A RETROSPECTIVE STUDY ON THE KEY TECHNIQUES OF FINGER VEIN IDENTIFICATION SYSTEM

Preethy Prabhakar, Tony Thomas

Abstract- Biometric technology is a well known and efficient human authentication and identification technique. Among all of the major biometric technologies, finger vein recognition has drawn greater attention among various researchers and users. This study presents a literature survey on finger vein recognition techniques. This study also presents greater idea relating to the finger vein-features, comparison with other major biometrics, key techniques etc. In key techniques, most of the existing work is systematically described and compared in four parts finger vein image acquisition, pre-processing, feature extraction and feature matching.

Introduction : The identification of individuals by physical or behavioural characteristics is known as Biometrics. Or in general we can say that Biometrics is the science of measuring physical properties of living beings. Example of recognition by physical characteristics include fingerprints, face, iris or retina scan based, hand geometry based, or based on thermograms of face, hand or even hand vein. Behavioural characteristic can be the voice, signature, handwriting, hand gesture, gait analysis or any other keystroke dynamics. The need of biometric technology is increasing rapidly in our day to day life because even an average person's life has become overwhelmed by crime occurrences that can originate anywhere or at any time in the world. Biometrics systems are the highly accurate identification systems and as it utilizes part of one's body, have become the ideal solution to these intense and complicated security needs and are already being adopted worldwide.Among the existing wide varieties of biometric techniques Finger vein authentication is a new biometric method. It utilizes the vein patterns inside one's fingers for personal identity verification. As they comes under the intrinsic biometrics characteristics (other examples include hand vein or palm vein, DNA based etc), they require more challenging efforts to acquire without the knowledge of an individual and, are hence more difficult to forge. As it uses the features which are hidden inside the human body, it can be a leading biometric technology nowadays in terms of security and convenience.

Originally, the motivation to develop finger vein pattern recognition technology was born of Hitachi's advanced research to measure brain-function activity in the field of medical science [2]. In that research, near-infra red light was used to observe the increase in blood flow and was found to be applicable to recognition of the finger vein pattern. As finger vein patterns differ for each finger and for each person, Hitachi thus discovered that finger vein pattern recognition is a viable biometric personal authentication technology for the commercial market and by 2000-2005 were the first to commercialize the technology into different product forms, such as ATM's.

A. Features

The special features of finger vein recognition system that gives more importance to it, compared to other major biometric technologies may include,

- Hidden patterns provide huge privacy: As the vein patterns in fingers stay where they belong and where no one can see them in the fingers, there is a huge privacy consideration.
- High accuracy.
- Uniqueness: 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 .
- Veins are both durable and usable : As they are looking below the skin; and issues like finger cuts, injuries, moisture or dirt will not affect them.
- The authentication device can be compact due to the small size of fingers.
- Fast authentication speed and minimal error rates
- Low Cost: Cost is essentially due to the biometric capture device or sensors which is very low in the case of finger vein identification.

Fingerprint is known as the widely applicable biometric technique due to the small size of its readers .But as it is a trait found on the exterior of the body, it is easily stolen and also has issues like worn away or sweaty fingerprints cannot be registered [2]. Iris recognition has low error rates of authentication, but some users feel psychological resistance to the direct application of light into their eyes. Precise positioning of the eyes is required for accurate iris authentication and hence it becomes necessary either to adopt high-cost position adjustment mechanisms.

Finger knuckle print and palm print based biometric systems are easy to replicate since these features are external to human bodies. And for the 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 and accuracy rates for these are limited.

B. Application Fields

- Bank and ATM : Solved the problem of illegal withdrawal using stolen cash cards. Revolutionizing Banking : Vein pattern recognition technology eliminates the need for bank cards or PIN numbers, thus eliminating problems relating to loss, theft or falsification of cards or passwords. Banks can also use finger vein authentication systems to effectively manage transactions at bank counter.
- Door entrance system for home and offices.
- In Smart Card System and mobile phones.
- PC login - PC authentication system: PC users can now guard against illegitimate access or leakage of information on their computers by using the vein patterns in their fingers as their computer login.
- Automobiles

\- Keyless Engine Starter

\- door handle with the system thereby only the enrolled people are entitled to use the car.

