THE BIOMETRICS OF VEIN RECOGNISION
The future of Biometrics

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Abstract

The shape of the subcutaneous vascular tree of hand contains information that is capable of authenticating the personal identity of an individual. Vein patterns are different for each person; and as they are hidden underneath the skin's surface, forgery is extremely difficult. These unique aspects of the vein pattern recognition set it apart from previous forms of biometrics. The vein authentication technology offers a high level of accuracy, and delivers the following results: a false rejection rate of 0.01%, and a false acceptance rate of 0.00008% or lower, based on Fujitsu research using the data of 140,000 palms.

1.0.INTRODUCTION:

Palm vein authentication uses the vascular patterns of an individual's palm as personal identification data. Compared with a finger or the back of a hand, a palm has a broader and more complicated vascular pattern and thus contains a wealth of differentiating features for personal identification. The palm is an ideal part of the body for this technology; it normally does not have hair which can be an obstacle for photographing the blood vessel pattern, and it is less susceptible to a change in skin color, unlike a finger or the back of a hand. The deoxidized hemoglobin in the vein vessels absorbs light having a wavelength of about 7.6 x 10-4mm within the near-infrared area. When the infrared ray image is captured, unlike the image seen in Fig.1, only the blood vessel pattern containing the deoxidized hemoglobin is visible as a series of dark lines (Fig.1). Based on this feature, the vein authentication device translates the black lines of the infrared ray image as the blood vessel pattern of the palm, and then matches it with the previously registered blood vessel pattern of the individual.

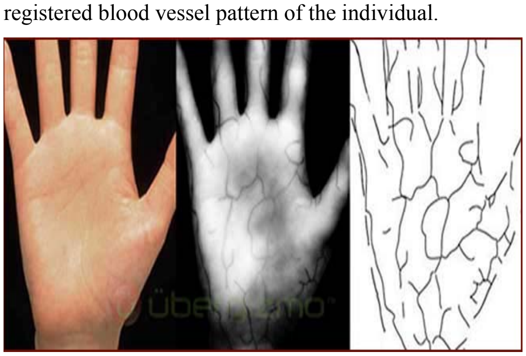


Fig.1: light image (left) and IR image (right) for the same person

2.0.PRINCIPLE:

The pattern of blood veins is unique to every individual, even among identical twins. Palms have a broad and complicated vascular pattern and thus contain a wealth of differentiating features for personal identification. Furthermore, it will not vary during the person's lifetime. It is a very secure method of authentication because this blood vein pattern lies under the skin. This makes it almost impossible for others to read or copy.

3.0.WORKING:

An individual's vein pattern image is captured by radiating his/her hand with near-infrared rays. The reflection method illuminates the palm using an infrared ray and captures the light given off by the region after diffusion through the palm. The deoxidized hemoglobin in the in the vein vessels absorbs the infrared ray, thereby reducing the reflection rate and causing the veins to appear as a black pattern. This vein pattern is then verified against a preregistered pattern to authenticate the individual.

As veins are internal in the body and have a wealth of differentiating features, attempts to forge an identity are extremely difficult, thereby enabling a high level of security. In addition, the sensor of the palm vein device can only recognize the pattern if the deoxidized hemoglobin is actively flowing within the individual's veins. This system is not dangerous, a near infrared is a component of sunlight: there is no more exposure when scanning the hand than by walking outside in the sun.

3.1.DATA ACQUISITION AND PROCESSING:

In visible light, the vein structure on the back of the hand is not easily discernible. The visibility of the vein structure varies significantly depending on factors such as age, levels of subcutaneous fat, ambient temperature and humidity, physical activity, and hand position. In addition a multitude of other factors including surface features such as moles, warts, scars, pigmentation and hair can also obscure the image. Fortunately, the use of thermo graphic imaging in the near IR spectrum exhibit marked and improved contrast between the subcutaneous blood vessels and surrounding skin, and eliminates many of the unwanted surface features. The temperature gradient between the veins and surrounding tissue is generally more pronounced than the difference that can be seen by the naked eye. A comparison between visible light image and infrared image for the same person's hand is demonstrated in Figure 3. A commercially available conventional charge-couple device (CCD) monochrome camera, rather than a considerably more expensive thermal camera, is used to obtain the thermal image of the back of the hand. Though principally designed for use in visible light, CCD cameras are also sensitive to near IR wavelengths of the electromagnetic spectrum up to about 1100 nm. This is an actinic IR range, which covers the near infrared spectrum from 700 nm to 1400 nm.

