Region of Interest Extraction for Biometric Cryptosystem

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***Abstract*—Biometric technology is becoming more and more significant these days. Most of the application in store today are using biometric as a means of person authentication as it offer a convenient and easy way of authentication. Palm vein biometry is mostly used in many authentication system as it offer better security as veins are located on the subcutaneous layer of the skin and is impossible to be forged. However, there are still some issues in order to obtain high accuracy in palm vein authentication system such as some feature are not correctly extracted because of poor preprocessing process. Poor preprocessing process will produce weak keys for authentication purpose. Therefore, this paper proposed a hybrid of Gabor filter and maximum inscribe circle to obtain better region of interest for feature extraction as well as improving the accuracy of the authentication system.**

Keywords—biometric cryptosystem, palm vein, maximum inscribe circle, Gabor filter.

I. INTRODUCTION

Biometric has become one of the most fundamental research topic in this era. It offers limitless potential to be explored in various field. One of the most highly develop area using biometric is in authentication field. This is due to its ability to provide confidentiality and security to the users as biometric trait are unique and different in each individuals. Besides, it require the person being authenticated to be present at the time and point of authentication [1].

Biometrics is all about providing the foundation of trust. It is a study of human physical and behavioural characteristic [2, 3, 4] that distinguish one person to another. Example of some famous physical biometric traits are hand, face, iris, finger print, palm print and palm vein. On the other hand, gait, keystroke, signature and voice are the example of behavioural characteristic [1].

Despite all the advantages that biometrics has to offer, it still suffer from security breaches. A raw biometric template is able to be attack from an attacker through various techniques such as intrusion attack, forgery and spoofing attack. On a serious note, it is difficult to replace a user biometric information that has been leaked [5]. In order to protect the template, a biometric template protection scheme has been established to provide security in biometric system.

Biometric template protection scheme can be classified into feature transformation based schemes and biometric cryptosystem. The biometric template is transformed using a transformation function in feature transformation based schemes before storing it in the database [6]. Salting and noninvertible transform are classified under feature transformation based schemes [6]. A transformation function is seeded by a user specific key in salting while noninvertible transform apply a trait specific noninvertible function on the biometric template. The parameters of the transformation function are defined by a key which must be available at the time of authentication [2, 7, 8].

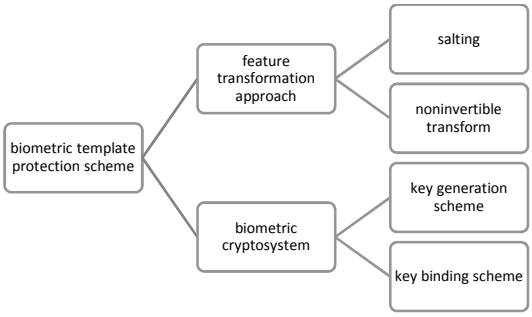

Figure 1. Biometric template protection scheme.

Another aspect of biometric template protection scheme is biometric cryptosystem where it is the art of combining encryption and biometric to provide security to biometric template. Biometric cryptosystems make used of the benefits of cryptography and biometric where they can produce biometric keys that has higher flexible security levels[9]. Data can be encoded with the aid of cryptographic techniques in order to ensure that it appears unintelligible to the public or third party and coherent only to the intended receivers [1, 6]. Biometric cryptosystem includes key binding scheme and key generation scheme [1, 2, 6, 10]. In key binding scheme, key are produce separately to be combined with biometric template. In contrast, key can be generated directly from biometric template in key generation scheme. The main advantages of a key generation scheme is that , it can provide a very strong cryptographic key and can be very useful in cryptographic applications as it is entirely comprised of biometric features [6].

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Although biometric cryptosystem offers a better security to the authentication system, it still suffers from few drawbacks. These drawbacks includes key management problem and biometric variations. These variation results from many factor such as acquisition method, light and illumination, position of biometric trait and many more. When the region of interest is not stable, biometric key produced from the region of interest is weak which will have a profound effect on the accuracy of the authentication system. Therefore, a good and robust region of interest of biometric trait is needed in order to improve the accuracy of the authentication system.

This paper proposed a region of interest (ROI) extraction method using palm vein as the biometric trait. Palm vein is chosen because it is very difficult to forge [11] as it lies under the surface of the skin. Furthermore, palm vein are unique since birth and it is time invariant [3,12,13,14]. The blood vessel structure stays constant throughout a lifetime of a person [12, 13] which certainly is a suitable trait for biometric authentication. It also does not require any contact with the scanners [15,16] and is assumed to be stable for longer duration. Furthermore, it is user friendly and universal [17]. Not to mention, palm vein is difficult to be destroyed, modified and simulated with fake palms[14, 18]. The transmitted infrared light is partially absorbed by haemoglobin in the veins which finally results in the image of a natural contrast of veins [13, 14,17]. The infrared radiation causes no vital effects in our bodies. Apart from that, there are no interferences from wrinkles, hand lines, hand roughness, dryness or other surface imperfections of the skin [14]. The above characteristic has certainly guarantee the security of a system using palm vein as the biometric trait.