C. Principle Of Vein Recognition

The principle of finger vein identification can be generally described as follows: Researchers found out that the infrared light with 740-960 nm wavelengths can pass through human skin and are absorbed by haemoglobin in the vein. Only portions in which the veins exist produce small reflections of the near infrared. The resulting vein image appears darker than the other regions of the finger because only the blood vessels absorb the rays. These vein patterns can be observed by using an infrared sensitive CCD camera. Features can then be extracted using algorithms and stored. The distribution and structure of vein branches and curves in the vein images is random and unique for every person and thus a matching algorithm can be used to identify individuals.

Depending on the application context, a biometric system may operate either in verification mode or identification mode [6].

- In the verification mode, the system validatesa person's identity by comparing the captured biometric data with his own biometric template(s) stored in the system database. Here the system conducts a one-to-one comparison to determine whether the claim is true or not. Identity verification is typically used for positive recognition, where the aim is to prevent multiple people from using the same identity.
- In the identification mode, the system recognizesan individual by searching the templates of all the users in the database for a match. Therefore, the system conducts a one-to-many comparison to establish an individual's identity. The purpose of negative recognition is to prevent a single person from using multiple identities.

THE MAIN STEPS INVOLVED IN THE PROCESS

The Existing works are described and compared separately in four parts; finger vein image acquisition, preprocessing, feature extraction, feature matching. (Fig.1).

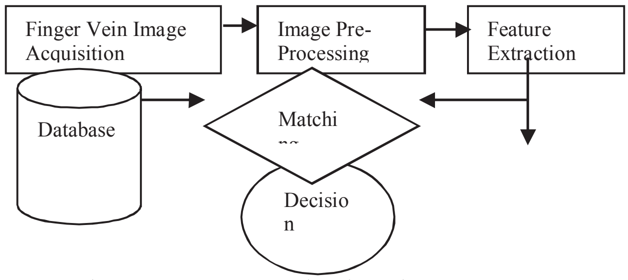

Fig.1.The main steps involved in the process.

Finger Vein Image Acquisition

Different from finger print, vein pattern cannot be capturedby ordinary CCD camera as it is not easily seen in visible light. Instead, finger vein is captured by two ways in most existing vein recognition methods [9], a near infrared CCD sensitive camera, or an array of near infrared Light- EmittingDiode (LED). The used near infrared wavelength can be about 760 - 850 nm. A special imaging device is used to obtain the infrared image of the finger (Fig.2). An infrared light irradiates the backside of the hand and the light passes through the finger. A camera locatedin the palm side of the hand captures this light. The intensity of light from the LED is adjusted according to the brightness of the image [20] [18].

As haemoglobin in the blood absorbs the infrared light, the pattern of veins in the palm side of the finger are captured as shadows. Moreover, the transmittance of infrared light varies with the thickness of the finger. Since this varies from place to place, the infrared image contains irregular shading. The length of the finger is in the horizontal direction, and the fingertip is on the right side of the image [12].

Pre-Processing

Preprocessing should be done before feature extraction. Each of the previous related work uses various methods of preprocessing. A generalized view of all these approaches may include 1) Region of Interest (ROI) Segmentation 2) Normalization 3) Enhancement of Finger vein image.

1) Region Of Interest Extraction

In the collected finger vein image the background area will also appears. This background region should be estimated and it should be removed. These involves the process of region of interest (ROI)extraction .First choosing a reasonable threshold value, the image points is finger area whose gray value is greater than the threshold, while the image points is background area whose gray value is less than the threshold [20].

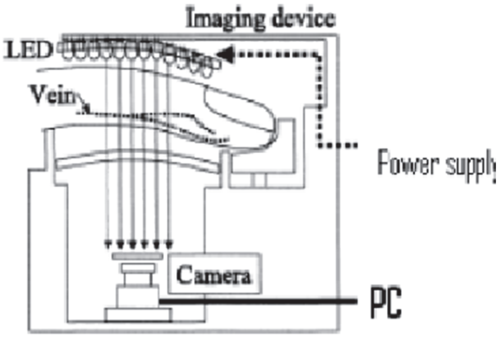

Fig.2.Finger Vein Image Scanner

2) **Normalization**

Next Finger vein undergone preprocessing operations like normalization [18] [17], two-dimensional normalization [12] using the outline of the finger.

a) **Size normalization**: The size of the ROI is different from image to image due to personal factors such as different finger size and changing location. Therefore it is necessary to normalize the ROI region to the same size before feature extraction and the size of the normalized ROI is set .All of the images must be converted to the standard image of the same mean and variance

b) **Gray normalization**: In order to extract efficient features, graynormalization is used to obtain a uniform gray distribution.

$$p(i,j) = \frac{p'(i,j) - G_1}{G_2 - G_1}$$

where $p'(i,j)$ is the gray scale value of original image; $p(i,j)$ is the gray scale value afte converted; $G1$ $is$the minimum gray scale of original image;$G2$ is the maximum gray scale of original image.

