Australian Journal of Basic and Applied Sciences, 7(8): 751-756, 2013
ISSN 1991-8178

Finger Vein Minutiae Points Extraction based on Maximum Curvature Points in Image Profile and Finger Print Application Methods

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Abstract: Biometric finger vein has been widely used for authentication as one of its advantages is resistance to criminal tempering whereby it is located underneath skin. Currently there are many methods proposed to extract the pattern of finger vein. In this paper, we extend one of the current methods by combining it with conventional method used in fingerprint for minutiae extraction to extract the minutiae points of finger vein. The minutiae points will be used for the authentication system that needs only points to be stored in its database. Experimentation has been conducted to monitor each of steps until the minutiae points were extracted. On the other hands, the trial also using different values of distance to evaluate which distance could produce acceptable results to be selected as good minutiae points.

Key words: Biometric, Finger vein, minutiae, extraction.

INTRODUCTION

Biometrics has becoming a powerful authentication method in recognizing a person by using physiological or behavioural characteristics. The characteristics vary from face, fingerprints, hand geometry, handwriting, iris, retinal, vein, and voice. Finger vein is one of newly recovered biometric. An article by Hitachi (2006) highlights the patterns only could be viewed through an image sensor that is sensitive to near-infrared light which has wavelengths range from 700 to 1000 nanometers. The dark shadow lines viewed in the captured image appear as the light passes through the tissue blocked by the pigments such as haemoglobin or melanin. Woodward *et al*. (2003) on that time described finger vein as an esoteric biometric. It refers to the under development or early stage of experimental for that kind of biometric. Two years after, Hitachi Ltd. has come out with finger vein authentication machine specifically used for Automated Teller Machine (ATM).

According to other article by Hitachi Ltd (2011), the history has been divided into some phases; First phase in 1997 until 2000 in which Hitachi has started developing the light transmission technology for the authentication of finger vein biometric whereby the transmission captured the pattern through the light that passes through the skin's surface. Second phase which was in 2000 until 2003, specifically in 2002, they developed physical access control system in product form. In 2004, ATM application using finger vein biometric was developed. Commercialization of the ATM started within financial sector in 2005.

The white paper by Hitachi (2006) also described about the features of finger vein biometric whereby it has many advantages from other biometric modals. It is resistance to criminal tempering where the locations of veins are underneath the skin. Forgery or theft risk would totally be avoided. The accuracy for authentication process is less than 0.01% False Rejection Rate (FRR), 0.0001% for False Acceptance Rate (FAR) as well as 0% Failure To Enroll (FTE). The patterns are developed before birth, differ even between identical twins and persist throughout life. The gadget used for finger vein is contactless to ensure the cleanliness and convenience for user. Feature extraction could be made easily by using low-resolution cameras for small-size vein images in which the patterns are stable and vividly captured. It provides quick processing time in which the authentication is only one-to-one and takes less than one second.

We proposed a small modification to the existing method of finger vein pattern extraction and fingerprint minutiae extraction through a combination of Maximum Curvature Points in Image Profile (Miura *et al*., 2005) and method used to extract the fingerprint minutiae points by Kussener (2007) since the maximum curvature points in image profile only extract up to get the pattern of finger vein image. It is very important to get the minutiae points of finger vein for the cryptographic system as in Aziz *et al*. (2011) that requires points to be stored as keys in the database rather than only storing the pattern.

Related Works:

Some methods were proposed in getting the pattern of finger vein image. The latest and comprehensive method is by maximum curvature points in image profile method (Miura *et al*., 2005). The method is resistance to the non uniform brightness of vein as well as the width. Other method used in getting finger vein pattern are

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matched filter (Hoover *et al*.,2000), morphological method (Walter *et al*., 2000) and repeated line tracking (Miura *et al*., 2004). Table 1 shows the drawbacks of the methods other than maximum curvature points method.

Table 1: Other Methods of Finger Veins Pattern Extraction.

Method	Drawback
Matched Filter	It extracts the vein pattern with constant width of veins. It can be done by using an assumed width. If the pattern is narrower or bigger than the width, the pattern could not be extracted
Morphological Method	It gives the drawback same with the matched filter method
Repeated line tracking method	Even though it can extract the pattern from an unclear image, the thin veins still not adequately extracted since it gives small statistics for the points that move on the thin veins

Kussener (2007) has introduced a method for fingerprint minutiae extraction. In this case, the segmentation and binarization parts will be replaced by the maximum curvature method since the parts is not suitable to be applied for finger vein image.

