Personal Authentication Using Knuckle Patterns of Palm-Dorsa Vein: A Survey

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Abstract –*The literature described the vein knuckle identification methods till present date. Finger vein authentication and identification can be leading biometric technology now-a-days since it provides security and convenience as it introduces features inside the human body. These are the reasons vein biometric have attracted numerous attentions from researchers from all over the world. This paper highlights the approaches proposed by many researchers over the world on pre-processing, feature extraction and classification stage specifically for recognizing individual's identity. The strengths and weaknesses of these approaches are critically discussed.*

Key Words: Authentication, Biometrics, Feature extraction, Personal identification, Security, Vein knuckle

1. INTRODUCTION

In this advancing era, every individual is trying to secure its own authentication and identity as everyone uses multiple online schemes regarding e-commerce and all online transactions. All such places and things are nowadays protected with many good options like passwords, pin number, unique patterns or any biometrics system. There are two types of conventional biometrics. The biometric identification systems that are based on behavioral patterns such as handwriting and keystroke dynamics and the system that are based on physiological patterns such as face and fingerprint. These system somehow have some disadvantages as the external body features which have been used as a biometric trait can be copies or prone to damage or spoofing attack. Iris recognition is contemplated as least user-friendly biometric. The brightness of the emitting lights during capturing process tends to cause discomfort to human eyes3. In addition, the accuracy of face identification is very sensitive towards illumination invariance, facial expressions, and poses. From the last few decades, biometrics based on vascular patterns seeks much more attention from the researcher from all over the world. Hand-vein and finger-vein are most popular vascular patterns.

Finger-vein features exhibit several other excellent advantages, these include:

- Finger vein pattern offers good dissimilarity between each individual as it is a unique characterization of human body.
- Finger-vein pattern does not change with time. They are permanent.
- Finger-vein patterns are not invisible to human's eyes. Due to this reason they are not obscured nor that easily replicated or damaged because it is located underneath the human skin.
- Finger-vein patterns acquisition is contemplated to be very user-friendly. The vein pattern images are captured non-invasively
- Every individual commonly has ten available fingers. Therefore, all fingers can be used for authentication
- Finger-veins can only be captured from a living body; hence, if a person is dead, it is impossible to steal his identity

2. OVERVIEW OF METHODS AND ALGORITHMS

The conventional method to achieve vein-knuckle patterns is to explore finger to the NIR sensor camera or any other NIR image capturing device. To process captured NIR image the vein patterns need to undergo various basic image processing techniques such as preprocessing, normalization, feature extraction and matching.

2.1 Pre-processing and Region-of-Interest Method

For accurate recognition of vein patterns from captured NIR images, it is requires to process the captured image by extracting appropriate ROI as well as an effective pre-processing technique that can highlight the vein patterns superiorly.

Raghavendra et.al [5] proposed the method of ROI extraction with boundary scanning of the obtained vein pattern. The main objective of the ROI extraction is to obtain the most prominent and superior region from the finger that presents the vein pattern. The preprocessing step involves identifying the boundary of the finger region and then computes the axis of the finger by considering the midpoint between upper and lower boundary of the finger. This axis is further needed to estimate the translation and rotation error. They adopted the method [5] that scans the boundary of the finger and then performs the rotation and translation to align the finger. In the next step, the finger tip is identified that in turn is used to crop the ROI to capture the prominent vascular pattern from the finger. D.Mulyono et al. [6] proposed different pre-processing tasks like noise removal and normalization. Noise removal is an important task as noises in images will cover the original information

in it. It is used to produce enhanced image and assuring that it won't introduce any false information .Method used for nose removal is Gaussian blur.

$$G(u,v) = \frac{1}{2\pi\sigma^2} e^{-(u^2+v^2)/2\sigma^2}.$$

Where r is the blur radius ($r^2 = u^2 + v^2$), and σ is the standard deviation of the Gaussian distribution. The values obtained from this distribution are further used to build a convolution matrix which is applied to original image.

