FINGER VEIN RECOGNITION USING PATTERN MAP AS FEATURE EXTRACTION

By

TEOH SAW BENG

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LIST OF ABBREVIATIONS

BP:	Back-Propagation
CMOS:	Complementary –Metal Oxide Semiconductor
LBP:	Local Binary Pattern
LED:	Light Emitting Diode
LLBP:	Local Line Binary Pattern
NIR:	Near-Infrared
PCA:	Principal Component Analysis
PPBTF:	Pixel-Pattern-Based Texture Feature
ROI:	Region of Interest

PENGECAMAN VENA JARI MENGGUNAKAN PETA CORAK SEBAGAI PENGEKSTRAKAN CIRI

ABSTRAK

Kebelakangan ini, vena jari telah menjadi satu teknologi biometrik yang baru. Cabaran pengecaman vena jari adalah semasa proses segmentasi. Oleh kerana imej-imej vena jari yang berkontras rendah berkemungkinan mengandungi bayang, jadi amatlah penting untuk memproses dan mengekstrak dengan tepat serta mengekalkan ciri-ciri vena. Algoritma-algoritma yang menggunakan 'Gabor Filter', 'Local Binary Pattern (LBP)' dan 'Principal Component Analysis (PCA)' telah dicadangkan sebelum ini untuk pengekstrakan ciri-ciri vena jari. Dalam tesis ini, pengecaman vena jari yang menggunakan peta corak sebagai kaedah pengekstrakan ciri telah dicadangkan. Daripada mendapatkan ciri-ciri vena jari dari imej-imej tapisan pelbagai, ciri-ciri vena diekstrak daripada templat corak yang diperolehi dengan kaedah PCA. Setiap imej vena jari kemudian ditukar kepada imej peta corak daripada proses pemadanan corak antara imej vena jari dan templat corak. Akhirnya, pengelas jiran terdekat dengan jarak 'Euclidean' metrik digunakan untuk pengelasan. Sumbangan utama tesis ini adalah penjanaan templat corak dengan cara baru, iaitu memilih blok-blok dalam kawasan tertentu dari setiap kelas. Selain itu, peta corak digunakan untuk pengecaman vena jari buat kali pertama. Keputusan eksperimen menunjukkan algoritma peta corak yang dicadangkan mempunyai prestasi yang lebih baik dengan kadar pengecaman yang konsisten, iaitu 99% dan ke atas berbanding dengan 'PCA' dan 'Gabor with FVCode'. Ini menunjukkan bahawa peta corak adalah kaedah pengekstrakan ciri yang baik dan mampu mewakili corak vena jari dengan berkesan.

FINGER VEIN RECOGNITION USING PATTERN MAP AS FEATURE EXTRACTION

ABSTRACT

Today, finger vein has become a new biometric technology. The challenge of finger vein recognition comes to during the process of feature extraction. Since the low contrast finger vein images may contain shading and noise, it is important to precisely preprocess, extract and preserve the vein patterns. Algorithms such as Gabor Filter, Local Line Binary Pattern (LLBP) and Principal Component Analysis (PCA) have been proposed in recent study to extract finger vein features. In this thesis, a modified pattern map feature extraction method is proposed for finger vein recognition. Instead of obtaining finger vein features from multi-filtered images, the features images are generated from pattern templates which are the eigenveins obtained from PCA process. Every finger vein image is then transformed into pattern map images from a pattern matching process between an input finger vein image and the pattern templates. Finally, nearest neighbour classifier with Euclidean distance metrics is used for classification. The main contribution of this thesis is the new way of generating pattern templates, which selects small blocks from every class within an area of constraint. Additionally, pattern map is implemented in finger vein recognition for the first time. Experimental results show that the proposed pattern map algorithm has better performance with a consistent identification rate of 99% and above compared to existing methods such as PCA and Gabor with FVCode. This shows that pattern map is a reliable feature extraction method and is able to represent finger vein pattern effectively.

CHAPTER 1

INTRODUCTION

1.1 Background

Biometric technology is an efficient and popular personal identification technique. In the modern society, the demands of identity management system have increased as the level of security breaches and transaction fraud are increasing. For example, one of the world events that have directed our attention towards safety and security is the tragic events of September 11, 2001 (Cassandra M. 2003). The obvious attention comes to biometrics and its use for authentication of authorized personnel within the flight deck and while in flight.

As a result, biometrics has become a major interest. Biometric-based solutions can be employed in various security applications such as data access control, transaction security, law enforcement and door access. These applications can be easily found in government, military and commercial infrastructures. Hence, research on different types of biometric solutions is very important in order to have more accurate, secured and yet cost effective authentication system.

