Survey on Finger Vein Biometric Authentication System

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ABSTRACT
In today's society with the rapid growth in the field of electronic information technology and its simultaneous deployment in every field, the personal or identity verification is a critical key problem. Due to this fact, the biometric authentication has gaining popularity as it provides a high security and reliable approach for personal authentication. Vein biometrics is one of the emerging technique over other types of biometric systems due to its strengths of low forgery risk, aliveness detection as well as stable over long period of time. A survey on different techniques used for different processes for authentication is described in this paper. Finger vein has an outstanding promise in variety of applications. The performance parameter for vein is Equal Error Rate (EER) which is calculated using different algorithms.

Keywords
Biometric, finger vein recognition, EER, verification

1. INTRODUCTION
Biometrics is an automated recognition of an individual based on uniqueness of their biological or behavioural characteristics. The personal information can be protected in the form of biometrics. The traditional authentication systems like identity card or password can be easily stolen or acquired by unauthorized person. All these traditional authentication systems are gradually replaced by biometric systems like fingerprints, iris recognition, palm print and finger vein recognition. The biometric authentication system is chosen over conventional authentication system because of their distinctiveness and highly secured nature.

Out of these biometric systems, finger vein biometric is gaining popularity. From the security and convenience point of view, the finger-vein is a promising biometric pattern for personal identification. In vein biometric the vascular pattern under one's skin is utilized as a unique feature for authentication. Veins are hidden underneath the skin surface and are mostly invisible to human eye, they are not prone to external distortion, and the vein patterns are much harder to replicate as compared to other biometric traits. Vein patterns are unique for each individual and are stable over a long period of time. Because of its uniqueness, stability and high resistance to criminal tampering, vein pattern offers a more reliable trait for a secure biometric authentication system.

The Biometric system is currently often implemented in an untrusted environment that uses an insecure and non-reliable central server for the storage of the biometric templates. This can be the source of biometric information leakage. The recent development in this vein authentication provides solution to these critical issues by hardware implementation of the system. It provides secure information storage, and tamper resistance, hence it provides the protection from physical and software attacks.

The finger-vein biometric pattern for personal authentication is promising in terms of its security and convenience. Compared with other biometric traits, the finger-vein is more advantageous because of these advantages as listed: a) the vein is hidden inside the body and is mostly invisible to human eyes, so the difficult to forge or steal is less. b) The non-invasive and contactless capture of finger-veins are more convenience and hygienic for the user, and that's why it is more acceptable. c) The finger-vein pattern can only be taken from a live body, so it is a natural And a more convincing proof that the person whose finger-vein is captured is alive. The comparison between different biometric systems is as shown in Table 1, I=insufficient, N=normal, G=good.

Table 1 Comparison of Major Biometrics Method

Biometric	Anti-forgery	Accuracy	Speed	Enrolment rate	Resistance	Cost
Fingerprint	I	N	N	I	I	G
Iris	N	G	N	N	I	I
Face	N	I	N	N	G	I
Voice	N	I	N	N	G	N
Vein	G	G	G	N	N	N

2. PERSONAL IDENTIFICATION USING FINGER VEIN PATTERN
In this section the procedure of typical finger vein authentication system is given.

The personal identification based on the vein pattern of an individual basically consists of four modules as shown in figure 1. Image acquisition module, Pre-processing module, feature extraction module and finally matching. The image acquisition module is for obtaining the image for authentication purpose either it is obtained from the available database or by using particular imaging device. After acquiring the image, due to some noise or strong reflection resulted from the skin's surface the original finger vein image contrast is small which makes it not distinct enough for identification. For that purpose the pre-processing of that image is performed for later analysis. The role of this image pre-processing module is to prepare the image for feature extraction by different image processing techniques like grayscaling, histogram equalization, image segmentation and image denoising. Afterwards the feature extraction is performed which is basically a form of dimensionality reduction, means the transformation of input data into a set of features. Lastly matching is performed. In this process, the pattern is converted into matching data, and these data are compared with the recorded data by measuring dissimilarity between the two vein patterns and authentication is done by verifying either the user is genuine or imposter.

