FINGER VEIN AUTHENTICATION

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Abstract - Identity verification has become increasingly important in many areas of modern life. However, current methods for identity verification, such as code numbers, password and smart cards carry the risk of loss, theft, forgery, or unauthorized use. Smart recognition of human identity for security and control is a global issue of concern in our world today. Financial losses due to identity theft can be severe, and the integrity of security systems compromised. Hence, automatic authentication systems for control have found application in criminal identification, autonomous vending and automated banking among others. Among the many authentication systems that have been proposed and implemented, finger vein biometrics is emerging as the foolproof method of automated personal identification. Finger vein is a unique physiological biometric for identifying individuals based on the physical characteristics and attributes of the vein patterns in the human finger. It is a fairly recent technological advance in the field of biometrics that is being applied to different fields such as medical, financial, law enforcement facilities and other applications where high levels of security or privacy is very important. This technology is impressive because it requires only small, relatively cheap single-chip design, and has a very fast identification process that is contact-less and of higher accuracy when compared with other identification biometrics like fingerprint, iris, facial and others. This higher accuracy rate of finger vein is not unconnected with the fact that finger vein patterns are virtually impossible to forge thus it has become one of the fastest growing new biometric technology that is quickly finding its way from research labs to commercial development. Historically, R&D at Hitachi of Japan (1997-2000) discovered that finger vein pattern recognition was a viable biometric for personal authentication technology and by 2000-2005 were the first to commercialize the technology into different product forms, such as ATMs. Their research reports false acceptance rate (FAR) of as low as 0.0001 % and false reject rate (FRR) of 0.1%. Although biometric authentication is already being used to some extent by companies and government authorities, it must become less intrusive for it gain wider acceptance.

I. INTRODUCTION

Fingerprints have been the most widely used and trusted biometrics. The reason being the ease of acquiring fingerprints, the availability of inexpensive fingerprint sensors and a long history of its use. However, limitations like the deterioration of the epidermis of the fingers, finger surface particles etc result in inaccuracies that call for more accurate and robust methods of authentication. Vein recognition technology however offers a promising solution to these challenges due the following characteristics. Its universality and uniqueness. Just as individuals have unique fingerprints, so also they do have unique finger vein images. The vein images of most people remain unchanged despite ageing. (2) Hand and finger vein detection methods do not have any known negative effects on body health. (3) The condition of the epidermis has no effect on the result of vein detection. (4) Vein features are difficult to be forged and changed even by surgery. These desirable properties make vein recognition a highly reliable authentication method. Vein object extraction is the first crucial step in the process. The aim is to obtain vein ridges from the background. Recognition performance relates largely to the quality of vein object extraction. The standard practice is to acquire finger vein images by use of near-infrared spectroscopy. When a finger is placed across near infra-red light rays of 760 nm wavelength, finger vein patterns in the subcutaneous tissue of the finger are captured because deoxygenated hemoglobin in the vein absorb the light rays. The resulting vein image appears darker than the other regions of the finger, because only the blood vessels absorb the rays. The extraction method has a direct impact on feature extraction and feature matching.

Therefore, vein object extraction significantly affects the effectiveness of the entire system. This paper discusses the origins, features, technology, applications and future development of finger vein authentication.

II.PRINCIPLE

The principle behind the finger vein authentication technique is as follows

The pattern of blood vessels is captured by transmitting near-infrared light at different angles through the finger, usually the middle finger. This can be done in a small instrument attached to wall or as part of an ATM machine. The light is partially absorbed by hemoglobin in the veins and the pattern is captured by a camera as a unique 3-D finger vein profile. This is turned into a simple digital code which is then matched with a pre-registered profile to verify an individual's identity. Even twins are said to have different finger vein patterns! Because the veins are inside the body, invisible to the eye, it is extremely difficult to forge and impossible to manipulate, Hitachi claims. The gruesome possibility that criminals may hack off a finger has already been discounted by Hitachi's scientists. Authentication cannot be forged with a severed finger, as the blood would flow out of a disconnected finger, making authentication impossible. Hitachi says finger vein authentication is less expensive than iris scanning or face/voice recognition and that the false rejection rate is much lower than with fingerprinting. And people don't have to remember a pin number. Hitachi's system is being used in Japan to verify user identities for ATMs, door access systems and computer log-in systems.

III.FINGER VEIN PATTERN IMAGING

There are two methods used for capturing vein pattern images

1. **Light Reflection**
2. **Light Transmission**

LIGHT REFLECTION

In the case of "light reflection," the light source and the image sensor are placed on the same side of the finger, and the image sensor captures the reflected light from the surface of the finger.

