A Survey of Finger Vein Extraction Techniques and Its Applications

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***Abstract*— Finger Veins are the non imitable biometric Identification. Unlike other conventional biometric features such as finger print, face, voice etc., the finger vein patterns do not leave any traces or information that can be used to duplicate the biometric data. As finger vein exists beneath human being's skin, they are completely hidden and unexposed even during the authentication process. It is therefore impossible to steal or copy the biometric patterns by photography or video recording, which makes it extremely difficult to duplicate the biometric data. Yet another advantage of using finger vein is flexibility. Most finger vein devices are designed to accept four to six fingers per person (i.e. index, middle and ring fingers of both hands), which means this biometric feature can be applied for far more people than other modalities that have less samples per person. This finger vein can be extracted from human finger by various methods. This paper explores the various methods for extracting the finger vein from the person.**

Keywords— Finger vein, Face, Voice Biometric Identification, Flexibility, Unexposed.

I. INTRODUCTION

Vascular network patterns are unique biometric feature that are robust against temporal and environmental changes. Researchers at Hitachi

Central Research Laboratory started the fundamental research of finger vein biometrics for personal identification in mid 90's and revealed that the biometric feature was extremely competitive. From medical point of view, the following features of finger vein are known:

1) Universality

Arteries and veins are vital organ that supply and circulate sufficient oxygen and nutrition to finger and other part of human body. It is well-known anatomical and clinical fact that veins of 0.3-1.0 mm diameter exist in every finger of healthy individuals.

2) Uniqueness

Embryology proves that blood vessel paths are generated by probabilistic factors such as tissue hypoxia (low-oxygen condition). The influence of inherited factors is almost ignorable in the peripheral and it is reasonable to regard finger vein patterns as individually unique feature.

3) Permanency

Fundamental blood vessel network is formed before birth. The vascular patterns, whose diameter is 0.3-1.0mm, are then kept stable by tight interfaces of endothelial cells forming blood vessels and other cells exist in the neighbouring area. Blood vessel patterns of this thickness are supported by constant blood flow and do not disappear by age-related factor. Neo vascularisation is, in principle, only caused by pathological conditions such as cancer or arteriosclerosis and does not occur to healthy tissue.

Furthermore, many techniques have been arrived today for extracting the finger vein from the human finger. Of the arrived techniques, we will conclude about the most accurate and widely used technique for extracting the finger vein. Unlike PIN number, biometric features including finger vein cannot be changed for life. However, as long as finger vein biometrics concerns, the enrolled pattern can be replaced up to six times. The compactness of finger vein biometric features is also an important advantage.

II. WHY FINGER VEIN USED AS A BIOMETRIC IDENTIFICATION?

Finger vein authentication is a new biometric method utilizing the vein patterns inside one's fingers for personal identity verification. Vein patterns are different for every finger and for every person; and as they are hidden underneath the skin's surface, fraudulent is extremely difficult. This uniqueness of finger vein pattern recognition set it apart from previous forms of biometrics and have led to its adoption by the major Japanese financial institutions as their newest security technology.

Originally, the motivation to develop finger vein pattern recognition technology was born of Hitachi's advanced research to measure brain-function activity in the medical science field. In that research, near-infrared light was used to observe the increase in blood flow and was found to be applicable to recognition of the finger vein pattern. As finger vein patterns will be different for each finger and for each person, Hitachi discovered that finger vein pattern recognition is a viable biometric personal authentication technology for the commercial market.

A. Features and Comparison

Finger vein authentication technology has several important features that set it apart from other forms of biometrics as a highly secure and convenient means of personal authentication.

(1) Resistant to criminal tampering: Because veins are hidden inside the body, there is little risk of forgery or theft.

(2) High accuracy: The authentication accuracy is less than 0.01% for the FRR (False Rejection Rate), less than 0.0001% for the FAR (False Acceptance Rate), and 0% for the FTE (Failure to Enroll).

(3) Unique and constant: Even for identical twins, the finger vein patterns appear to be different.

(4) Contactless: Near-infrared light is used to allow non-invasive, contactless imaging that ensures both convenience and cleanliness for the user experience.

(5) Ease of feature extraction: Extracted Finger vein patterns are relatively stable and clearly captured, enabling the use of low-resolution cameras to take vein images for small-size, simple data image processing.

(6) Fast authentication speed: One-to-one authentication takes less than one second. Moreover, the authentication device can be compact due to the small size of fingers. Finger vein authentication thus offers several key advantages compared to other forms of biometrics. These comparative advantages are collectively shown in Table 1.