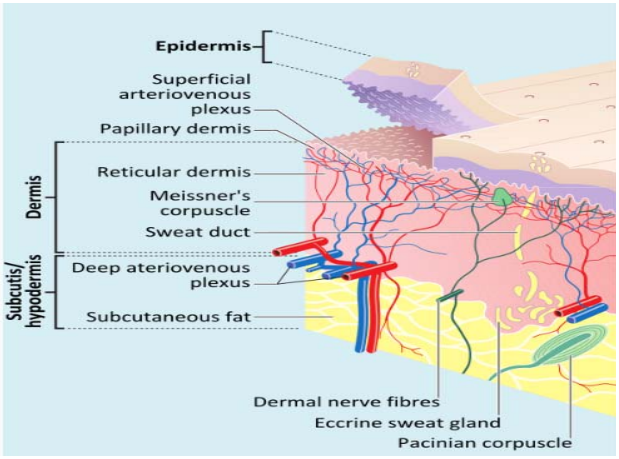

Figure 2. The anatomical view of the skin [26].

II. RELATED WORK

There are many methods for selecting the region of interest in a palm vein for authentication. ROI is a process of extracting the region from any biometric trait to be focussed on. In other word, only a region which is rich in information and useful is chosen as the ROI [19,20]. It is also a process of making some adjustment and key points location for the biometric trait which in this case is palm vein [19]. ROI extraction can be either fixed [21, 22] or dynamic. [12]. It is important to identify the Region of Interest (ROI) because a well defined ROI will enable a good feature extraction and hence improve the accuracy of the authentication system[23].

Many researchers has proposed a ROI extraction method based on palm vein for recognition purpose. Prasad et al., used dynamic ROI to extract feature from the hand vein which is able to extract more features and therefore achieved 0.05 error rate. The ROI is a rectangular region extracted after image preprocessing which include global thresholding, morphological operator and Euclidean distance. Raut et al., used Gabor filter and canny edge detector to extract vein feature from an image and trace the boundaries of the blood vessel.

Kubanek et al., used the entire palm area as the ROI where he examine the entire palm pixel by pixel over a specified threshold and able to achieve false acceptance rate of 0.14 and false rejection rate of 2.37. Lin et al., used centroid method and maximum inscribed circle to obtain the ROI of palm vein as there is more information of palm vein near the centroid of palm and able to achieved accuracy rate of 99 percent.

Sandhiya et al., used binary conversion with a threshold of 127 to detect strong vein points from the palm [10]. Fronitasari et al., used CHVD to determine the ROI and Local Binary Pattern (LBP) fused with Probabilistic Neural Network (PNN) to extract and match palm vein image for recognition and able to achieve accuracy of 96.6 percent.

Sun et al., used concavity analysis to extract the ROI from palm vein area where he used the distance extension factors to extend the normal ROI extraction and obtain an information-richer region. Arakala et al., used the entire captured image as the ROI and creates a palm vein graph representing the vein structure. Dandawate et al., used Euler's distance to determine the ROI and border tracing algorithm to extract the feature of the vein where he is able to achieved accuracy of 99 percent.

III. PROPOSED METHOD

Region of interest extraction is one of the vital part in an authentication system. This is because, a great properties of veins are determine during the process of ROI extraction which will be further process in feature extraction. A poor ROI selection will cause a poor feature extraction for authentication system. [19] has proposed maximum inscribe circle method for R OI extraction. However, it is found that some feature are not correctly extracted because of poor preprocessing process. Therefore, maximum inscribe circle method and Gabor filter is fused together in this paper in order to acquire a better ROI for the authentication process.

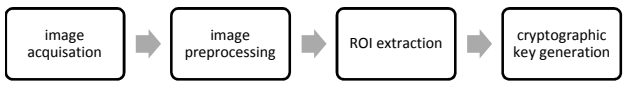

Figure 3. Flow of the proposed method.

A. *Image preprocessing*

The palm vein image is captured using Fujitsu palm vein scanner. In order to obtain a good quality ROI, image preprocessing is applied to the palm vein image. The preprocessing step include image enhancement using adaptive histogram equalization which is used to enhance the contrast of the palm vein image. Figure 4 and figure 5 shows the grayscale image and adaptive histogram equalization of palm vein image.