Proposed Work:

For this work realization, two combinations of method have been used to get up to minutiae points extraction. The Maximum Curvature method is converted into code by Ton (2012) has been referred for the design of segmentation up to binarization part. Meanwhile FingerPrint Application code by Kussener (2007) has been added to do thinning process up to get the minutiae points of finger veins. Finger veins image templates were collected from PKU Finger Vein Database (V4) (2007) which is a free online database of finger vein features that available for research purposes. The image size used is 512 x 384 pixels with 8-bit depth. All works has been done in MATLAB 7.12.0.

Segmentation and Binarization:

For this section, the method used is maximum curvature points in image profile. This method will try to extract the centre lines of the veins. This is done by calculating local maximum curvatures in cross-sectional profiles of a vein image. The method is supposed to be robust against varying vein widths and non-uniform brightness.

As mentioned by Muira et. al (2005), this method involves three steps for extracting finger-vein patterns from finger images. First step is the extraction of the center positions of veins. The dent formed from cross-sectional profile of vein resulting in high curvature of curvature graph since the vein is darker than the background. The center position of veins can be obtained by calculating local minimum curvatures in cross sectional profiles regardless of vein's size. Second step is the connection of the center positions.It could be done by filtering operation. Two neighbouring pixels on the right and left-side of pixel *(x,y)* are checked. A line will be drawn horizontally if the neighbouring pixels and pixel *(x,y)* have large values. A line is drawn with a gap if the pixel *(x,y)* has a small value meanwhile neighbouring pixels have large values. The value of *(x,y)* should be reduced in eliminating the noise in condition of the pixel *(x,y)* has large value while the neighbouring have small values. Third step is labeling of the image. This step is more about to binarize the vein pattern. The pixel will be a part of background if it has value smaller than the threshold and if otherwise, it will be a part of a vein region.

Minutiae Extraction:

As mentioned, to extract the minutiae after getting the skellaton image of finger vein, the same method such in extracting fingerprint will be used. According to Kussener (2007), minutiae will be computed through three types:

1. If the central is 1 and has only 1 one-value neighbour, then the central pixel is a termination such in Figure 1
2. If the central is 1 and has 3 one-value neighbours, then the central pixel is a bifurcation as in Figure 2.
3. Figure 3 shows if the central is 1 and has 2 one-value neighbours, then the central pixel is a usual pixel.

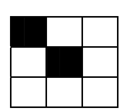


Fig. 1: Termination.

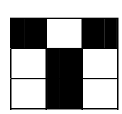


Fig. 2: Bifurcation.

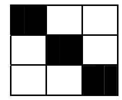


Fig. 3: Usual Pixel.

But for this work, only bifurcation will be marked as minutiae points since vein has no ridge ending or termination. In order to eliminate false minutiae, some processes must be done to them. Before that, an acceptable distance between two points of D must be initialized. In first stage, if the distance of termination and bifurcation is smaller than D, the minutiae must be removed. Second stage, if the distance between two bifurcations is smaller than D, the minutiae must also be removed. Then the final points left will be taken as the minutiae points of the finger vein.

Results:

Following are the images obtained for each step carried out through simulation. Figure 4 shows one of the original images of finger vein taken from PKU database (2007). Figure 5 is the finger region results from input of the vascular image, height and width of the mask. Finger vein pattern then has been extracted such in Figure 6 by using the maximum curvature points method. Figure 7 results from converted original image to a binary image. The method for binarization is based on the median value. The binarized image then has been thinned according to the skeleton of binary image as in Figure 8. Thinned image is one pixel wide line to present the structure of an object (Khanyile *et al*., 2011). Figure 9 illustrates all bifurcation points found in the thinned image. The image may contain fake points. To eliminate that, it must undergo the processes stated in the previous section. For this experiment, it has been tested with D=2,3,4 and 5 as in Figure 10. For D=2, as in Figure 10(a), It can be seen that the image still contain some spurious points. Then it has been tested for D=3 and D=4 as in Figure 10(b) and 10(c), they seem to be accepted. The difference is the points in D=4 is fewer than in D=3. In Figure 10(d), D=5 was used. It shows that it only gives only a few points and it is not so reliable to be used in authentication system. The best choice is by using D=3. Figure 11 shows the stored points in database in *x* and *y* coordinate as for D=2,3,4 and 5. In this case, it yields 41, 14, 8 and 7 points for D=D=2,3,4 and 5 respectively.

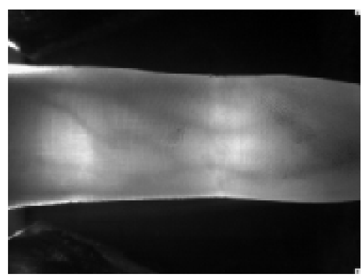


Fig. 4: Original image from PKU database (2007).

Fig. 5: Finger region.