Table 1 Comparison of Frequently used Biometrics Methods

Biometrics	Security		Convenience				
	Anti-Forgery	Accuracy	Speed	Availability	Acceptability	Cost	Size
Fingerprint	● green	● green	● red	● blue	● blue	● red	● red
Iris	● green	● red	● green	● green	● red	● blue	● blue
Face	● green	● blue	● green	● green	● blue	● blue	● blue
Voice	● green	● blue	● green	● green	● blue	● green	● green
Finger Vein	● red	● red	● red	● red	● red	● green	● green

● (red): good, ● (green): normal, ● (blue): insufficient

III. APPLICATIONS

Finger vein products have been successfully adopted by major corporations in the fields of financial, physical and logical security in Japan and other parts of Asia (see Fig. 7). In Japan, finger vein products have enjoyed great success in the financial sector, where 70% of major financial institutions have adopted finger vein technology as a biometrics solution that ensures privacy by storing templates securely on a smart card rather than in a database. Physical security systems (standalone or connected by server and used with a smartcard, PIN code) have also sold widely in Asia, and particularly in Singapore, where well-known buildings such as IBM Singapore, Mizuho Bank, the Caltex Tower, and the Hitachi Towers have adopted finger vein technology for biometric entry access.

In the future, besides embedded applications for portable IT devices such as cellular phones, finger vein authentication will take full advantage of its unique use of the finger to expand into applications such as opening automobile doors with a simple grip of the handle, for which the necessary grip-type authentication technology is already in development. Grip-type technology embeds personal authentication in the natural motion of opening a door, ensuring the highest security without forcing the user to learn complicated new procedures.

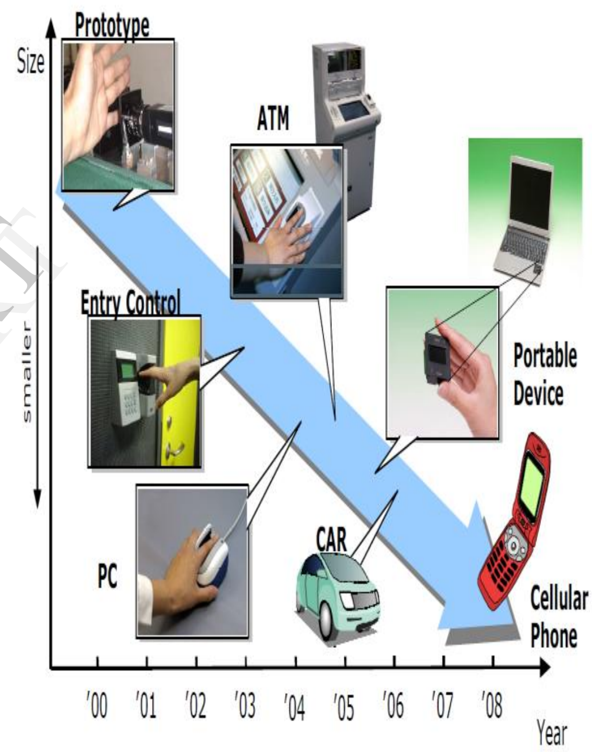

Fig1: Applications of finger vein authentication and future developments

This technology will be applicable to home, office or car doors and will usher in a secure future without keys. Supporting this expansion of finger vein authentication applications is the miniaturization of this technology. The very first prototype was as large as over one liter in volume, while the newest embedded module in mobile PCs has shrunk to 19 cc. Miniaturization enables finger vein authentication technology in a greater variety of devices and is thus the driving force behind the expansion of finger vein authentication applications.

IV. Finger Vein Extraction Techniques

Finger vein Authentication is a 100% accurate identification for any security purpose. For using the vein as a secure identification, one must extract the vein from a human finger. For extraction of vein from a finger, various methods have been adopted so far. Now we will see some of the important and widely used methods of vein extraction.

A. *Finger vein Recognition system using NIR laser*

Near Infra Red laser system is a conventional system used for extracting vein from a finger. In this system, there will be a direct contact with the LED for extracting the vein and this will cause a sanitary problem. Moreover, there will be a chance of non uniform illumination existence. This will cause many problems for human.

Here in this method, the finger is having direct contact with the LED. Thus causes many problems. The Finger is having a direct contact with the LED rays emitted from the finger vein reader.

