about 120 degrees) can obtain the high performance equal with a transmission type.

3.2 Feature Extraction Algorithm for Vein Blood Flow

•Noise Removal
Conventionally CCD sensor is used for vein authentication systems. CMOS sensor is one of the solutions for cost saving and size down. CMOS Image sensors are widely used by cellular phone because of low cost and low power. But there are some shortcomings for using CMOS small sensor for finger vein authentication. The disadvantage of CMOS imagers is the noise of the image. We analyzed the characteristics of this noise and tested various kind of noise filter. Based on these investigations, we developed noise reduction algorithm for finger vein image. This enabled to use low cost and small size CMOS sensor whish has the same performance as CCD sensor for finger vein authentication.

•The extraction algorithm for vein patterns
It is possible to classify it into two types roughly though there are various techniques in the extraction algorithm for vein patterns.

Type1. Path search algorithms
Type2. Zero crossing methods

There is a report on Type 1 with the line tracking method for vein pattern (Naoto Miura et al., 2005).

Our technology is based on Type2.
The zero-crossing method is known as a method that is appropriate for such a pattern extraction. The Laplacian filter is one of the generalized method for zero- crossing detection. It is defined as follows.

$$L(I) = Ixx + Iyy \quad (1)$$

However, because the character of the vein image is greatly different according to the race, sex, the age, and the health condition it was very difficult to achieve a steady vein pattern extraction by this method.
We resolved this problem by developing a new filter with special characteristics that is appropriate for the vein image noise and the vein continuous patterns. It has higher-speed than Path search algorithms.

•Centreline detecting of the vein
This method improves the robustness for the variation of the climate and the health condition.

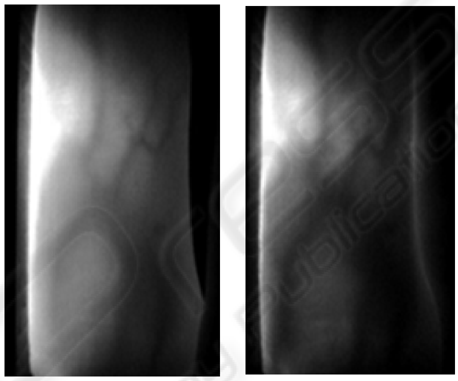

Figure 2: The change of the vein width.

It is said that the vein patterns changes very little as a person ages. But it does not mean the vein itself will not change in any case. Actually the thickness of vein changes by the physical condition, climate, and temperature. This two pictures show the change of the vein width by the height of hand to heart (See the Figure 2).

Our approach extracts the centreline of the vein accurately (see Figure 3). This method improves stability enormously by removing such uncertainties. Furthermore, this approach is very fast and very compact.

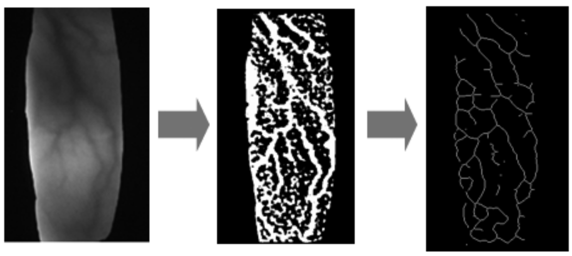

Figure 3: Feature Extraction Approach.

3.3 New Compact-fast-matching Algorithm

Another issue is the comfortable authentication algorithm for mobile usage.

Conventionally it is necessary to use a guide place it accurately. It is quite difficult to install the finger guide used for ATM in mobile use.
And it cannot be expected from the user to a certain forced adjustment on finger position.

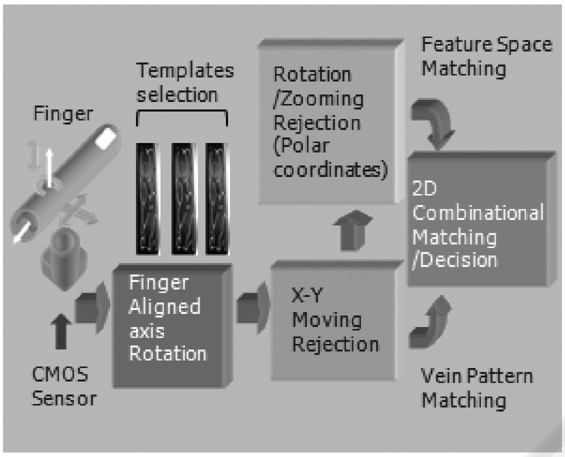

Figure 4: New compact-fast-matching scheme.

The common problem of the vein pattern recognition is repeatability of the taking picture images using the camera. On the other hand, the algorithm corresponding to the change including the zooming and the rotation generally requires big calculation power. This is a reason why conventional vein authentication systems need the assistance of finger or hand guide (BioGuard 2008, Chris Roberts 2006). In our device, it is enough only by the correction of a little rotation and a little zooming. We developed a new match method to correct these errors on polar coordinates as shown in Figure 4. The shortcoming of the conventional finger guide was resolved by our approach of combining the match in the direction of X-Y and the match in polar coordinates. The rotation axially of the finger is corrected by the selection from three templates or more.
The purpose of this approach is to improve the convenience of the finger vein authentication. Our approach resolves these uncertainties of height, the rotation, the angle, and the distance. An efficient authentication was achieved without a special guide of the finger by this approach. The test environment and the result are shown in Table 1 as follows.