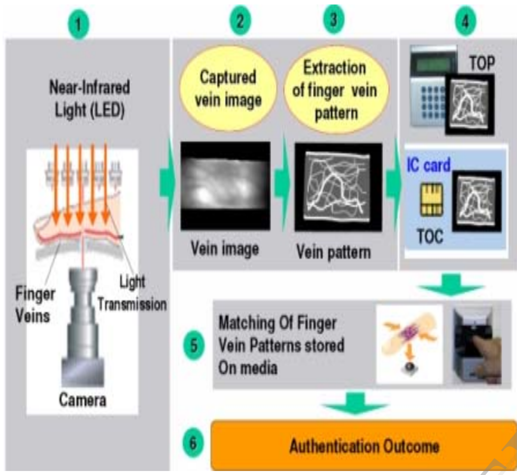


Fig.2 : Data acquition

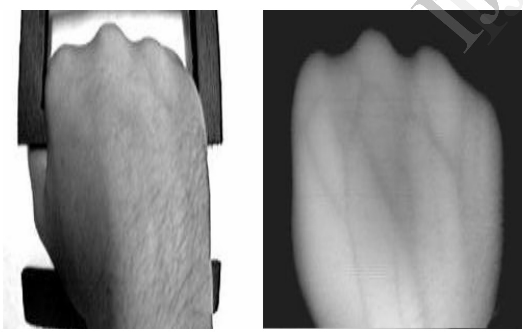


Fig.3. Visible light image (left) and IR image (right) for the same person

3.2.HAND VEIN IMAGE PROCESSING STAGES:

This is the second stage in the Hand Vein Verification System (HVVS), which covers the detection of vein structures from the acquired infrared image for the back of the hand. The vein tree detection stage includes four steps, which are hand region segmentation (i.e. region of interest localization and background elimination), smoothing and noise reduction, local thresholding for separating veins and finally the post processing.

Figure 4 lustrates the block diagram of the processing stage.

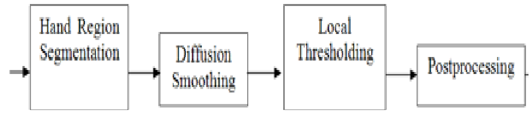


Fig.4 Block diagram of processing stage

3.3. HAND REGION SEGMENTATION:

Image segmentation is one of the most important steps leading to the analysis of processed image data. Its main goal is to divide an image into parts that have a strong

Correlation with objects or areas of the real world contained in the image. Binarization is the case of segmenting the image into two levels; object (hand region) and background; the object segment which is the region of interest (ROI) in white and the background segment in black as shown in Figure 4. e algorithm used in the segmentation sub stage is an iterative method used for calculating and selecting an optimal threshold, which is used to segment the image into two distinct parts; hand and background. We used this resultant binary image to calculate the center of gravity (COG) for our ROI (hand region). Then we translated the grayscale hand region to the center of the image after assigning the background area to zero value pixels. Thus we completely localized, separated and centered the hand region for subsequent processing steps as shown in Figure 4.

