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By A.Ushapriya, M.Subramani

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HIGHLY SECURE AND RELIABLE USER IDENTIFICATION BASED ON FINGER VEIN PATTERNS

Strictly as per the compliance and regulations of:

Highly Secure and Reliable User Identification Based on Finger Vein Patterns

A.Ushapriya[α], M.Subramani[Ω]

Abstract- With the evolution of consumer electronics technologies, personal information in consumer devices is becoming increasingly valuable. To protect private information from misuses due to the loss or theft, secure user identification mechanisms should be equipped into the consumer devices. Biometrics based personal identification is regarded as an effective method for automatically recognizing, with a high confidence, a person's identity. A new biometric approach to the personal identification using finger-vein technology. The aim of this paper presents a user identification system framework using finger-vein technology for consumer electronics devices. The finger-vein identification is one of the biometrics sensor technologies, which provides high security and reliability than other identification technology. This paper proposes the Radon transform and Principal component analysis algorithms for the feature extraction and normalized distance measure for classification. The results show that the proposed system achieves good performance in terms of the false rejection rate and the false acceptance rate.

Keywords – consumer devices, user identification, finger-vein, Radon Transform, Principal component analysis.

I. INTRODUCTION

Recently, due to the increasing demands of the fast-growing consumer electronics market, more powerful mobile consumer devices are being introduced continuously. With this evolution of consumer electronics technologies, personal information in consumer devices also becomes increasingly rich and valuable. For example, cell phones are now used for the payment of goods, bank transfer, stock dealing, and e-mail checking. This convenience also means that it can be a disaster if the cell phone is lost or stolen. To address this problem, secure user identification technologies for consumer devices are being introduced.

Accurate automatic personal identification is becoming more and more important to the operation of our increasingly electronically inter-connected information society. Traditional automatic personal identification technologies to verify the identity of a person, which use "something that you know," such as Personal Identification Number (PIN), or "something that you have," such as ID card, key, or both, are no longer considered reliable enough to satisfy the security requirements of electronic transactions. All of these techniques suffer from a common problem of their inability to differentiate between an authorized person and an impostor who fraudulently acquires the access privilege of the authorized person. Biometrics is a technology which (uniquely) identifies a person based on his/her physiological or behavioral characteristics. It relies on "something that you are" to make personal identification and, therefore, can inherently differentiate between an authorized person and a fraudulent impostor .Biometrics based personal identification is regarded as an effective method for automatically recognizing, with a high confidence, a person's identity.

In contrast to the existing methods, the Finger Vein identification system employs Principal Component Analysis to achieve more accurate matching results. The implemented Principal Component Analysis technique is much more accurate than the previous Singular Value Decomposition technique. The main disadvantage of Singular Value Decomposition is that once a particular image structure is not visible due to the poor choice of basic functions, its presence is unlikely to be seen in future images since the basic functions being used are not tailored to visualizing it and it also takes more memory [14]. To avoid this problem Principal Component Analysis technique are used for instead of Singular Value Decomposition technique.

Finger vein authentication is a biometrics technology based on vein patterns underneath the skin's surface that are unique to each finger and each person. The major advantages for finger-vein identification technique[7],[8] are the following:

(1) High accuracy: Because veins are hidden inside the body, there is little risk of forgery or theft.

(2)Unique and constant: Finger vein patterns are different even among identical twins and remain constant through the adult years.

(3) Contactless: The use of near-infrared light allows for non-invasive, contactless imaging that ensures both convenience and cleanliness for the user experience.

(4) Ease of feature extraction: Finger vein patterns are relatively stable and clearly captured, enabling the use

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About [α] - P.G. Scholar K.S.R. College of Engineering.
E-mail: usha_ppm2000@yahoo.com, CELL: 9262403684
About[Ω] - Asst.Prof/ECE Department K.S.R. College of Engineering.
E-mail- smsubramani20@gmail.com, CELL:956670739

of low-resolution cameras to take vein images for small-size, simple data image processing.

(5) 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 Table1

Table1- Comparison of Major Biometrics Method

BIOMETRICS	SECURITY		CONVENIENCE				
	Anti-Forgery	Accuracy	Speed	Enrollment Rates	Resistance	Cost	Size
Fingerprint	I	N	N	I	I	G	G
Iris	N	G	N	N	I	I	I
Face	N	I	N	N	G	I	I
Voice	N	I	N	N	G	N	N
Vein Pattern	G	G	G	N	N	N	N