Captured finger vein pattern image may be of poor contrast. Basically normalization is contrast stretching of histogram stretching. Normalization is a process of changing range of pixel intensity value of an image.

2.2 Segmentation Methods

Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. The result of image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image.

D.Mulyono and H.Jinn et al.[5] proposed an Adaptive Threshold method. The method proposed to obtain the new threshold image in the same size of the original one.

Adaptive threshold is same as smoothing algorithm (Thresholding is simply the conversion of binary image from grayscale image and smoothing algorithm is used to reduce noise or process image for further processing like segmentation)

First, it defines N X N window size and copy boundary pixel of original image. Then performed convolution on the original image f(x,y) depending on window size and calculate mean gray value and copy this calculated value to the threshold image T(x,y)

$$T(x,y) = \frac{\sum_{i=0}^{N-1}\sum_{j=0}^{N-1} g(x+i, y+j)}{N^2}$$

Where T(x, y)is the threshold value of threshold image in the position (x,y)with respect to the original image f(x,y).N is window size.

$$f(x,y)=0 \qquad f(x,y) \geq T(x,y)$$

$$f(x,y)=255 \qquad f(x,y) < T(x,y)$$

2.3 Feature Extraction Algorithm

When NIR image of finger is obtained by NIR sensor camera or any capturing device, the vein patterns contain various features like shape features, minutiae and features obtained from hand boundary shape. So it is important to extract only those feature which are useful for further processing and for individual's identification. To build highly accurate personal identification system finger vein patterns should be extracted precisely from captured images. Generally feature extraction methods can be broadly classified into two categories as local feature extraction and global feature extraction.

N.Miura et al.[7] proposed method to extract the finger vein patterns from unclear image by using line tracking that starts from various points. First local lines are identified and then tracking executed from pixel to pixel. When a dark line is not detected a new tracking starts from new point. All dark lines in an image are detected by such repeated tracking operations. Finally the loci of the line overlap and the patterns obtained statistically. Along with the dark lines noise in the image is also detected, this makes the extraction more robust.

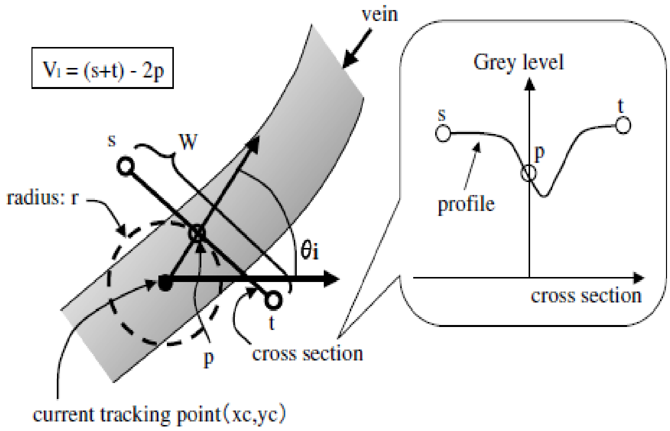

Fig-1: Dark line detection

Where (xc, yc) is a current line tracking point and s-p-t is a cross-sectional profile.

N.Miura, A.Nagasakaand et al.[7]proposed an algorithm based on maximum curvature point which extract centerlines consistently without affecting by the fluctuations in vein width and brightness. In MCP the centerline of vein is calculated by maximum curvature k(z) which is given by formula,

$$K(z) = \frac{d^2 P_f(Z)/d_{z^2}}{1 + \{dP_f(Z/dz)2)^{3/2}}$$

R.Raghavendra et al.[3] proposed a method of spectral minutiae representation. This method first extract the maximum curvature points using convolution filter and then finally the location of the estimated minutiae points are used to calculate the SMR of the finger vein. B.Huang et al. [5] proposed a method in which a feature image is generated by setting the pixel values of the background to 0 and vein as 255. The $I_{WLD}(x0, y0)$is calculated as,

$$I_{WLD}(x0, y0) = 0 \quad m(x0, y0)>g$$

$$255 \quad otherwise$$

Where $I_{WLD}(x, y)$ is a feature image.