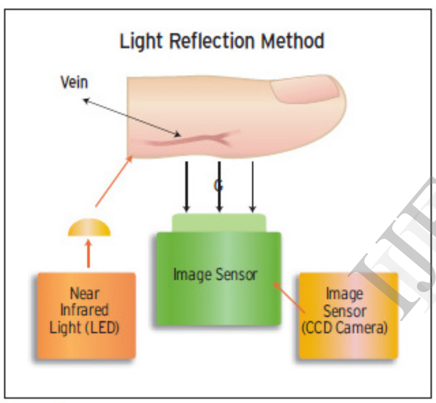


Figure 1

LIGHT TRANSMISSION

In the case of "light transmission," the finger is placed between the image sensor and the light source, and the near-infrared light passes through the finger where it is captured by the image sensor.

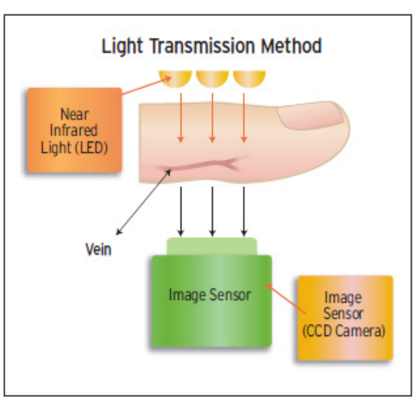


Figure 2

Near-infrared rays generated from a bank of LEDs (light emitting diodes) penetrate the finger and are absorbed by the hemoglobin in the blood. The areas in which the rays are absorbed (i.e., veins) thus appear as dark areas in an image taken by a CCD camera located on the opposite side of the finger. Image processing can then construct a finger vein pattern from the camera image. This pattern is compressed and digitized so that it can be registered as a template of a person's biometric authentication data. The finger vein pattern and the template are then authenticated by mean of a pattern-matching technique.

IV .COMPARISON OF THE METHODS IN IMAGING

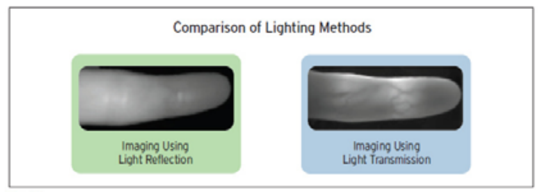


Figure 3

V.SIDE LIGHTING METHOD

Hitachi has developed a new method called "side lighting" which combines advantages from both of the conventional methods. In this new method, light sources are placed on both sides of the finger as shown in Figure 4 (below). Near infrared light shines through the sides of the finger and scatters inside the finger, then passing through the other side of the finger and detected by the image sensor to capture the vein pattern image. This new method enables high-contrast imaging as well as easy placement of the finger on an open, ceiling-less device.

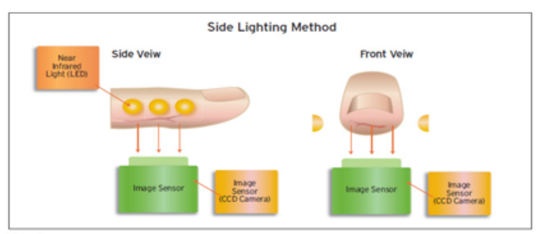


Figure 4

VI.FINGER VEIN AUTHENTICATION PROCESS

Block diagram of the complete finger vein authentication system is shown. The system consists of an authentication unit and other related devices in addition to the near-infrared light source and the image sensor. The authentication unit includes a CPU core for all sorts of signal processing, video I/O for capturing data from the image sensor, LED power controller, and I/O controller. The authentication outcome flows through the I/O controller. Security applications such as door locking are activated by the signal from the controller. The system executes four tasks.

(1) Capturing of finger vein pattern image
(2) Normalization of the image
(3) Feature pattern extraction from the image
(4) Pattern matching followed by judgment of outcome.