I=insufficient, N=normal, G=good

For example, Compared to key and password methods, these biometric sensor technologies are more convenient and accurate as well as do not have the danger of password exposure. To protect the information stored in mobile consumer devices, traditional ways are used by passwords or PINs (Personal identification number). Although these ways are easy to implement, passwords or PINs have the risk of exposure, and also being forgotten. Therefore, a more reliable and friendly way of identification needs to offer to user. Recently, biometrics, which is the personal identification technology based on human physiological traits, have attracted more and more attention and are becoming one of the most popular and promising alternative to solve these problems. A number of biometric characteristics such as face[6], iris, palm print [4],[5], finger-vein[1], fingerprint[2],[3] or other biometric other biometrics combination[9] can be used in various user identification systems. Fingerprinting is known for being widely applicable due to the small size of its readers, yet because the fingerprint is a trait found on the exterior of the body, it is not only easily stolen but also has issues with low user enrollment rates, as worn away or sweaty fingerprints cannot be registered. Iris recognition is known for low error rates of authentication, but some users feel psychological resistance to the direct application of light into their eyes. Moreover, as precise positioning of the eyes is required for accurate iris authentication, it becomes necessary either to adopt high-cost position adjustment mechanisms or to place the burden of proficiency onto the user. As for face and voice recognition, they are the means by which humans recognize one another in everyday social interaction and are thus the most natural forms of personal identification; yet impersonation is easily performed, and accuracy rates for these are limited.

However, finger-vein pattern recognition offers high accuracy personal identification that is at the same time difficult to forge, non-invasive, and easy to use, offering a balance of advantages that makes it superior as a form of biometric identification. Moreover, finger-vein patterns are different even among identical twins and remain constant through the adult years [7]. Therefore, identification technique based on finger-vein has become the most favorite and novel biometric method.

The proposed scheme first attempts to exploit Radon transform to derive desirable directional features of finger-vein image. Then PCA applies to Radon space to obtain lower-dimensional feature vector and accelerate the identification speed. Experimental results showed the proposed scheme has good performance in terms of the FAR and FRR.

The remainder of this paper is organized as follows. In sections 2 and 3, briefly review Radon transform and PCA, respectively. In section 4, 5, and 6, describe preprocessing, feature extraction using Radon transform and PCA, and identification measure based on finger-vein identification system, respectively. Experimental results and performance evaluation are presented in section 7. Finally, represented the conclusions and other applications in section 8.

II. RADON TRANSFORM

The Radon transform is a useful tool in identification areas [8], [10], [11] because it can effectively capture the directional features in the pattern image by projecting the pattern onto different orientation slices.

Applying the Radon transform on an image *f* (*x*,*y*) for a given set of angles can be thought of as computing the projection of the image along the given angles. The resulting projection is the sum of the intensities of the pixels in each direction, i.e. a line integral. The result is a new image *R*(r,q). This is depicted in Figure 1 on the facing page. This can be written mathematically by defining,

$$\rho = x\cos\theta + y\sin\theta \qquad (1)$$

after which the Radon transform can be written as

$$R(\rho,\theta) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x,y)\delta(\rho - x\cos\theta - y\sin\theta)\,dx\,dy \qquad (2)$$

where $\delta(.)$ is the Dirac delta function. The $x' - \theta$ space will be referred to as the Radon space. The Radon transform is a mapping from the Cartesian rectangular coordinates (*x*,*y*) to a distance and an angel (ρ,θ), also known as polar coordinates.

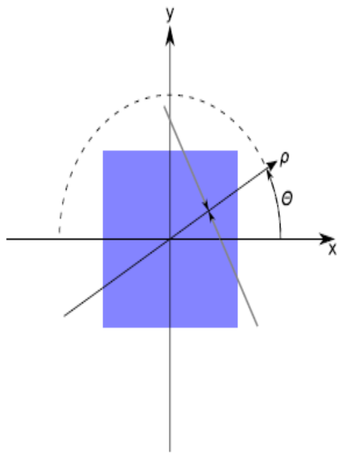

Fig.1. Geometry of Radon Transform

III. PRINCIPAL COMPONENT ANALYSIS

The principal component analysis has been used in the feature extraction of pattern analysis [6]. PCA is a standard technique used to choose a dimensionality reducing linear projection that maximizes the scatter of all projected samples. The basic approach of the PCA is to compute the eigen vectors of the covariance matrix, and approximate the original data by a linear combination of the leading eigen vectors [13].