Table 1: The performance of the algorithm.

Example column 1	Average operation time
Windows PC	15ms

The authentication performance of this algorithm was tested by the reference finger vein sensor by the reflecting scattering light method.

The result is also shown in the following Table 2.

Table 2: FAR and FRR of new algorithm.

Test item	FAR (%)	FRR (%)
performance	0.0001	0. 1

3.4 Vein Pattern Data Compression with Accuracy

Our compression scheme transforms shown in Figure 5 vein pattern into geometric Information. It compresses the centre lined data of the vein with accuracy compensation as small as to 112Byte. This data size is nearly equal to one of the minutiae-based fingerprint authentication systems. The small size template is suitable for smart card storing and mobile phone. It achieves quick authentication operation.

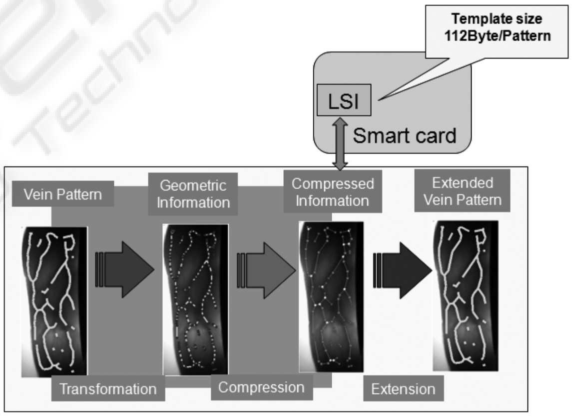

Figure 5: Vein Pattern Data Compression.

4 PROTOTYPE PHONE

We made the prototype for cellular phone. This prototype phone adopted the reflecting scattering light method for the vein sensor. New approach is coded in C language and suitable for mobile OS. We investigated the performance of the combination of new sensor and algorithm, under mobile environments. The following are the results in the enrolment and verification of 100 people. This actual test was as shown in Table 1 shows the comfortableness and without any failure. Although this data is not enough estimating the FTE, FAR and FRR, yet it shows practicality for mobile usage.

Table 3: The results in the enrolment and verification.

Test item	False number	Test number
Enrolment	0	100
False Acceptance	0	2000
False Rejection	0	2000

The prototype for cellular phone structure is explained in Figure 6. The Infra-red LED Unit is placed at the head of display and sensor is at the bottom of display. Finger vein authentication software runs on the OS of cellular phone. The distance between sensor and finger is about 60mm. The stability of the authentication performance depends on this enough distance. It is necessary for the steady reproducibility of the finger vein image.

Figure 6: The image of Prototype Phone.

The average time of authentication is 250ms with ARM CPU (150MHz) as shown in Table 4. It achieved higher speed than a general fingerprint authentication of a cellular phone.

Table 4: The average time of authentication.

Example column 1	Average time
Mobile Phone @ARM9 150MHz	250ms

5 CONCLUSIONS

In this paper, we focus on our achievement of our newly developed finger vein authentication technologies. The sensor size is improved by the reflecting of scattering light and the new feature extraction scheme. By the well combination of these technologies we realized the use of the low cost small sized CMOS sensor for the finger vein authentication. Furthermore, the new compact-fast-matching and compression scheme contribute to the efficient authentication. This new Finger vein technology is expected to be the promising technology which can improve the shortcomings of the fingerprint. We expect that our new technologies will expand the application range of the vein pattern recognition, especially for mobile usage.

REFERENCES

Virginia Ruiz-Albacete, Pedro Tome-Gonzalez, Fernando Alonso-Fernandez, Javier Globally, Julian Fierrez, and Javier Ortega-Garcia 2008, Direct attacks using fake images in iris verification

Tsutomu Matsumoto, Hiroyuki Matsumoto, Koji Yamada, Satoshi Hoshino, 2002. Impact of Artificial "Gummy" Fingers on Fingerprint Systems

Privacy International, 2005, UK Identity Cards and Social Exclusion

Naoto Miura, Akio Nagasaka, Takafumi Miyatake 2005.Extraction of Finger-Vein Patterns Using Maximum Curvature Points in Image Profiles (Hitachi)

BioGuard 2008. Palm Vein Authentication Technology

Chris Roberts 2006, Biometric Technologies - Palm and Hand

ISO-standard on vein. Biometric data interchange formats - Part 9: Vascular image data (ISO/IEC 19794-9). Conformance testing methodology for biometric data interchange formats - Part 9: Vascular image data (ISO/IEC 29109-9)

JIS (JP) standard on vein. Evaluation Method for Accuracy of Vein Authentication Systems (JIS-TR X0079)