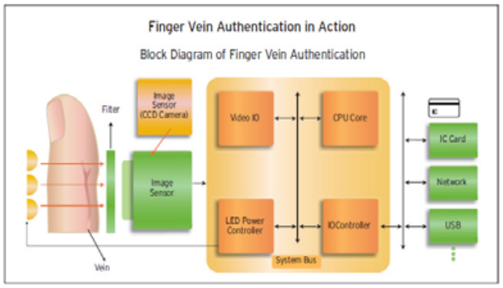


Figure 6

VI. PROCESSING

After vein image extraction, comes segmentation. The traditional vein extraction technology can be classified into three broad categories according to their approach to segmentation i.e separating the actual finder veins from the background and noise. There are those based on region information, those based on edge information, and those based on particular theories and tools. However, the application of the traditional single threshold segmentation methods such as fixed threshold, total mean, total Otsu to perform segmentation, faces limitations in obtaining the desired accurate segmentation results. Using multi-threshold methods like local mean and local Otsu, improve these
results but still cannot effectively deal with noise and over-segmentation effects. In a related research, reference proposed an oriented filter method to enhance the image in order to eliminate noise and enhance ridgeline. Authors in used the directionality feature of fingerprint to present a fingerprint image enhancement
method based on orientation field. These two methods take the directionality characteristic of fingerprints into account, so they can enhance and de-noise fingerprint
images effectively. Finger vein pattern also has textural and directionality features, with directionality being consistent within the local area. Inspired by methods in and, we discuss in this chapter, finger vein pattern extraction methods using oriented filtering from the directionality feature of veins. These utilize the directionality feature of finger vein images using a group of oriented filters, and then extracting the vein object from an enhanced oriented filter image.

VII. NORMALIZATION

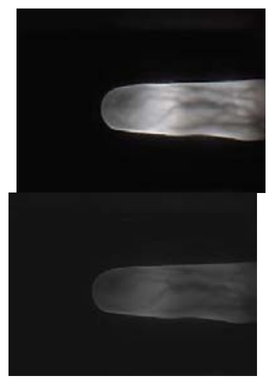
Normalization is a pixel-wise operation often used in image processing. The main purpose of normalization is to get an output image with desirable mean and variance, which facilitates the subsequent processing. The uniformly illuminated image becomes normalized by this formula:

$$M = \frac{1}{M \times N} \sum_{i=0}^{M-1} \sum_{j=0}^{N-1} I(i,j)$$

$$VAR = \frac{1}{M \times N} \sum_{i=0}^{M-1} \sum_{j=0}^{N-1} (I(i,j) - M(I))^2$$

$$G(i,j) = \begin{cases} M_0 + \sqrt{\frac{VAR_0}{VAR} \times (I(i,j) - M)^2}, I(i,j) \geq M \\ M_0 - \sqrt{\frac{VAR_0}{VAR} \times (I(i,j) - M)^2}, I(i,j) < M \end{cases}$$

Where M and VAR denote the estimated mean and variance of input image and = 0 M 150, = 0 VAR 255 are desired mean and variance values respectively. After normalization, the output image is ready for next processing step. The result of the abovementioned process is shown. We note that Fig. image has lost some of its contrast but now has uniform illumination.



(a) Original finger vein image
(b) Normalized finger vein image

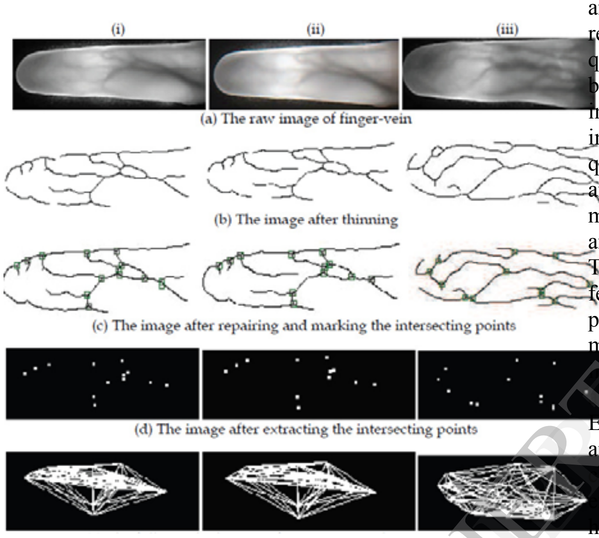
NOVEL FINGER VEIN RECOGNITION METHODS BASED USING FUSION APPROACH

The above-mentioned algorithms have different advantages for different problems in finger-vein recognition. However, because fingers have curved surfaces, finger vein diameter is not consistent and the texture characteristic is a periodic. When near infrared light is used to acquire the image, the gray-scale is uneven and contrast is low; besides, finger veins are tiny and few in number, such that only very few features can be extracted. What is more, a change in the finger position can cause image translation and rotation and influence recognition negatively. To deal with these problems some novel fusion methods are used. First, we discuss a method based on relative distance and angle. This approach makes full use of the uniqueness of topology, the varied distances between the intersection points of two different vein images, and the differences in angles produced by these intersection points connections, all combined for recognition. This method
overcomes the influence of image translation and rotation, because relative distance and angle don't

change. Therefore, the method based on these identified characteristics has great use in practice.

