A Survey on Biometric Authentication Techniques Using Finger Vein

G. Gowsica[1], L. Latha[2]

[1]PG Student, Kumaraguru College of Technology, Coimbatore, India

[2]Associate Professor, Kumaraguru College of Technology, Coimbatore, India

Abstract: ***In the electronic world development, securing the personal database or other information is important. Biometric is user friendly and convenient systems for securing the information. Unimodal biometric authentications such as iris, gait, face, voice, signature, finger print etc have many shortcomings. For privacy protection about the person, it is required to develop the protected and safe authentic recognition system. Finger vein is highly reliable and secure biometric because it is present below the skin of finger. In this survey different finger vein technique of for feature extraction is analyzed. Finger vein has an outstanding promise in different application. The performance framework for vein parameter such as EER is calculated using different algorithms.***

Keywords: Biometrics, Unimodal biometrics, Finger vein, identification, verification

1. Introduction

Traditional information base and token base identifications are prone to scam because PINs may be guessed by imposter or forgotten and the token may be misplaced or stolen [1] [5]. Generally, biometrics is based on repeatable physiological character and behavioral character. Finger print, iris, face, DNA etc are the physiological characteristics and voice, signature are the behavioral characteristics [4] [7]. Biometrics is used in various systems such as ATM for transactions, online banking, driver identification, e-commerce, aadhar card and many more.

Biometrics has seven factors [6]:1) Uniqueness 2) Universality 3) Performance 4) Measurability 5) Permanence 6) Circumvention 7) Acceptability. An assessment of biometrics is exposed in Table 1.

Fingerprint detection is easily spoof biometric using copy fingerprint and sensitive to dirt, wet [9].Voice recognition is not protected from recorded voice and it depends upon the ecological conditions [7]. Face recognition is sensitive to age and face expression. Iris recognition occupies lots of memory for the data to store up and also very expensive [8] [3]. Users feel psychological resistance to the straight application of light interested in their eyes.

By considering these challenges in the current recognition system, to secure the privacy information, now time to develop the new recognition system with high performance, high security and accuracy [15]. In the recent development of biometric, one of the securing and promising biometric is finger vein [1]. According to the reported results in literature, finger vein outperforms the iris, palm print, finger print scan recognitions. Finger vein patterns are blood vessel present underneath the covering of finger, so it is unique for every individual even for twin [17] [18]. The main uniqueness such as permanence, universal and uniqueness is high as compare to existing biometric modalities [9]. Hand vein and palm vein are correlated modalities for finger vein, but it is not popular because it needs large space for storing the database and high cost [20].

The individuality of finger vein compared to existing biometrics is as follow [6]:

1) Finger vein is not sensitive for environmental conditions or finger conditions such as wet, dirt, dry.
2) Live body identification.
3) It is fraud-proof biometric.
4) It remains constant throughout the life.
5) It is protected by skin, so it has less damage.
6) Finger vein devices are smaller in size.
7) Non-contact acquisitions.
8) No failure to enrolled rate.

Finger vein patterns are captured by LED and CCD camera. LED is located above the finger and CCD camera is placed below the finger [3] [5]. As infrared light of 760-1000 nm is able to pass through the skin while the hemoglobin in vein can absorb the light. This identification method does not subject to touch the sensor, because it is detected by CCD camera through a near infrared filter [10]. Blood vessels are almost transparent in range of infrared light wavelength.TS-E3F1 device is the world's first finger vein authentication device introduced for banking.

Table 1: Comparison of Parameters for Different Biometric Technologies [21] [22]

Biometrics	*Universality*	*Uniqueness*	*Permanence*	*Collectability*	*Performance*	*Collectability*	*Circumvention*
Finger Vein	*H*	*M*	*M*	*M*	*H*	*M*	*L*
Face	H	L	M	H	L	H	L
Iris	H	H	H	M	H	L	H
Signature	L	L	L	H	L	H	L
Finger print	M	H	H	M	H	M	H

*H- High M-Medium L-Low

2. Basic Identification Steps of Finger Vein Pattern

2.1 Image Acquisition of Finger Vein Image:

Safe Infra Red imaging technique is used for personal identification of finger vein. A camera is placed in the side of palm of hand. LED is in step according to the image brightness. Hemoglobin in blood vessels absorbs the infrared light. Vein patterns in palm side of finger as captured as shadows.

2.2 Pre-Processing

Pre-processing involves ROI detection, Image enhancement and segmentation.

2.3 Denoising the Image

Remove the noises in the image by using Median filter.

2.4 Minutiae Extraction

In this process the minutiae in the finger vein are observed and extract the vein features.

2.5 Verification

In this process the input image and vein template image are compared then the matching decides the user is imposter or genuine.

The detailed explanations of the above steps are to be followed: Finger vein recognition has two stages: 1) Enrollment stage 2) Verification stage. In enrollment period, biometric from individual is captured and stored. In verification stage, the comparison between stored template image in biometric database and captured image is verified fir personal identification. Four steps involved for each phase: i) Image acquisition ii) Pre-processing iii) Feature Extraction iv) Matching. Each steps described in detail for finger vein biometric traits in the following section.