Fig2: Direct contact with LED for vein recognition

B. *Non-contact finger vein acquisition system using NIR laser*

The conventional system using direct contact with the infrared rays causes too many problems to the human. Firstly it will cause sanitary problem and then, it will cause illumination problem. To avoid this problem, non contact finger vein recognition system is used. In this method, they use a non contact finger vein acquisition system using NIR laser and Laser line generator Lens. Laser line generator lens generates evenly distributed line laser from focused laser light. Line laser aimed on the finger longitudinally. NIR camera was used for acquisition of image.

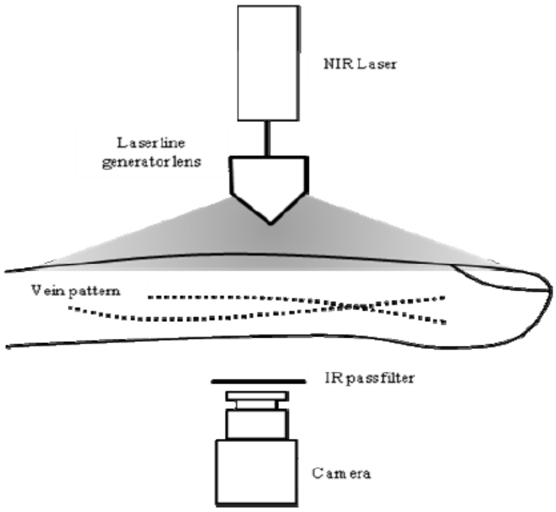

Fig3: Non-Contact Finger vein recognition using NIR

4.3 Extraction of Finger vein patterns using Maximum curvature Points in Image profile

The vein images are extracted from the finger for the identification. The vein extracted by the laser having various distractions. To remove those destructions and to get the clear image, maximum curvature method is used. While extracting the vein, there will be a fluctuation of blood due to temperature, physical conditions etc. Due to this, there will be a change of vein shape. So, we cannot get the accurate information.

To robustly extract the precise details of the embed veins; we developed a method for calculating local maximum curvatures in cross-sectional profiles of a vein image. This method is used to extract the centerlines of the veins consistently without being affected by the fluctuations in vein width and brightness, so that pattern matching is highly accurate. Thus experimental results show that our method extracted patterns robustly when vein width and brightness gets fluctuated, and that the equal error rate for personal identification was 0.0009%, which is much better than that of conventional methods.

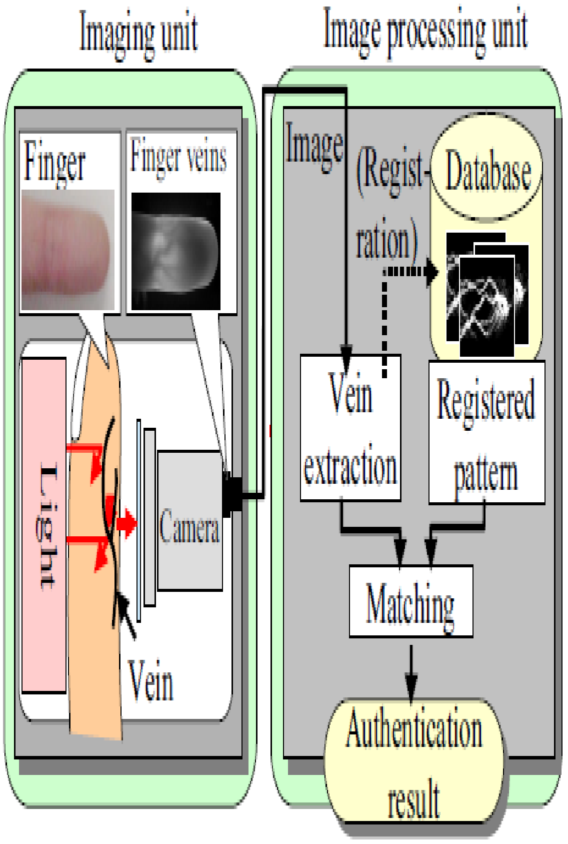

Fig4: Flow of finger-vein personal identification

C. Extraction of Finger vein patterns using repeated line tracking method

The extracted vein also having some shadows, which will reduce the accuracy of the content in the vein image. This method is used for obtaining the clear image from the unclear image. The following algorithm is used for extracting the clear image.

The method of feature extraction is described in this section. $F(x, y)$ is the intensity of the pixel (x, y), (xc, yc) is the position of the current tracking point of line tracking in the image, Rf is the set of pixels within the finger's outline, and Tr is the locus space.

Suppose the pixel in the lower left in the image to be (0, 0), the positive direction of the x-axis to be rightward in the image and the positive direction of the y-axis is upward within the image, and $Tr(x, y)$ is initialized to 0.