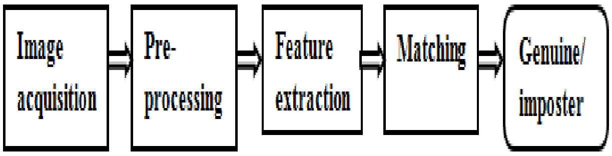

Figure 1 A Typical finger vein authentication system

3. METHOD FOR FINGER VEIN RECOGNITION

In this section the methods for authentication is discussed. The method includes image acquisition, preprocessing, feature extraction and matching.

3.1 Image Acquisition for finger vein image

Image acquisition is of two type off-line and online. On-line images are the images which are taken real time and off-line images means the images which are taken from already created database. The images in real time can be obtained by normal web camera or by designing a finger-vein imaging device based on light transmission for more distinct imaging.

For on-line images there are two ways of finger vein image acquisition, i.e., light reflection and light transmission method. The main difference between two is the position of near-infrared light. In light reflection method near-infrared light is placed in finger palmer side and finger vein pattern is captured by the reflected light from finger palmer surface. Whereas in light transmission method, near-infrared light is placed in finger dorsal side and light will penetrate finger. Compared with light reflection method, light transmission method can capture high contrast image, that’s why most of the image acquisition devices employ light transmission method [1][3][6][8].

3.2 Preprocessing

In image-based biometric systems like finger vein system, a number of pre-processing tasks are required prior to enhance the image quality, some of these tasks are contrast, brightness, edge information, noise removal, sharpen image, etc, furthermore, to produce a better quality of image that will be used for later stage as an input image and assuring that more relevant information can be detected for authentication.

Better quality of image will gain the better accuracy rate to the biometric system itself. Initially in samples of finger vein image pre-processing involves, image segmentation and alignment [2][6][8], image denoising i.e. noise removal [1][8], image ROI(Region of Interest) detection[1][4][5], image enhancement[4][5][6][7], image size normalization[1][2][4].

In image segmentation the actual image is separated from its background and also noise is removed up to some extent but it is quite difficult to extract precise details of the vein pattern because of irregular noise and shades around the finger vein. For this threshold image method [2] is used which computes thresholds for every pixel, it creates a binary image i.e. image with only black or white colour. The most essential thresholding [8] operation will be the selection of a single threshold value which is the peak values of the image this process also called binarization.

In [6], the image segmentation and alignment is performed by following steps: firstly the part between the two joints in the finger vein image is segmented based on the peak values of the horizontal projection of the image. Secondly the canny operator [8] with locally adaptive threshold is used to get the single pixel edge of the finger. Thirdly the midpoint of the finger edge are determined by edge tracing so that the midline can be obtained, then image is rotated to adjust the midline of the finger horizontally and finally the ROI of the vein image is segmented according to the midline. After image segmentation & alignment the image enhancement is carried out by first resizing the image using Bicubic interpolation [6] [5] and finally, histogram equalization [4][6][5] is used for enhancing the gray level contrast of the image.

In [8], the image segmentation involves three processes first is finger edge detection using canny edge detection [6] which detects the finger edge. Second is edge smoothing by morphological dilation to join the broken edge. And lastly finger region filling, in this the region inside the finger region is filled with white pixels.

Histogram equalization [4][5][6] is a method of image enhancement, this method usually increases the global contrast of image, especially when the usable data of image is represented by close contrast values. Generalization of this method uses multiple histograms to emphasize local contrast, rather than overall contrast. Some of such methods are adaptive histogram equalization and contrast limiting adaptive histogram equalization (CLAHE) [4] it operates by partitioning the image into regions and perform histogram equalization on each region separately.

After thresholding the vein image contains noise, this unwanted noise can be removed by applying binary median filtering technique. The convention method for performing denoising of a finger vein image includes median filter, involving sorting all pixel values in the $w*w$ window area [8]. In this process the median value is calculated by first sorting all pixel values within the window centered at the pixel being considered. The another method for noise removal is Gaussian blur [1][2].

3.3 Feature Extraction

Feature extraction is a special form of dimensionality reduction. The transformation of input data into the set of features is called feature extraction. Variety of algorithms are used for this process also filters such as median filter [8], Gabor filter [1][2]are used for feature extraction to extract the features of vein without noise and deformation. To develop highly accurate personal identification systems, Finger-vein patterns should be extracted precisely from the captured images, and the process must be executed speedily in order to satisfy requirements for user convenience.