Biometrics refers to an automated method to identify a person by utilizing physiological and behavioral characteristic (Alfred 2006). Some of these characteristics are shown in Figure 1.1 which include fingerprints (Cappelli, Ferrara & Maltoni 2010), iris and retina (Choras 2010), facial patterns (Unsang, Yiying & Jain 2010), signature pattern (Radhika, Sekhar & Venkatesha 2009), palm print

(Tamrakar & Khanna 2011) and vein patterns (Lee, Park & Lee 2009; Miura, Nagasaka & Miyatake 2007).

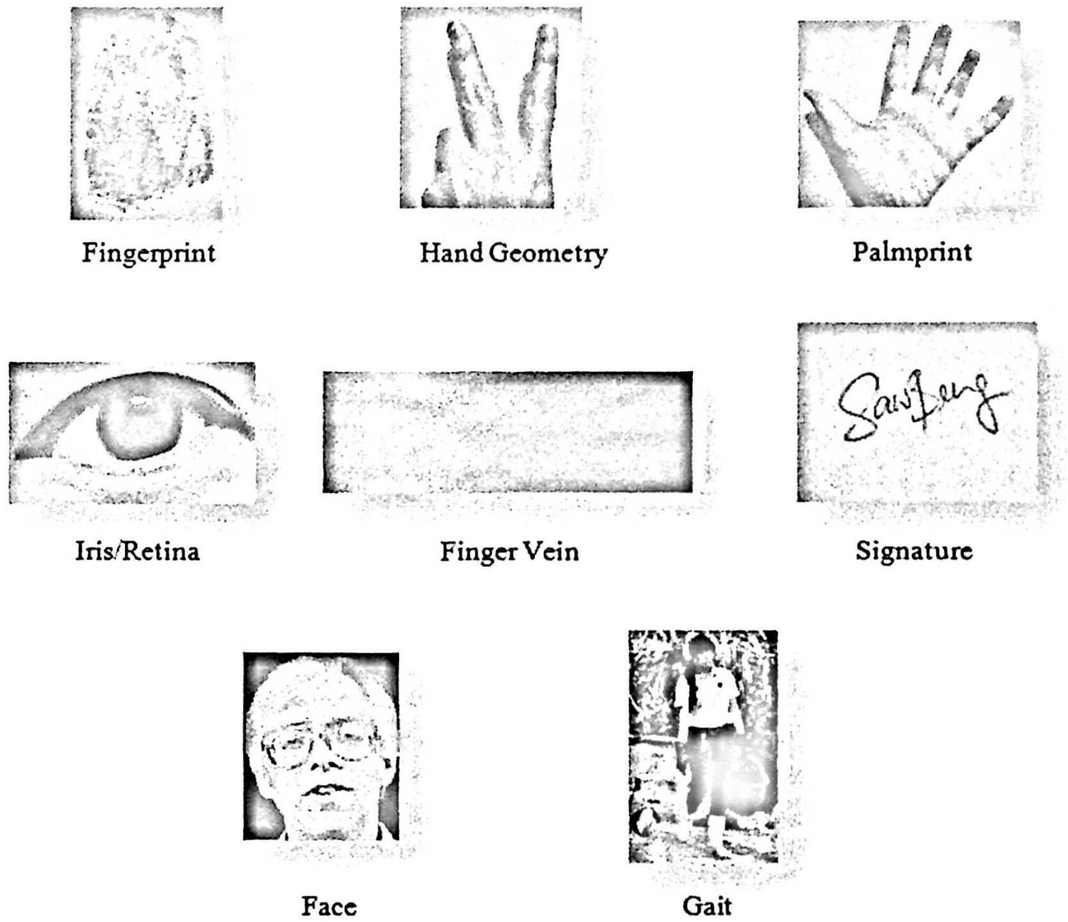

Figure 1.1: Types of Biometric Features

There are two methods used in biometric recognition: verification (Am I who I claim I am?) and identification (Who am I?) (Jain 1999). Verification is 1 to 1 matching system which confirms or denies a person's claimed identity. On the other hand, identification is a 1 to others recognition system which recognizes a person from a list of numbers of users in the database. In this work, closed identification is used in recognition process. During closed identification system, all the classes of tested images are from the database.

Recently, the development of finger vein recognition technique makes a great research interest. It is a fairly new biometric technology and it can be used to identify individuals based on the finger vein patterns. The idea of achieving personal identification based on vein pattern was suggested by Dr. K. Shimizu from Hokkaido Univeristy in 1992 (Shimizu 1992). In recent years, finger vein patterns are suggested as a new biometric feature (Lee, Park & Lee 2009; Miura, Nagasaka & Miyatake 2007; Wu & Liu 2011).

In anatomy, finger vein pattern network lies underneath the finger skin which is not visible to human eyes. Generally, finger vein recognition is a personal identification technology using vein patterns acquired by infrared imaging. A study done by Yanagawa et. al (Yanagawa, Aoki & Ohyama 2007) proved that finger vein patterns could be effectively used for personal identification. Their investigation showed that the diversity among the different persons of the human finger is similar to that of the iris pattern. This diversity is essential for a biometric feature.