Principal component analysis (PCA) is a mathematical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of uncorrelated variables called principal components. The number of principal components is less than or equal to the number of original variables. It is a way of identifying patterns in data, and expressing the data in such a way as to highlight their similarities and differences. Since patterns in data can be hard to find in data of high dimension, where the luxury of graphical representation is not available, PCA is a powerful tool for analyzing data. The other main advantage of PCA is that once found these patterns in the data, and compress the data, i.e. by reducing the number of dimensions, without much loss of information. The PCA transformation that preserves dimensionality (that is, gives the same number of principal components as original variables) is then given by:

$$Y^T = X^T W = V\Sigma^T \qquad (3)$$

(V is not uniquely defined in the usual case when $m<n-1$, but Y will usually still be uniquely defined.) Since W (by definition of the SVD of a real matrix) is an orthogonal matrix, each row of Y^T is simply a rotation of the corresponding row of X^T. The first column of Y^T is made up of the "scores" of the cases with respect to the "principal" component; the next column has the scores with respect to the "second principal" component, and so on.

IV. PREPROCESSING

The size of captured images is 640×480 pixels with an 8-bit gray scale image. The performance of an identification system based on finger-vein depends heavily on the quality of input finger vein images. For this reason, several additional steps are needed to enhance the quality of the finger-vein images before the matching algorithm. Therefore, in the preprocessing stage, it includes four steps: average and Gaussian filter, finger-vein region segmentation, size normalization, gray-scale normalization. After filtering the image normalizes the finger-vein image to accommodate geometric changes in the positioning or angle of the finger in the image is detected and then the entire image is rotated so that the slope of the outline is to be constant. The examples of finger vein patterns are shown in Fig. 2.

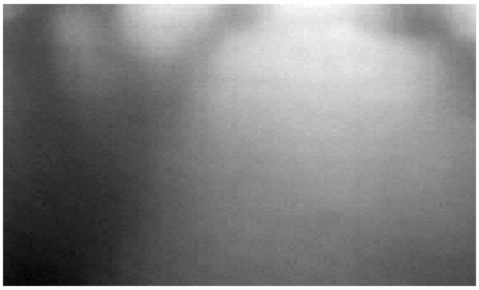

Fig.2. Example of finger-vein pattern

V. FEATURE EXTRACTION USING RADON TRANSFORM AND PCA

After the finger-vein image preprocessing stage, hence extract important finger-vein features for identification task. Radon transform and PCA are employed for feature extraction in our finger-vein identification system.

This process is essential for reliable authentication while controlling the variation of image data caused by body metabolism or changes in imaging conditions. In particular, unevenness of brightness due to individual variations in finger size or lighting conditions often appears in the vein pattern image, so the system must extract only the vein patterns from such an otherwise unstable image.

In the proposed approach, the finger-vein features are the directional information of finger-vein images. The features are derived by using the Radon projections of a finger-vein image in different orientations. For each projection, a vector, which is the projection of image intensity along a radial line oriented at a specified angle, is computed. The elements returned in the vector are the sum of intensity values along the x', which is oriented at θ (theta) degrees counterclockwise from the x – axis. The origin of axes is the center pixel of an image. The projection matrix is constructed by first forming a row stacked version of the individual projections, i.e.

$$G = \begin{bmatrix} g_{\theta_1}(1) & g_{\theta_1}(2) & \cdots & g_{\theta_1}(N) \\ g_{\theta_2}(1) & g_{\theta_2}(2) & \cdots & g_{\theta_2}(N) \\ \cdots & \cdots & \cdots & \cdots \\ g_{\theta_M}(1) & g_{\theta_M}(2) & \cdots & g_{\theta_M}(N) \end{bmatrix} \quad (4)$$

Where M denotes a total of projection angles, N denotes the number of projection points at angle $\theta_i (i = 1,2,\ldots,M)$ Radon space (transform) image for 0- 45° orientations is shown in Fig. 3. This has reduced the dimension of feature vector significantly.

PCA analysis is applied to this projection matrix G , and then singular values can be gotten. Arrange these values with descending order to compose a feature vector , then the feature vector is unique, and also describe uniquely finger vein image. So the proposed approach can be applied to finger vein identification system.

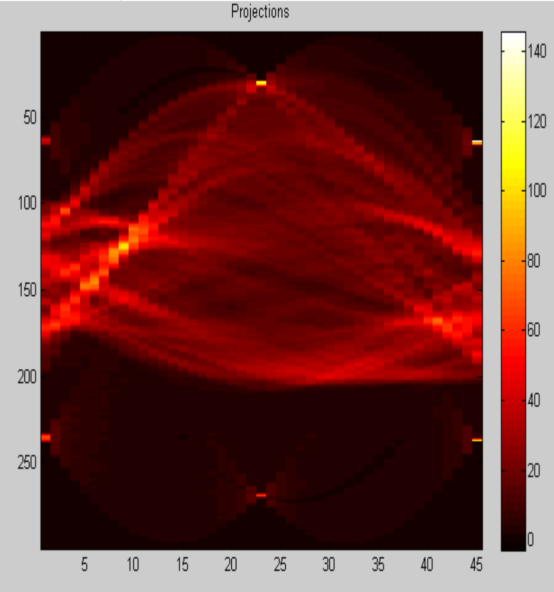

Fig.3. Radon Transform using 180 projections

VI. FINGER-VEIN IDENTIFICATION

After the finger-vein feature extraction stage, the proposed system measures the similarity between the input finger-vein features and the previously enrolled ones. To measure the similarity, defining a normalized distance between the two feature vectors sets as follows:

$$D = D(A,A_i) = \left\| \frac{A}{|A|} - \frac{A_i}{|A_i|} \right\|_F \quad (5)$$