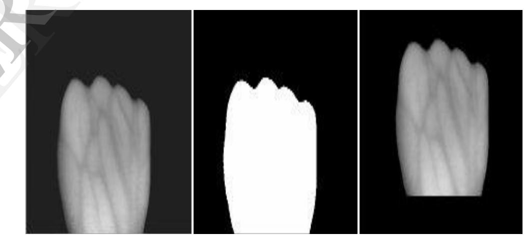


Fig.4:Segmentation results; (a) Input gray scale image (b) Binary image

and (c) Output image after ROI determination and centering

3.4.SMOOTHING AND NOISE REDUCTION:

Two approaches could be used for noise filtering. One approach is using Gaussian blur filter. The disadvantage of Gaussian filter that it is not an edge preserving technique, since it blurs the image with equal weights, which also blurs edges of the veins after several iterations. The second approach is an edge-preserving technique like nonlinear

Diffusion. Perona-Malik is used in which use only image gradient to weight the diffusion process. the smoothing filters used in this work where we used a median filter of 5*5 mask in order to remove the hand traces from the acquired image then we used the nonlinear diffusion filter based on edge weighted diffusion in order to smoothen the image while preserving the vein edges.

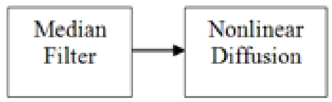


Fig.5:Block diagram of smoothing and noise reduction stage

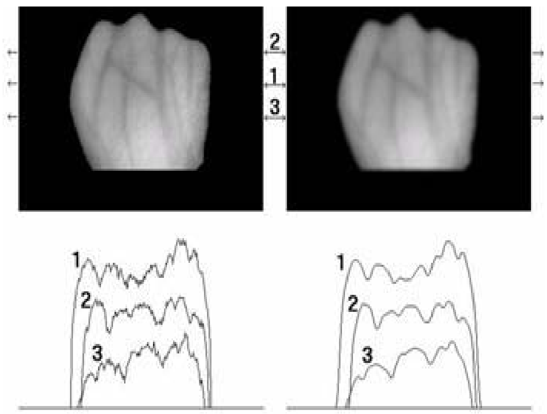


Fig.6: Effect of smoothing sub stage on the image line profiles(edges not affected)

3.5.HAND VEIN PATTERN SEGMENTATION:

Specifically, hand vein segmentation is to divide a hand vein image into a foreground (veins in the back of the hand) and a background (non-vessel areas). Segmentation methods can be divided into four groups, which are threshold-based segmentation, edge based segmentation, region based segmentation and segmentation by matching. In this study, the first thresholding method is adopted since it is computationally cheap and fast. Considering that we want to process and study veins only, global thresholding (i.e. single threshold for the whole image) is not a good technique for this purpose. A better approach is to calculate the average around each pixel of the image in an area of NxN neighbor pixels and to use average value as a threshold value . The local threshold process separates the vein pattern from the background; hence the desired vein image is extracted. Experimentally we have chosen a 31x31 mask size for computing thethreshold for binarizing the central pixel.

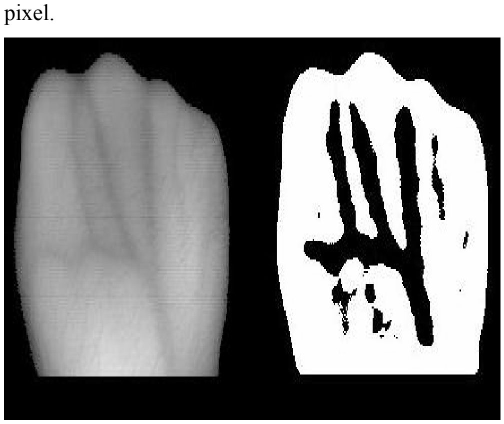


Fig.7: Processed image (left) and its local thresholded image (right)

3.6.HAND VEIN PATTERN PREPROCESSING:

It is demonstrated from Figure 7 that the resultant binary hand vein contains some noise and un-sharp edges. We experimentally applied 5x5 median filter for improving and validating the output binary hand vein pattern and for reducing the effect of these unwanted defects. We also converted the vein pattern into white in a black background which in this case the entire image. The final pattern after the post processing sub stage is shown in Figure 8.