VIII. FINGER VEIN TOPOLOGY

Using Kejun Wang's method for pre-processing hand-back vein image, combined with region merging and watershed algorithm, the finger-vein skeleton is extracted, thinned and further repaired. A fully meshed topology is formed by selecting the intersecting points on the thinned finger-vein image as character points and connecting these points to each other with straight lines, partitioning the image into several regions as shown.



(a) The raw image of finger-vein

(b) The image after thinning

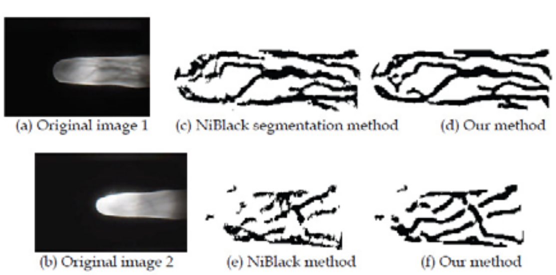
(c) The image after repairing and marking the intersecting points

(d) The image after extracting the intersecting points

In Fig (i) and (ii) are two finger-vein images from same source, so their topology is similar. However, (iii) is of a different source and its topology is obviously different from (i) and (ii). Specifically, the topology expresses an integral property and peculiarity of finger veins, the relationship between corresponding character points is of importance.

EXPERIMENTAL RESULTS
PROCESSING EXPERIMENTAL RESULTS

To verify the effectiveness of the proposed method, we test the algorithm using images from a custom finger vein image database. The database includes five images each of 300 individuals' finger veins. Each image size is 320*240.



(a) Original image 1 (c) NiBlack segmentation method (d) Our method

(b) Original image 2 (e) NiBlack method (f) Our method

We can use a variety of traditional segmentation algorithms and their improved algorithms to segment vein image. But segmentation results of vein image by these algorithms aren't ideal. Because the result of NiBlack segmentation method is better than other methods, we use NiBlack segmentation method as the benchmark for comparison. Segmentation was done for all the images in our database using NiBlack segmentation method and using our method. Experimental results show that our method has better performance. To take full account of the original image quality factor, we select two typical images from our database with one from high quality images and the other from poor quality images to show the results of comparative test. Where Fig. is the high-quality vein image in which veins are clear and the background noise is small. Fig. is the low quality vein image. The uneven illumination caused the finger vein image to be fuzzy, which seriously affects image quality. We extract veins feature by using our method and compare with results of the NiBlack segmentation method. Experimental results shown in Fig. and Fig. are obtained from the NiBlack method applied in. This algorithm extracts smooth and continuous vein features of high-quality image. There are a few pseudo-vein characteristics in Fig. But in Fig., there is much noise in the segmentation results. Segmented image features have poor continuity and smoothness, and there is the effect of the over-segmentation. Experimental results show that apart from smoothness and continuity or removal of noise and pseudo-vein characteristics, the method proposed in this paper extracts vein features effectively not only from the high-quality images but also from the low-quality vein images as shown in Fig. We show that the algorithm proposed in this paper performs better than the traditional NiBlack method.

IX .FEATURES

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.

- Resistant to criminal tampering

Because veins are hidden inside the body, there is little risk of forgery or theft.

- 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).

- Unique and constant

Finger vein patterns are different even among identical twins and remain constant through the adult years.

- Contactless

The use of near-infrared light allows for non-invasive, contactless imaging That ensures both convenience and cleanliness for the user experience.

- Ease of feature extraction

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.

- 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 the fingers.

X. CONCLUSION

Accurate extraction of finger vein pattern is a fundamental step in developing finger vein based biometric authentication systems. Finger veins have textured patterns, and the directional map of a finger vein image represents an intrinsic nature of the image. The finger vein pattern extraction method using oriented filtering technology. Our method extends traditional image segmentation methods, by extracting vein object from the oriented filter enhanced image.

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. In Japan, finger vein products have enjoyed great success in the financial sector. Physical security systems (standalone or connected by server and used with a smartcard, PIN code or by itself) 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 Tower have adopted finger vein technology for biometric entry access. Beyond embedded applications for portable IT devices such as cellular phones, finger vein authentication will in the future likely 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. This technology will be applicable to home, office or car doors and will usher in a secure future without keys.

The expansion of finger vein authentication applications is the miniaturization of this technology. Miniaturization enables finger vein authentication technology to be embedded in a greater variety of devices and is thus the driving force behind the expansion of finger vein authentication applications. One of the principal mechanisms behind miniaturization of finger vein authentication technology is the miniaturization of the image sensor. With the popularization of camera phones, small yet highly sensitive image sensors have become widely accessible. Using the highly secure authentication principle of finger vein authentication, corporate and banking Institutions can ensure customer identity and data security and minimize data security breaches and cyber crimes taking place at enterprises worldwide.

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