Repeated line tracking [1][9] is used for feature extraction. Extraction of the patterns is based on the number of times the tracking lines pass through the points. The method is based on line tracking, which starts at various positions. Local dark lines are identified, and line tracking is executed by moving along the lines, pixel by pixel. When a dark line is not detectable, a new tracking operation starts at another position. All the dark lines in the image can be tracked by repeatedly executing such local line tracking operations. Finally, the loci of the lines overlap and the pattern of finger veins is obtained statistically. As the parts of the dark lines are tracked again and again in the repeated operations, they are increasingly emphasized. Although noise may also be tracked, noise is emphasized to a smaller degree than the dark lines. This makes line extraction robust. Also reduction of the number of tracking operations and the spatial reduction of the pattern can reduce computational cost.

Radon Transform [2][3] and Principle Component Analysis (PCA) is another method for extracting features from vein pattern. Finger-vein features are the directional information of the vein image. In this particular algorithm the features are derived by using the Radon projections of a vein image in different orientation for each projection, a vector which is the projection of image intensity along a radial line oriented at a specified angle is computed. The projection matrix is constructed from the individual projection. PCA analysis is applied to this projection matrix and then singular values are calculated and the arrangement of these values with descending order to compose a feature vector, this feature vector is unique and also describe uniquely finger vein image.

In [3], Radon transform and Singular Value Decomposition (SVD) are employed. The algorithm first attempts to exploit Radon transform to derive desirable directional features of finger vein image. Then SVD applies to Radon space to obtain lower-dimensional feature vector and accelerate the identification speed.

In [5], feature extraction is performed by HAAR classifier and line detection. HAAR transform is a simplest of the wavelet transform. This transform cross multiplies the function against the HAAR wavelet [7] with various shifts and stretches like a Fourier transform, cross multiplies a function against a sine wave with two phases and many stretches. The important feature of HAAR transform is, it is fast for implementation and able to analyze the local feature.

The fractal model and the concept of lacunarity [6] can be used for feature extraction of the finger vein image. The fractal model provides an excellent method for representing the ruggedness of natural surfaces. Since different fractal sets with different textures may share the same fractal dimensions, so the concept of lacunarity is used to discriminate among textures. Lacunarity is to quantify gaps presented in a given surface. Lacunarity is a measure of spatial heterogeneity. Visually different images may have similar values for their fractal dimensions, lacunarity estimation can help to distinguish such images. Higher value of lacunarity implies more heterogeneity. Lacunarity is computed based on Blanket method. For feature extraction these two concepts are combined.

In [8], the feature extraction module utilizes the minutiae features extracted from the vein patterns for recognition. The minutiae points include bifurcation points and ending points. The method used for minutiae feature extraction is cross number (CN) concept. It is the number of transaction from 0 to 1 and vice versa for the surrounding pixel, by this concept the pixels can be classified as ridge ending point or bifurcation point and in this way the vein pattern is extracted from the minutiae points.

3.4 Matching

Matching is one of the important stage in finger vein identification. After features are extracted from the vein image the matching stage measures the similarity or dissimilarity between the input finger vein image features and the previously enrolled ones in the database. Template matching [1] is performed in this stage.

In [2] [3] to measure similarity, a normalized distance between two feature vectors are defined. Smaller the normalized distance means that two feature vectors are more similar. Radon transform is used to reduce the dimension of a feature vector due to this the response time (identification time) is reduced.

Phase only correlation (POC) for finger vein recognition reduces the need of feature extraction module. POC at the matching stage is used, this technique uses phase component of two-dimensional discrete Fourier transform (2D-DFT) of an image. If two images are matched the normalized score is equal to one. But if two different images of the same finger are matched the score is degraded. In order to eliminate high frequency component, it is excluded in the calculation of cross phase spectrum. The high frequency component is eliminated by setting a band-limit during calculation of the cross-phase spectrum; this is called Band Limited POC (BLPOC) [4]. For every set of image the BLPOC function is calculated between shadowed areas of the registered and the input image. The highest score among the sets is selected as a final matching score. This matching technique gives high accuracy.

In [6], as the concept of lacunarity based on blanket method is used for feature extraction, for matching purpose the blanket dimension distance and lacunarity distance are calculated and two threshold values for these two distances are set and matching is performed. This technique gives low computational complexity.