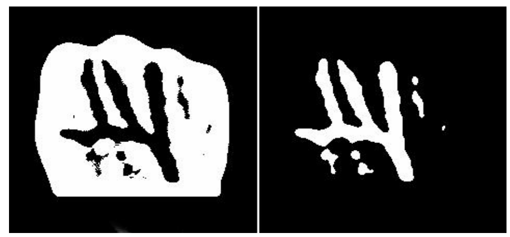


Fig.8: Hand vein pattern before (left) and after postprocessing (right)

3.7.MATCHING OF HAND VEIN PATTERNS:

After image acquisition and hand vein extraction sub stages, we have a binary image contains the segmented back of the hand vein pattern. This is suitable for the next and the final sub stage, the matching of hand vein patterns.As it is expected, the input for the matching sub stage is two binary hand vein binary images like the one in Figure 8 (right), the matching output is Yes (the two images are for the same pattern) or No (the input images is not correlated). We used rigid registration technique since we already constrained our data acquisition system with the attachment in order to prevent any large translation or rotation. One of the two images is remained stationary while we apply 2D transformation (x-translation, ytranslation and rotation) on the other image in order to align it with the first pattern (Registration) to find the maximum correlation percentage between two hand vein images. However Fujitsu researchers have presented a contactless/touchless palm vein authentication which is more convenient and non hygienic for users we restricted our designed prototype for a contact system type in order to simplify our matching phase and derive a dependent statistical measures for this proposed prototype. However accounting for scale (Age or hand to camera distance) in the registration algorithm is simple, we did not account for the scale in our matching. In real systems capturing the hand template at equal monthly intervals after correct authentication is suggested in order to track the changes in the hand with age. The matching (similarity) percentage is calculated as the ratio of the count of overlapped white pixels between input images to the number of white pixels in one of the two input images (the image with the minimum count of the white pixels). We calculated the matching ratio for each transformation step then we choose the maximum ratio as the final matching ratio between the two input hand vein patterns. In our implementation and for saving time of matching, we made the parameters (x-translation, y-translation and, rotation) steps equals five, getting the maximum matching ratio on this grid, finally we made a fine search (tune) to find the overall maximum correlation ratio. The result of matching sub-stage is shown in fig 9, in case of correct true match it is demonstrated that the resultant pattern is correlated to the input images and it is shown that the matching ratio is 81.87 % (same person). A case of correct mismatch is shown in Figure 10, it is shown that the matching ratio is small as 48.27 % (different persons).

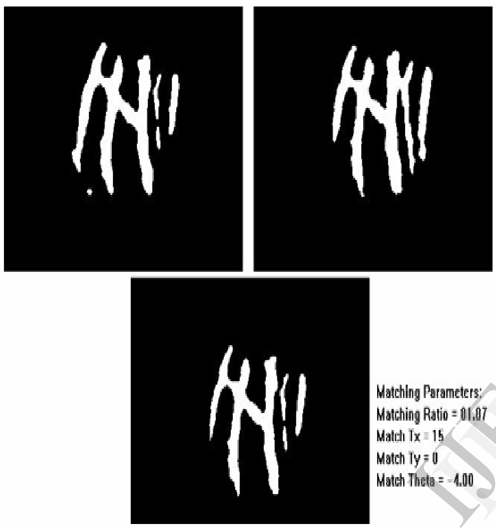


Fig 9: Example of true match for different patterns of the same person

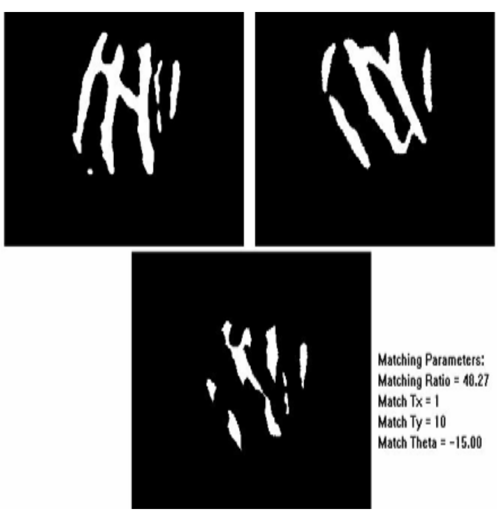


Fig 10: Example of correct mismatch between different persons

4.ADVANTAGES OVER OTHER BIOMETRIC TECHNOLOGIES:

As palm veins are inside the hand, they are protected and this system is not susceptible to minor trauma, cuts, etc (conversely to some fingerprint systems). Also, this sytem doesn't have the same potential civil libery issues as face recognition techniques: Your face face can be scanned without you being aware of it, but your palm vein remain hidden.