W.Yang et al.[7] developed ordinal code representation for better feature extraction. This ordinal code method is well suited especially for palm prints as well as iris biometric. This method gives the enhanced image I and the ordinal code is obtained as,

$$I_{or} = I \ * Ord(0)$$

In this work, they obtained 8 bit ordinal codes based on the sign of filtering results which have selected based on the experimental database.

X.WU et al.[10] developed the Derivative of Gaussian filter(DoG) code which is widely used as feature extraction of both dorsal and palm print recognition .This method provides the convolution with Gaussian derivative in both x and y direction.

$$I'_x = I * G'_{\sigma x}$$

$$I'_y = I * G'_{\sigma y}$$

Where * denotes the convolution operator,$G_{\sigma x}$denotes derivative of $G_\sigma$in x direction and $G_{\sigma y}$denotes derivative of G_σ in y direction.

At last the derivative of Gaussian is encoded based on the sign of each pixel. C.Watson at al.[7]has provide the method to extract the minutiae locations using the NIST open source MINDTCT function.

2.4 Matching

In the matching process, the extracted and enhanced vein patterns are converted into matching data and these data is compared with recorded data. Two common methods adopted for matching process which are structural matching and template matching.

Zhang.W et al.[9]proposed a method described the structural matching which requires some additional features of vein patterns such as line endings and bifurcations. M.Nagao and Jain AK et al. [1] proposed template matching method which is typically based on pixel comparison so it is more appropriate for finger-vein matching.

3. DISCUSSIONS

Various algorithms have been proposed for pre-processing and feature extraction of finger vein patterns. The vein patterns either of dorsal or ventral fingers obtained either with web camera or with the NIR(Near Infrared) sensor camera. The image grabbed by common web camera has some salt and pepper noise and gray level distribution among different trail is uneven. So we need to do effective threshold segmentation to get good and effective binary image from grayscale image so as it provide all needed and important vein pattern information.

R. Raghvendra et al. [2] have proposed a low cost multi-modal biometric sensor to capture finger vein pattern. The system contains a low cost sensor employs a single camera followed by near infrared along with good physical structure.

The basic and traditional methods used for segmentation of vein image like single or multi threshold(fixed threshold, total mean, OTSU local OTSU)is not suitable when the captured vein patterns are blur. Thus adaptive thresholding [8] is well-suited to obtain a new threshold image.

The Spectral Minutiae Representation (SMR) method is better than the state-of-the-art scheme [4] as it replaces multi-scale filter method with the maximum curvature method [7], to accurately extract the vein patterns.

Use of MCP method is far better than state-of-the-art method because the multi-scale filter used in it is not only computationally expensive but also more sensitive to the acquisition noise that may cause false vein patterns.

The repeated line tracking method of feature extractions provides the line patterns and cross-sectional profiles which emphasize noise. Whereas the conventional method emphasizes the depth of the intensity profiles leads to partial feature extraction.

3. CONCLUSIONS

Finger vein based biometric recognition has increasingly generated interests among the researchers all over the world. There are many techniques and algorithms have been developed for accurate methodology of the system and accurate result. Effective feature extraction techniques like MCP(Maximum Curvature Point),SMR(Spectral Minutiae Representation),Repeated line tracking are useful for effective feature extraction but still there will be some possibility of inappropriate pattern formation and partial feature extraction.

Another issue is the image formation of vein patterns. Need to develop an effective image capturing device which will be low in cost and high in performance.

To improve the benefits, accuracy and robustness of the finger-vein based biometrics need more detailed study and research in the respective field.

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