The critical points of the extracted images such as bifurcation point and ending point [8] are taken to calculate the similarities between the input image and template image stored in the database. The Hausdorff distance [8] can be used for measuring the two-dimensional points in the vein pattern. This method achieves 0.7% Equal Error Rate (EER). Euclidean distance can also be used for matching which measures the degree of mismatch between two sets of points

4. PERFORMANCE AND ANALYSIS

In this section we have given the performance and analysis of the finger vein recognition system on different platform. From this analysis it is clear that the hardware implementation of the system [5][6][7][8] gives more reliability and it is highly secured. The Biometric system is currently often implemented in an untrusted environment that uses an insecure and non-reliable central server for the storage of the biometric templates. This can be the source of biometric information leakage. The implementation of the biometric system on an embedded system can overcome this critical issue, because the embedded system can provide secure communication medium, secure information storage and tamper resistance, hence it provides the protection from physical and software attacks.

In [5], the hardware implementation of the finger vein recognition system for vehicle security application is given. It consists of embedded main board with AT89C51 microcontroller and communication module. System can also be implemented on digital signal processor (DSP) [6] for mobile application which gives low computational complexity and low power consumption. In both [5][6] the applications the EER calculated is about 0.07%.

Similarly the system is also be implemented on ARM7TDMI core [7] for the application of Automatic Teller Machine(ATM) and on Field Programmable Gate Array (FPGA) [8] which provides a secure environment for the storage of the biometric template. And also provide less response time and fast recognition rate.

5. CONCLUSION

This study presents the survey of finger vein recognition for personal identification and also its hardware implementation for different applications. In this paper the different approaches of image acquisition module and also the authentication using different algorithms for feature extraction and matching are studied. The paper presents the general framework and key techniques available for finger vein technology. According to the literature available the finger vein biometric ensures high performance, spoofing resistance, fraud proof authentication and also its hardware implementation can be used for variety of applications which gives more reliability, high accuracy and security. Thus finger vein recognition system is more reliable and secure than other conventional modalities.

6. REFERENCES

[1] David Mulyono, "A study of finger vein biometric for personal identification" IEEE Proceedings of the Tnternational Symposium Biometrics and Security technologies, pages 134-141, 2008.

[2] M.Subramani, "Highly secure and reliable user identification based on finger vein patterns" Double Blind Peer Reviewed International Research Journal, 11, 2011.

[3] D. Wang , J. Li, and G. Memik, "User identification based on finger vein patterns for consumer electronics devices", IEEE Transactions on Consumer Electronics, vol. 56, no. 2, pp. 799-804, 2010.

[4] Nurhafizah Mahri, "Finger vein recognition algorithm using phase only correlation" IEEE, 2010.

[5] V.Ramya and P.Vijay kumar, " A novel design of finger vein recognition for personal authentication and vehicle security" Journal of Theoretical and Applied Information Technology, 65, 2014.

[6] Zhi Liu and Shangling Song, "An embedded real-time finger-vein recognition system for mobile devices" IEEE Transactions on Consumer Electronics, 58(2), 2012.

[7] K. Amruthavally, "An embedded real-time finger-vein recognition system for security levels" International journal of Engineering Research and General Science, 1, 2013.

[8] M. Khalil-Hani and P.C. Eng., "FPGA-based embedded system implemention of finger vein biometrics" IEEE Symposium on Industrial Electronics and Applications, 2010.

[9] N. Miura, A. Nagasaka, and T. Miyatake, "Feature extraction of finger vein patterns based on repeated line tracking and its application to personal identification", Machine Vision Application, vol. 15, no.4, pp.194–203, 2004.

[10] J. Hashimoto, "Finger vein authentication technology and its future" 2006 Symposium on VLSI Circuits, Digest of Technical Papers, pp. 5-8 2006.

[11] H. Lee, S. Lee, T. Kim, and Hyokyung Bahn, "Secure user identification for consumer electronics devices," IEEE Transactions on Consumer Electronics, vol.54, no.4, pp.1798-1802, Nov. 2008.

[12] K. Jain, S. Pankanti, S. Prabhakar, H. Lin and A. Ross, "Biometric: a grand challenge" Proceedings of 17th International Conference on Pattern Recognition (ICPR) vol 2, pp 935-942, 2004.

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