High Accuracy

It is a known fact that around 3% to 5% of the worldwide population cannot use fingerprint technology because of the inability to lift a usable fingerprint image from their fingers. Finger Vein biometrics does not have such a problem and nearly all users can be enrolled. Studies conducted by the International Biometric Group show that Hitachi's Finger Vein Biometric technology displayed high usability and strong accuracy rates:

False Acceptance Rate (FAR): 0.0001%False Rejection Rate (FRR): ‹ 0.01% Failure To Enroll Rate (FTER): Near Zero

4.1.HIGH ACCEPTABILITY:

Light is transmitted through the veins to gather biometric data rather than reflected off the skin’s surface, so there is no interference to image quality and accuracy due to dry, wet or dirty skin. Finger Vein image is resistant to temperature and humidity and are generally unaffected by temperature or humidity. It can authenticate users of all skin types resulting in a near Zero Failure to Enroll Rate (FTER) unlike other biometrics.

4.2.EASE OF USE:

Vein ID technology requires no physical contact with the sensors, only a minimal area of a finger guide comes into contact with the finger. It is both easy to use and very hygienic.

It offers the following Access Control applications:

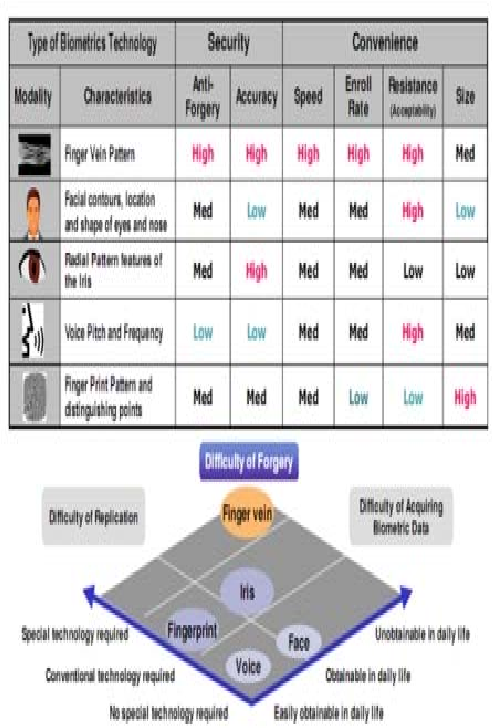
1. Physical Access Control (eg. entry to buildings, offices, facilities, etc.)

2. Logical Access Control (eg. logging into computer resources, database, etc.)

Using Finger Vein Biometric technology, Hitachi has developed products that address the security needs of today's organizations.

4.3.PHYSICAL ACCESS:

Reliability and usability of biometrics are key concerns. Corporations, institutions and governments alike are looking beyond card access systems. The need for accountability is driving the implementation of advanced security technologies such as biometrics for Physical Access Control.



Type of Biometrics Technology		Security		Convenience			
Modality	Characteristics	Anti-Forgery	Accuracy	Speed	Enroll Rate	Resistance (Acceptability)	Size
	Finger Vein Pattern	High	High	High	High	High	Med
	Facial contours, location and shape of eyes and nose	Med	Low	Med	Med	High	Low
	Radial Pattern features of the Iris	Med	High	Med	Med	Low	Low
	Voice Pitch and Frequency	Low	Low	Med	Med	High	Med
	Finger Print Pattern and distinguishing points	Med	Med	Med	Low	Low	High

Fig.11: Comparision between vein biometrics and other types of biometrics

4.4.QUICK AUTHENTICATION:

Using advanced compression technology, Vein ID allows fast authentication of less than 0.5 seconds. Matching Finger Vein pattern is completed within a blink of an eye, providing users a speedy authentication experience without the hassle and **without the** wait.