Where A is the feature vector which is obtained from the input finger-vein image, A_i the feature vector which is obtained from the enrolled finger-vein image. $\|.\|_F$ is Frobenius norm and $|.|$ is amplitude of vectors. A smaller value of $D(A,A_i)$ means that the two feature vector sets are more similar. It is noted that D is between 0 and 1. The distance for perfect matching is zero. If the correlation value is higher than a pre-defined threshold value, the input vein pattern is authenticated. The vein pattern image and the extracted feature pattern are ultimate personal information. Fig. 4 shows the block diagram of the proposed finger-vein identification system.

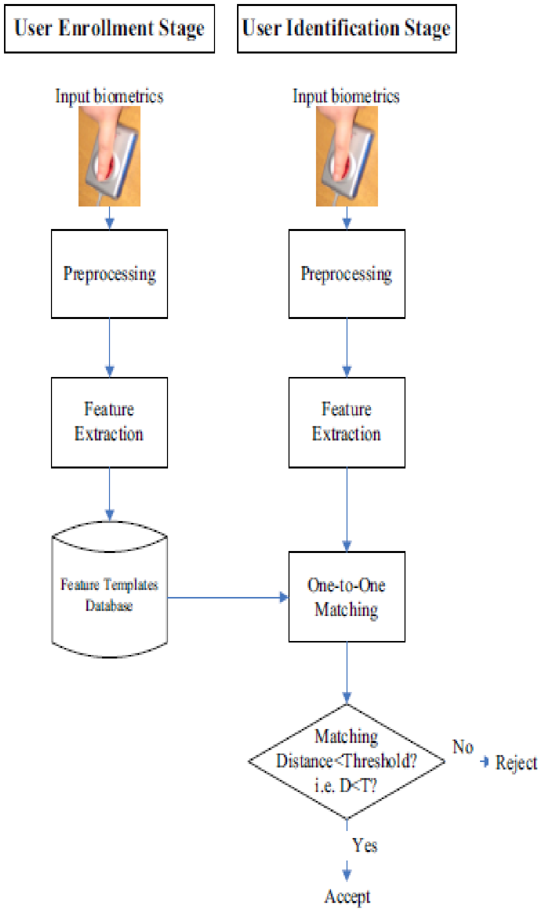

Fig.4. Block diagram of the proposed finger-vein identification system

VII. PERFORMANCE EVALUATION

To evaluate the effectiveness of the proposed finger-vein based identification scheme, performed simulation experiment by Matlab 7.0 on a Intel CORETM 2 Due CPU 2.40 GHz processor with 2.0 GB RAM.

The finger-vein database in the experiment collected a total of 100 images which were organized by acquiring 10 images for the forefinger of right hand from 10 testers through our capturing device. The size of captured images is 640×480 pixels with an 8-bit gray-scale image. Radon transforms are used to reduce the dimension of feature vector. It used two performance measures, namely the false rejection rate (FAR) and the false acceptance rate (FRR). FAR refers to the acceptance rate of unauthorized users and FRR refers to the rejection rate of the legitimate users. In both of the measures, a lower value implies better performance[2].

Table 2 shows the FAR and FRR of the proposed finger-vein identification scheme with different distance measure threshold. As can be seen from the table, the identification system shows the best performance when the distance measure threshold is 1. FAR and FRR are 0.008 and 0.000, respectively.

Table 2- Performance Evaluation in terms of FAR and FRR

Distance Threshold	FAR	FRR
0.80	0.048	0.000
0.90	0.050	0.090
1	0.008	0.000

VIII. CONCLUSIONS

In this paper, a new finger-vein based user identification system for personal consumer electronic devices. The system provides effective and efficient features using Radon transform and PCA. The Radon transform has been used to derive desirable directional features of finger-vein image. The PCA has been applied to Radon space to obtain lower-dimensional feature vector. The experimental results showed the proposed scheme has good performance in terms of the FAR and FRR.FAR and FRR are 0.008 and 0.000 at the distance measure threshold 1. Finger-vein based identification technology has high security and reliability compared to the traditional authentication mode.

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