3) **Enhancement**

In [7], to robustly exploitreal vein information, this paper proposes a novel method offinger-vein enhancement based on multi-channel Gabor filters.Firstly, multi-channel Gabor filters are used to prominentlyprotrude vein vessel information with variances inwidths and different orientations in images. The vein information in different scales and orientations of Gabor filters is then combined together to generate an enhanced finger-vein image. By experiments they have showed that the proposed method is capable of enhancing finger vein images effectively and reliably.

In [16] the authors proposed a new method to enhance the contrast of the finger vein image. It consists of five parts: wavelet de-noising, normalization, adjacent node threshold image method, eliminate black block and burr, thinning. Their experiments shows that this method can properly enhance the contrast of the finger-vein image and make the skeleton express geometric structure of the hand vein image better.

Feature Extraction. : Many works have already been done for finger-vein based personal identification and extracting features related to the finger-vein network, is the most important part of these works.

Conventional methods such as the matched filter and morphological methods [3] [1] can extract patterns if the widths of veins are constant. They can extract pattern at a faster rate but this can also cause irregular shading, which presents an obstacle to personal identification since this obscures parts of the pattern of veins. Dots of noise are also emphasized because continuity is not considered. Above all, in the case of matched filters due to the large size of the convolution kernel, it may take a long time to run this algorithm on an ordinary computer.

Then comes extracting features based on repeated line tracking [12]. This method extracts the finger-vein pattern from the unclear image by using line tracking that starts from 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 trackingoperation starts at another position. All the dark lines in theimage can be tracked by repeatedly executing such local line trackingoperations. Finally, the loci of the lines overlap andthe pattern of finger veins can be obtained. This method is far superiorto the conventional method based on a matched filter. Furtherexperiments showed that the equal error rate was 0.145% and response time was 460 ms, which means the method is very effective as a means for personal identification. The problem with the method was that noise may also get tracked while executing the repeated line tracking. Extraction of Finger-Vein Patterns Using Maximum Curvature Points in Image Profiles [13].This method can extract the centrelines of the veins consistently without being affected by the fluctuations in vein width and brightness, so its pattern matching is highly accurate. The main steps involved in the process are 1.Extraction of centre portions of vein: This may include Calculation of curvature of profiles, detection of vein centres and assignment of scores to the centre position.2.Connection of vein centres Labelling the image. Experimental results show that this method extracted patterns robustly when vein width and brightness fluctuated, and that the equal error rate for personal identification was 0.0009%. They have proved that the results using this methods are much better than their previously proposed repeated line tracking method.

The work [19], proposes a novel method applicable to finger vein recognition. Firstly they have extracted the features of the vein patterns for recognition. Secondly, the minutiae features are extracted from the vein patterns for recognition, which include bifurcation points and ending points. These feature points are used as a geometric representation of the shape of vein patterns. Finally, the modified Hausdorff distance algorithm is proposed to evaluate the discriminating between all possible relative positions of the shape of vein patterns. Experimental results show the equal error rate (EER) reaches 0.761% where the threshold value for the distance measure HD is observed to be 0.43. This result indicates the minutiae features in the vein patterns can be used as a feature sets in the personal verification applications efficiently. Feature extraction based on morphological algorithm [11], includes dilation, erosion, opening and closing. Besides that the white top hat operation and black top hat operation are also done. White top-hat image contains local peaks of the intensity (bright feature) and black top-hat image contains local valleys of the intensity (black feature).In order toimprove the robustness and stability of detecting the finger-vein, an enhanced method for extractingfinger-vein feature based on morphology is proposed which combines with morphological peakand valley detection. The images will be scanned across the boundaries and the valley detection will be done from four directions. Such feature extraction method based on morphology improves theconventional point-wise comparison procedure and speeds up the operation. In the experiment, thefinger-vein extracted by the proposed method has more precise details and better continuity comparatively. And with the noise added, the result of the proposed method makes the average error decreased. In [15] anovel and effective algorithm for extracting finger vein from low quality NIR images are presented. The algorithm combined local threshold method and repeated line tracking method and expressed the pattern in probability way. Experimental results revealed that the proposed method could achieve better results than existed ones. This strategy couldalso be a reference for low quality and poor contrast image processing.In the work [14], authors presented a convolution approach to extract the minutiae patterns of vein which may include end points and bifurcations. The algorithm for feature point detection, ie for detecting end points and bifurcation points are described well under this paper. They have proved that Minutiae based feature extraction is the best among all of the existing methods, and one of thedrawback of the feature point detection using convolutionis that the patterns need to be known in advance. In the context of biometrics the skeleton needs to be stable, small islands and false minutiae can disturb the comparison of two biometric samples. Hence further researches have to focus more on the reliable extraction of the skeletal features.