5.PRACTICAL APPLICATIONS:

5.1.PRODUCT DEVELOPMENT GEARED TOWARD FINANCIAL SOLUTIONS:

A rapidly increasing problem among financial sectors in Japan is the illegal withdrawal of bank funds using stolen or skimmed fake bankcards. To address this, palm vein authentication has been utilized for customer confirmation of transactions at bank windows or ATMs. The smart card from the customer's bank account contains the customer's palm vein pattern and the matching software of the palm vein patterns. A palm vein authentication device at the ATM (Fig.12) scans the customer's palm

vein pattern and transfers it into the smart card. The customer's palm vein pattern is then matched with the registered vein pattern in the smart card. Since the registered customer's palm vein pattern is not released from the smart card, the security of the customer's vein pattern is preserved. In 2004, the Suruga Bank and the Bank of Tokyo-Mitsubishi in Japan deployed a secured account service

Utilizing the contactless palm vein authentication system. Several other banks in Japan have followed suit in 2005. Fujitsu plans to develop another type of ATM for use at convenience stores in Japan, embedding the palm vein authentication sensor in the ATM.

Fig.12: ATM with palm vein pattern authentication sensor unit

5.2. ACCESS CONTROL DEVICE USING PALM VEIN AUTHENTICATION:

The palm vein pattern sensor is also used for access control units. The "palm vein authentication access control device" (Fig.13) is comprised of the palm vein pattern sensor, a keypad and a small display. This device controls access to rooms or buildings that are for restricted personnel. The device consists of two parts: the palm vein sensor, plus the control unit that executes the authentication processing and sends the unlock instruction. A simple configuration system can be achieved by connecting this device to the electric lock control board or electric locks provided by the manufacturer

Fig.13: Palm vein access control unit

5.3.IN LAPTOPS & PC'S

A new photographic optical system has allowed Fujitsu to build a palm vein scanner that's only about the size of a coin. According to the company, the palm vein structure is much harder to replicate than finger prints and offers a higher number of reference points to provide secure user authentication. Vein scanners have been known to be an effective alternative to finger print scanners for some time. Measuring just 29 mm × 29 mm [x× 11.2 mm, the new sensor is considerably smaller than its predecessor; Fujitsu said that this is also due to a new image-reflective method. With the new smaller size, the option of using a vein scan to log into a notebook is therefore coming within reach. To collect the largest possible amount of recognition data with the highest possible degree of precision, the sensor captures images of the user's palm at a rate of 20 frames per second. The best picture is then selected for authentication. Users no longer need to hold their hand motionless above the sensor or touch the sensor: It is sufficient to simply place the palm over the sensor briefly.

Fig 14: Vein recognition in laptops

5.4.IN GUNS:

Guns are a highly dangerous device. It must be highly secure. Thus we can use this vein biometric technology in guns. We introduce a vein recognition device at the handle bar of the gun which detects the person using it. Thus the gun operates only when the person is recognized.

6.0 CONCLUSION:

The designed system was tested for verification purpose only over a database collected with the designed system. Dataset for 500 persons of different age and gender of which ten images per person were acquired (five for the right hand and five for the left) in different scenes at different intervals and are independent of each other, i.e. ten images for each person. Verification performance statistical parameters were estimated for the overall system such as: Genuine Accept Rate (Sensitivity), Genuine Reject Rate (Specificity), False Accept Rate (FAR), False Reject Rate (FRR), Efficiency and Receiver Operating Curve (ROC). System testing performance (overall efficiency) was found to be 99.88% at threshold (matching ratio) equal 78. At this maximum efficiency the Sensitivity is 92.16%, the Specificity is 99.966%, FAR is 0.03%, and FRR is 7.84%. However the difference in methods, datasets, and algorithms that were found in the hand biometric work of, our performance results are comparable. Finally, we studied the similarity between right and left hand vein pattern for the same person. We verified that the hand vein pattern is unique for each person and is also unique for each hand.

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