3. Methods of Finger Vein Recognition

3.1 Image Acquisition

Finger image is obtained by homemade finger vein images [1] which can automatically capture finger vein imaging. Finger vein pattern cannot be capture by normal CCD camera. In most existing methods [1] [2], finger vein pattern is capture by NIR LEDs and two added LEDs with wavelength of 760nm and CCD sensor is placed underneath the finger. For enhancing the veins and tissues the additional LEDs are used. By comparing the finger dorsal and finger vein [3], finger dorsal is captured by placing the camera on top of the finger. Two position sensors are placed to decrease the variation of imaging pose when a finger is placed suitably [2]. The CCD camera captures the image and saved it in the computer via image capturing card [3]. The hemoglobin in the blood absorbs the more NIR light than surrounding environment, thus the finger vein images appears brighter than other areas [1] [5]. The cutoff wavelength of infrared light pass through the finger is 1000nm [5]. While the surrounding tissue presents the bright background the vein appears as "shadows" on the imaging plane [2]. The shadows in the finger vein images called "angiogram" [2]. Image restoration using scatter removal method [2] is to improve the quality of finger vein images.

The quality of finger vein images is influenced by many factors such as position of finger, image capturing environment, performance of capturing device used [6]. The low quality images can be classified into four types [6]: 1) Skewed image, the vein image has show a certain degree of distortion; 2) Very dark image, the vein is in the very dark part; 3) Very light image, the vein is in very light part; 4) Blurred image, very less vein patterns with low contrast in the vein images. The other techniques [4] used in applications such as X-ray imaging, computerized topography, magnetic resonance imaging, ultrasonic scanning using high frequency transducer could provide valuable image data for personal identification. The optical imaging techniques are not only feasible but also sensitive to detect deeper tissue features/characteristics [4].

3.2 Preprocessing

After the finger vein raw image captured, before feature extraction it is required to be preprocess the raw image. The captured finger vein images are noisy and low contrast with translational and rotational variations from unconstrained imaging [6]. Initially in samples of finger vein image preprocessing involves image ROI detection [7] [8] [12], image enhancement [8] [4], image size normalization [8] [4] [12]. ROI extractions are carried out with three primary steps [6]: 1) Detect and correct the skewed image, 2) Determine height of ROI using Phalangeal joints of finger distance, 3) determine the width of ROI using the internal tangents of finger's edges. If the image is skewed then find the skew angle to correct the image. Skew angle is calculated using linear fitting method [6] and middle points of finger's left and right edges.

In ROI localization methods [7] [2], ROI segmentation, Orientation correction and ROI detection are determined for resized images. In ROI segmentation [7] the resized image is coarse binarized. After coarse binarization if false background exists then to elaborate the binarization, if not exists calculate the orientation angle. Delete the wrong middle points, then by combining coarse binarization and orientation angle the segmented image is obtained [7].

In finger vein recognition algorithm [11], the phase only correlation (POC) function is used for displacement correction. This function involves two steps: 1) Edge detection 2) Determine the pair of edge points. An efficient and robust method for ROI segmentation is using Multiscale and multidirectional matched filters [9] based on dyadic transform. In this method, the Multiscale filters, automatic segmentation by local neighborhood threshold and vein pattern extraction by morphological post processing are the processes involved.

Segmentation of ROI [20], orientation and translation alignment and image enhancement of vascular patterns are employed for preprocessing. Each image is segmented to binarization [7] by using threshold value 230, to localize the finger shape. Due to uneven illumination some portions of background are appear as connected to bright finger regions. The loosely connected binarized images are eliminated in two stages [20]; 1) Using Sobel operator for entire image, the edge map is subtracted from binarized image, 2) Eliminate the white pixels which are less than threshold value. Morphological operations and feature encoding [9] are used for further enhancing the clarity of finger vein patterns.

In image size normalization [10] the size variations due to the position of sensor and individual ROI variation, the image should be resized to obtain the consistent size of images. For finger vein enhancement 2D convolution operation [2] and venous region enhancement method are used to enhance the vein vessels with diameter and orientation variations.

Some criteria for capturing the finger vein images with high quality are, the finger should be healthy and clean, stable and suitable illumination, non-invasive and contact less data capture, position of finger is corrected, limited finger movement and capture the finger images in different sessions [6]. After these steps the biometric sample are reduced to mathematical form of templates and only these templates are stored in the database. To eliminate the burden of more storage space, the template size should be applicable (e.g., 256 or 512 bytes).

3.3Feature Extraction

Next step after preprocessing is feature extraction. The representation of images in numerical features to remove redundancy and reduce dimension is feature extraction. Feature extractions are based on approaches like wavelet based approach [9] [14], local vein shape approach [11] and holistic approach [20]. The wavelet transforms [14], Hough transforms [10], Fourier transform [14] are used to extract the numerical feature values. Filter such as median filter, Gabor filter [20] are used for feature extraction to extract the features of vein without noise and deformation.