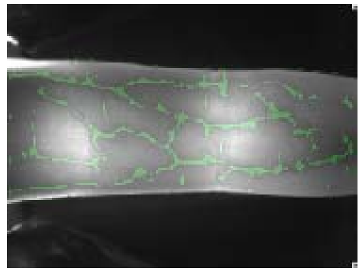


Fig. 6: Finger vein pattern by Maximum Curvature Method.

Fig. 7: Binarize image.

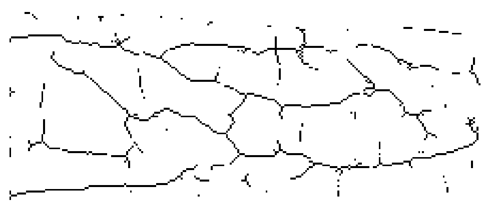


Fig. 8: Thinning.

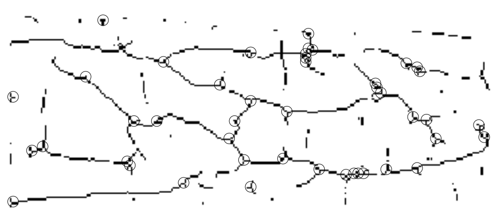
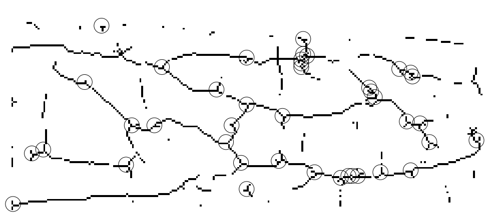
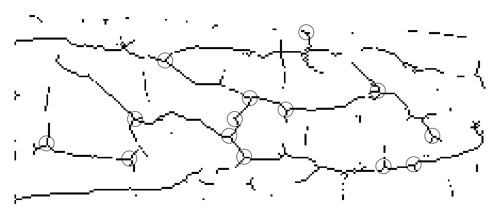


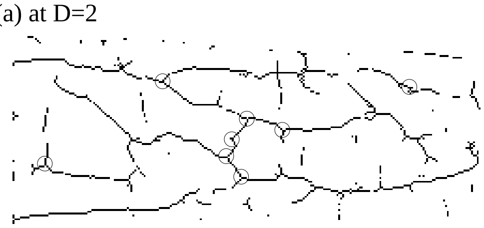
Fig. 9: Thinned image with all minutiae.



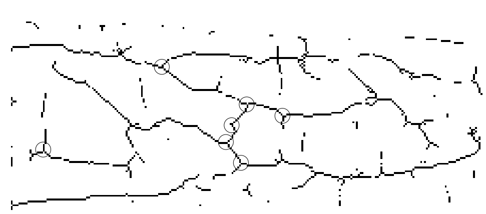
(a) at D=2



(b) at D=3

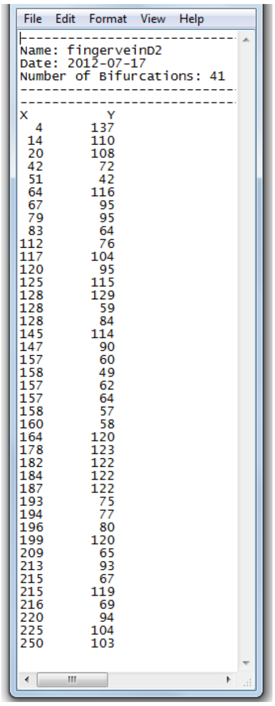


(c) at D=4

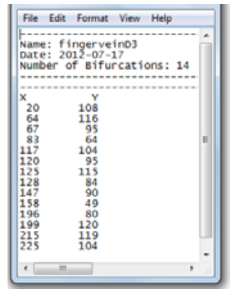


(d) D=5

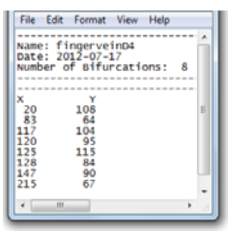
Fig. 10: Extracted minutiae after removing false minutiae.



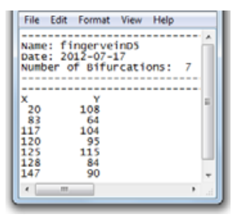
(a) at D=2



(b) at D=3



(c) at D=4



(d) D=5

Fig. 11: Stored minutiae points.

Conclusion:

We proposed a method to extract the minutiae points of finger vein by combining two methods of maximum curvature points in image profile and the usual method used in extracting the minutiae points of fingerprint. These points will be used in an authentication system that needs points rather than storing and comparing the pattern of finger vein. This work will further be applied to the Biometric Fuzzy Vault proposed by Aziz *et al*. (2011) in securing the cryptographic key based on finger vein biometric.

ACKNOWLEDGMENT

This work was supported by USIM grant PPP/FST-1-17111, Vote No. 27000

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