Matching ; Object detection and recognition is an important task for aerial image analysis. To recognize objects reliably, a key problem is to find an efficient approach to image matching for object search and identification, wherethe method should be easy to implement, less time consuming and produce reasonable results. The matchingtechniques can be viewed as the measurements to determine the degree of resemblance between two objectsthat are superimposed on one another. In other words, matching is usually regarded as a maximization of ameasure of similarity.

Correlation Method [5]:

It is quite simple in principle. Let $f(m,n)$ and $g(m,n)$ be two images and $F(u,v)$ and $G(u,v)$ be the 2D Discrete Fourier Transform (DFT) of two images.

$$F(u,v) = \sum_{m=-M}^{M} \sum_{n=-N}^{N} f(m,n) e^{\frac{-2jum\pi}{M}} e^{\frac{-2jun\pi}{N}}$$

$G(u,v)$ is also defined in the same way. The cross phase spectrum of the two images is given by

$$R_{FG}(u,v) = F(u,v)\overline{G(u,v)}$$

$\overline{G(u,v)}$ is the complex conjugate of $G(u,v)$ .The correlation
is the 2D inverse DFT of $R_{FG}(u,v)$

$$r_{fg}(m,n) = \frac{1}{MN} \sum_{u=-M}^{M} \sum_{v=-N}^{N} R_{FG}(u,v) e^{\frac{j2\pi mu}{M}} e^{j\frac{2\pi nu}{N}}$$

1) *Phase Only Correlation Method [10]:*

The only difference of POC with that of Correlation method is in the calculation of cross phase spectrum. It is given by the equation,

$$R_{FG}(u,v) = \frac{F(u,v)\overline{G(u,v)}}{|F(u,v)\overline{G(u,v)}|}$$

The other steps are similar to that of correlation method.

2) *Hausdorff Distance Method :*

The study performed by Huttenlocher [4], shows that the Hausdorff method is more tolerant of perturbations in the locations of pixel points and applicable to aerial images. However, the directed comparison method using the Hausdorff distance is time-consuming because it considers every possible translation of the model within the given test image. The computation of Hausdorff distance does not require point correspondences between the two point sets. They proposed efficient computational algorithms for speeding up the process of finding similar patterns in an image by searching the regions with the smallest Hausdorff distances in the image. For the two point sets $X = \{x_1, x_2, x_3 \ldots.\}\, and\ \ y = \{y_1, y_2, y_3 \ldots..\}$the following equations give the definition for hausdorff distance. The smaller the value of HD, the more similar the two point sets are.

$$HD(X,Y) = max\big(d(X,Y), d(Y,X)\big)$$

$$d(X,Y) = max_{x_i \varepsilon X} min_{y_j \varepsilon Y} ||X_i - Yj||$$

Conclusion

This study presents a wide knowledge relating to the finger vein identification, its features, comparison with other major biometrics, steps involved in the identification process, application fields etc. Most of the related works in the four major steps of the finger vein recognition system has been covered separately under this paper. The merits and limitations of most of the works are also described here. After analysing the different methods of finger vein identification, we can finalize that the best method ever proposed for feature extraction is the finger vein identification based on minutiae feature extraction. As the patterns are minutiae points, matching process is easy and hence computation is not time consuming. The major technical issue with this method is the reliable extraction of the minutiae patterns in order to provide fast and error free identification. And to conclude we can say that the finger vein technology is an outstanding biometric technology in terms of security and convenience.

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*College Of Engineering
Karunagappally, Kollam.
#Indian Institute Of Information Technology
And Management, Kerala.