Step 1: Determination of the start point for line tracking and the moving-direction attribute N. Miura et al.: Feature extraction of finger-vein patterns 197
Step 2: To detect the direction of the dark line and movement of the tracking point
Step 3: To update the number of times points in the locus space have been tracked
Step 4: Repeat the execution of step 1 to step 3 (N times)
Step 5: Extraction of the finger-vein pattern from the locus space

D. Finger vein evaluation using SVMs.

In finger vein recognition system, the finger vein image quality is significant. For this we proposed a Support Vector Machines for getting the quality image. We extract three features including the, image contrast, gradient and information capacity.

Cross-validation is also employed to verify the reliability and stability. Our method is used for evaluating the quality of finger-vein images, and therefore by discarding low-quality images can be detected. By using this method, the overall finger-vein recognition performance is considerably improved.

SVM is proposed by Vapnik et al.This is as an effective method for general-purpose pattern recognition. In this theory, SVM classification can be used to trace back the classic structural risk-minimization approach, which makes the fixation of the classification decision function by minimizing the classification risk.

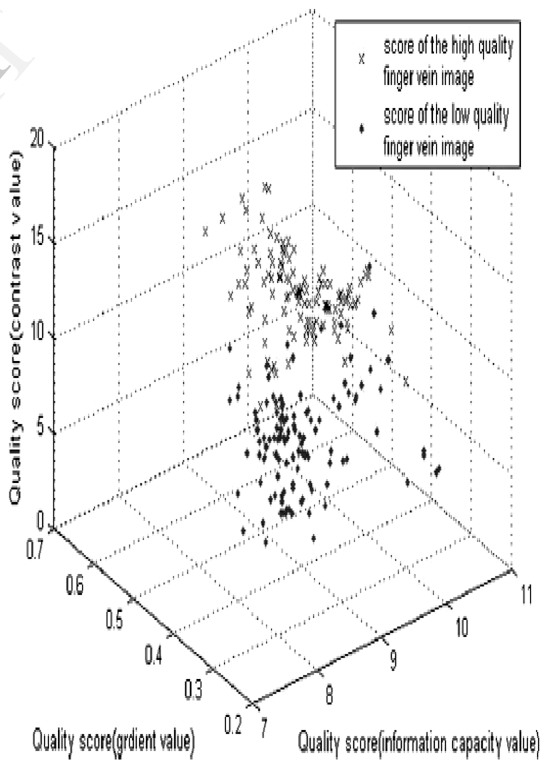

Fig5: Distribution of finger-vein images with different quality levels.

The purpose of training a SVM classifier is exactly finding the optimal decision surface that separates the positive training samples from the negative ones with the largest margin. Here the decision surface is a weighted combination of elements called support vectors of the training set.

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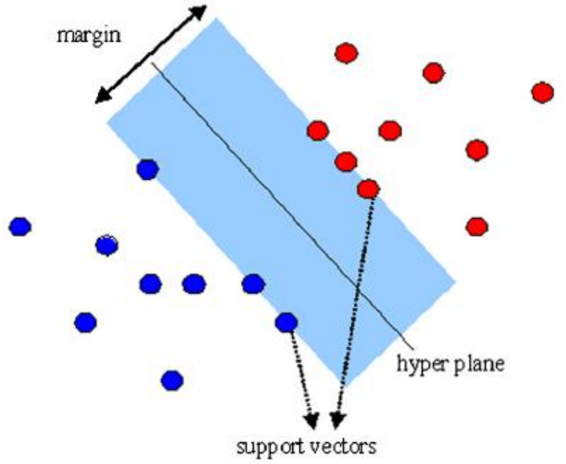

Fig6: Linearly separable support vector machine (SVM).

For extracting the vein images by SVM 200 high-quality images and the first 40 low-quality images in database 1 for training and the rest for testing. Nonlinear classifier SVM is used to classify images. In the training process, SVM uses the default radial basis function kernel function, and error penalty C and parameter γ are set by cross-validation, which is performed by the Grid.py tool in LIBSVM.The results of classification by

SVM is shown in Table

Method	High-quality images	Low-quality images	All images
SVM	100%	81.82%	90.48%
R-SMOTE plus SVM	92.4%	91.82%	92.09%

Table 2: Accuracies of different classification methods.