Local Directional code in [12] describes LDC descriptor to present how to convert a finger vein image into LDC image. In LDC conversion process, the pixels in edge are removed then the dimension of extracted LDCs is (W-2) × (H-2) where W and H are width and height of the images. The performance of LDC is 100% compared to Local Line Binary Pattern.

In [13], the Pyramid Histogram of Gray (PHG) at different levels is extracted by three steps: 1) Divide the image into sequence of finer spatial grids by repeatedly doubling the division at each pyramid resolution level. 2) For each grid cell calculate the gray histograms. 3) For final feature concatenate all histogram vectors in pyramid resolution levels then final feature is normalized to sum to unity. Pyramid Histogram of Texture (PHT) in [13] by using above three steps to extract the texture images. In this LBP operator [13] [16] is used for representing the texture.

Transformation in Orthogonal Neighborhood Preserving Projections (ONPP) [8] are use to map infrared finger vein images into lower dimensional feature space. This method is to represent both global and local geometry of high dimensional data samples. The equal error rate [8] of verification model is 0.8%.

Fast Fourier Transform (FFT) in [14] is used for analyzing and transforming the images in frequency domain. In finger vein capturing device, when the fake image is recaptured most of the lines in vein are less focused and less distinct than live images. Using wavelet transform [14] the original image is decomposed into four types: 1) LL- Low frequency in both horizontal and vertical directions 2) LH- Low and High frequency in horizontal and vertical directions 3) HL- High and Low frequency in horizontal and vertical directions 4) HH- High frequency in horizontal and vertical directions. The EER of fake detection with testing database using SVM is 0.476%.

Extracted features are applied to binary patterns [15] such as Local Binary Pattern, Local Line Binary Pattern from the preprocessed images. A LBP in [15] be defined as set of ordered binary values by comparing the values of neighboring pixels and center pixels .If the value of binary pixels is lower than neighboring pixel, 1 will be given as corresponding bit binary code, otherwise 0 will be given. A LLBP operator [14] [15] first obtains the binary code with horizontal and vertical direction and its magnitude. The characteristic of binary code changes the image intensity such as edges and corner.

Minutiae extractions in [16] adopt two kinds of minutia such as Bifurcation Point (BP) and Ending Point (EP) from binary finger vein images. Minutiae using singular points and chain codes are observed in [10]. The derivative is not continues from the slick curve in wavelet function [10], because function has favorable frequency domain and time domain characteristics. [20] Proposed Local Radon Transform for finger texture extraction in local area. The process of LRT is analyzing the small piecewise line segments in curved lines and the intensity value of pixels that fall into the confined line width area is integrated in local region.

3.4 Classification by Matching

Matching is the important stage of the system. After feature extraction, a minutia matching is next stage. In minutiae matching three stages are involved: 1) Minutiae Pairing, 2) False removing and 3) Score calculating [17] [18] [19] [20]. Initially Singular Value Decomposition (SVM) [16] is used for minutiae pairing. In Local Extensive Binary Pattern (LEBP) stage the images with false are removed, which using a rich local characteristics for minutiae representation. LEBP is the combination of Local directional Binary pattern (LdBP) and Local multilayer Binary Pattern (LmBP).

Support vector machine [17] is widely used for image classification. Support vector machine classifier involves finding a hyper plane classifier [17] [18]. The main reason for using wide application using SVM is its capacity to handle nonlinearly separable data. The SVM takes less time and it is a robust classifier. [18] Extracted vein image is matched with the database. The database contains all the features of vein images. The features extracted from the input image matched with all the extracted veins in database. If the image is matched with extracted veins the user will be genuine [16] [18]. If the image is not matched with extracted veins then the user will be imposter.

By combining finger vein and finger dorsal texture the score level combination is better than decision level and feature level combination [20]. Two score level fusion such as holistic fusion and non linear fusion are used to calculate the score values. Holistic fusion is investigated to utilize the prior knowledge in dynamic combination of matching scores. According to degree of consistency between the two matching score non linear fusion is adjusted with the combined score [20].

The critical points of the extracted image such as bifurcation point and ending point [16] [19] are taken to calculate the similarities between the input image and template image stored in the database [19]. The Hausdorff distance can be used for measuring the two-dimensional points in the vein pattern. This method achieves 0.761% EER. [21] Multiple Pixel Ratios (MPR) is the ratio of matching the number of pixels and total number of pixels in matching vein patterns. If there is any rotation or translation then it is difficult for matching. The EER of mean curvature has 0.0025%.

3.5 Applications of finger vein

The finger vein recognition techniques are used in many applications [8]. They are;

- Login authentication
- Door security controls
- Personal Computer Security
- Physical access management
  Health care

4. Conclusion

This study presents the survey of finger vein recognition for personal identification. In this paper the finger vein recognition with various feature extraction methods and different matching algorithms are studied. It presents the general framework and key techniques and available methods for finger vein technology. According to the available work literatures and commercial experiences finger vein ensures high performance, spoofing resistance and high accuracy and security. Thus the finger vein recognition is more reliable and secure than other conventional modalities.

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