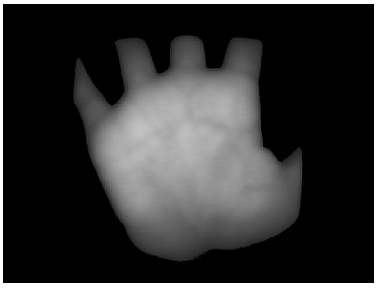

Figure 4. Grayscale image of palm vein.

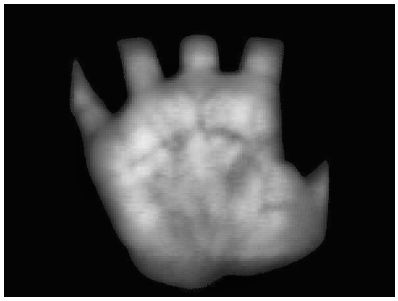

Figure 5. Adaptive histogram equalization of palm vein.

B. *ROI extraction using Gabor Filter and Maximum Inscribe Circle*

After preprocessing, the image is filtered using gabor filter. Gabor filter is widely used as a feature extraction method [13, 18, 24]. The Gabor filter is defined as:

$$g(x,y;\lambda,\theta,\psi,\sigma,\gamma)=\exp\left(-\frac{x'^2+\gamma^2y'^2}{2\sigma^2}\right)\cos\left(2\pi\frac{x'}{\lambda}+\psi\right) \quad (1)$$

Where

$$x'=x\cos\theta+y\sin\theta \quad (2)$$

$$y'=-x\sin\theta+y\cos\theta \quad (3)$$

'ψ' represent phase off-set, 'λ' stand for wavelength of a sinusoidal aspect, 'θ' represent orientation, and 'σ' stands for standard deviation, and 'γ' stands for spatial ratio [5]. Figure 6 shows the example of palm vein image after Gabor Filter. The ROI of this image is then extracted by using maximum inscribe circle.

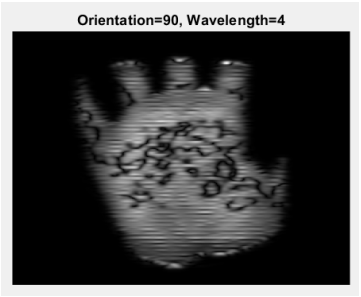

Figure 6. Gabor filter of palm vein.

Maximum inscribe circle [19,23] is a method of finding the largest circle possible in the palm area. The center and radius is determined in the palm area. Rich information of veins are mostly found in the center of the palm.

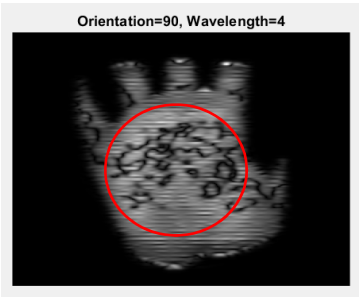

Figure 7. Maximum inscribe circle of palm vein.

C. *Cryptographic key generation*

The ROI is then used to generate a cryptographic key. The key is generated by using MD5 hash tool as shown in figure 8.

5B2DD0883CE51BF7ACF05DEF3E237B90

Figure 8. Cryptographic key from palm vein

IV. DISCUSSION

ROI extraction is considered as one of the most important process in a biometric cryptosystem. Accuracy of authentication system will be affected without a proper ROI extraction method. Palm vein is no doubt a good modality for a biometric cryptosystem. However, it is not completely perfect as there are still some issues regarding ROI extraction using palm vein such as important veins can be miss during vein extraction. This is due to several factors such as environmental conditions, vein widths vary as we grow, noise in image, veins are not bulging enough and different pose during acquisition which may affect the accuracy of the authentication system [14, 17]. Therefore, this paper present a hybrid of Gabor filter and maximum inscribe circle in order to obtain a good region of interest for feature extraction. This ROI will be use to generate a cryptographic key which will be used for authentication purpose and improve the accuracy of the authentication system.

Table 1 below show previously proposed ROI extraction method using palm vein and their performance.

TABLE I. PREVIOUS PALM VEIN ROI EXTRACTION METHOD

Method	Performance
Dynamic ROI	EER = 0.05
Gabor filter	Accuracy = 99.47%
Two-dimensional density function	EER = 0.19, 0.21
Phase symmetry	Percentage error = 2.6
Maximum inscribed circle centroid methods	Accuracy = 97%
binary conversion	Not stated
CHVD	Accuracy = 96.6%
Concavity Analysis	Not stated
The entire captured image	Not stated
Border tracing algorithm and Euler's distance	Accuracy = 99%.

V. CONCLUSION

This paper presents a hybrid of maximum inscribe circle and Gabor filter for ROI extraction of a palm vein biometric cryptosystem. A good ROI extraction method is crucial in an authentication system in order to obtain high accuracy.

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