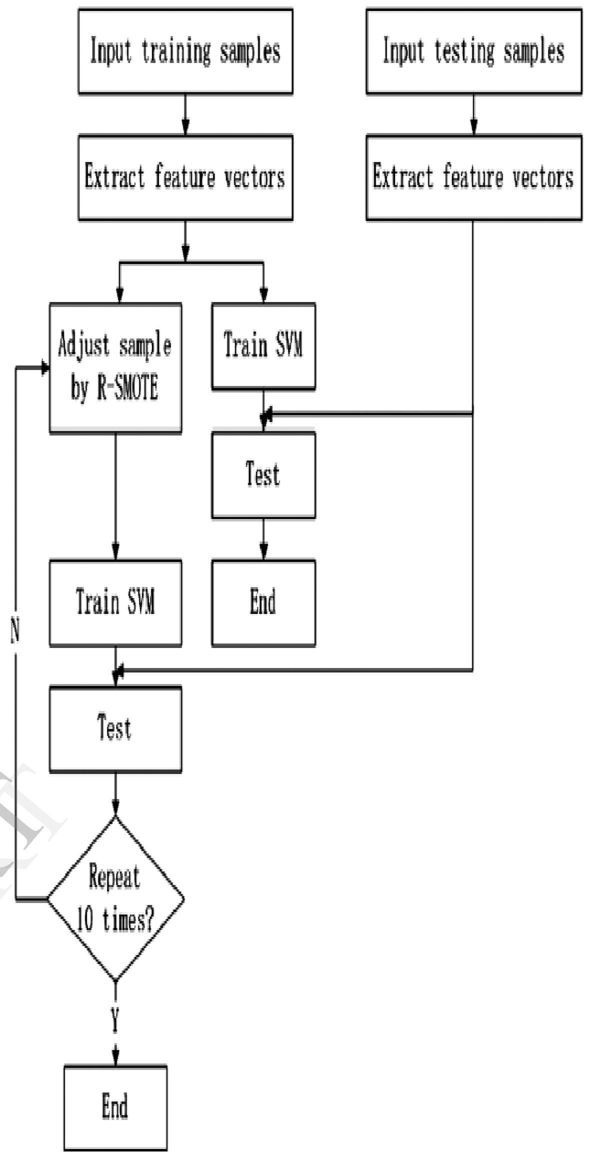

Fig7: Framework of Experiment

E. Extraction of Finger vein patterns based on curvelets and local interconnection structure neural network

In this method we proposed a multiscale feature extraction of finger-vein patterns based on curvelets and local interconnection structure neural networks. The curvelets is used to perform the multiscale self-adaptive enhancement on the finger-vein image .A neural network with local interconnection structure is designed to extract the features of the finger-vein pattern. In this method, the finger vein has the following features.

Firstly, the feature of finger-vein is line feature, or anisotropy, which is more suitable to be processed by curvelets than wavelets. Secondly, when the multiscale self-adaptive enhancement transform is applied to the finger-vein image, the noises are refrained greatly. Thirdly, a local

interconnection neural network with linear receptive field is designed to deal with finger-vein patterns of different thickness and capture the patterns. Fourthly, the method is very fast by using the integral image method. Finally we conclude that proposed method is superior to other methods in finger-vein feature extraction and solve the problem of how to extract features from obscure images efficiently.
There are two reasons to construct such kind of local interconnection neural network:

1. The receptive field has the form similar to the straight line which is convenient to extract the straight-line feature;

2. The nodes in each receptive field are independent to each other and the ones in the same receptive fields have a correlation with each other.

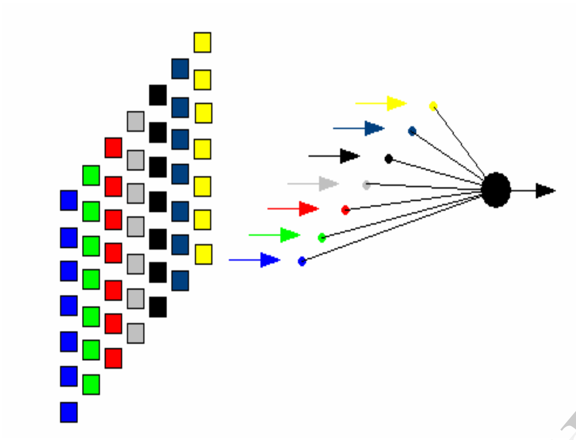

Fig8: The BP network structure with local interconnection to detect the straight line feature

V. RECOMMENDATIONS AND NEXT STEP

Biometric technology has come to stay. When compared to various biometric identifications, finger vein is the more securable. There will be many processes for extraction of the vein from the finger. Every process has its unique feature comparably with one another. In feature we will define method having all the advantages of the described methods. By doing, so we can get a secured biometric identification for any authentication process.

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