Compared with other biometric characteristics such as fingerprint, face or voice, the finger vein pattern has more advantages (Wu & Ye 2009). The advantages include:

- Contactless – no need of contact between finger skin and sensor
- Live body identification – requires blood in veins to be registered
- High security – less prone to forgery or theft as vein patterns are underneath the skin

Hence, finger vein biometric technology becomes popular. Companies like Hitachi (Hitachi 2007) and Sony Corporation (Sony 2009) have developed devices as shown in Figure 1.2 that scan the pattern structure of finger vein. The basic principle of this technology is by projecting near-infrared rays (760-850nm) from LEDs of a finger vein reader through the user's finger. Since hemoglobin absorbs infrared rays and human skin passes it through, image showing dark subcutaneous vascular net on a bright background of other tissue is obtained. This image can be captured by either Charge-Coupled Device (CCD) or CMOS sensor and saved as templates for finger vein recognition.

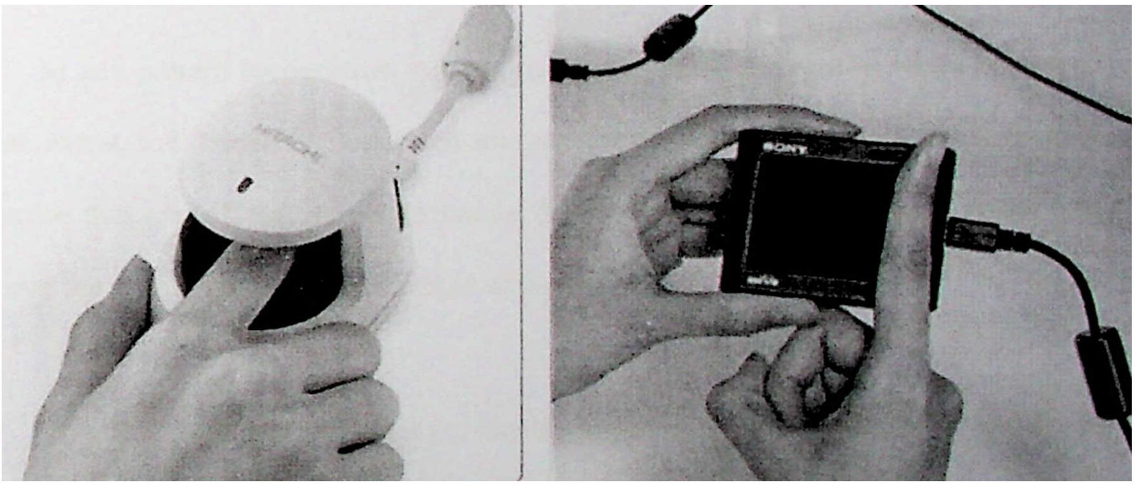

Figure 1.2: (a) Finger vein reader from Hitachi (Hitachi 2007), (b) Finger vein reader from Sony (Sony 2009).

However, finger vein images often are low contrast and low contrast images normally face challenges when comes to feature extraction. Therefore, feature extraction is an important step. In this thesis, the method used for feature extraction is based on pixel-pattern-based texture feature (Zeng et al. 2004) which has been successfully applied in facial expression recognition (Lu, Huang & Chen 2007). All the finger vein images are transformed into pattern map images before classifications. In the proposed approach, finger vein features are obtained from pattern map images instead of multi-filtered images such as Gabor-filtered (Yang, Shi & Yang 2011) or wavelet-filtered (Fengxu et al. 2009). Pattern map images are simpler as the pixel values are ranging from 1 to the number of pattern templates which will be explained in Chapter 3. The main contribution of this thesis would be the new ways of generating pattern templates for pattern map.

1.2 Problem Statement

In any pattern recognition system, there are many challenges when comes to feature extraction. Since the captured images for recognition may contain shading and noise that can affect the performance, how to precisely prepocess, extract and preserve the vein pattern are the critical steps.

Practically, finger vein image usually appears in low contrast, as shown in Figure 1.3. A low contrast image may contain shading and noise that can result in big challenge for finger vein recognition. The finger vein pattern may be unstable when methods are used for feature extraction are weak.

Figure 1.3: Finger Vein Image

In recent study, many have proposed similar fundamental finger vein recognition algorithm which use multichannel filtering techniques called Gabor filter and wavelet transform (Lee, Park & Lee 2009; Li et al. 2007; Yang et al. 2009). Multichannel filtering methods are used to enhance lines and edges of an image. However, it is computationally expensive. For example, the number of Gabor filter banks chosen affects the recognition accuracy. It is expensive to convolve images with multi-banks of Gabor filters to extract multiscale and orientational coefficients.

Besides multichannel filtering methods, local binary pattern (LBP) is another popular approach used in finger vein recognition (Lee, Park & Lee 2009; Rosdi, Shing & Suandi 2011). It is proved to be simple yet effective statistical texture descriptor in terms of the characteristics of the local features. However, it has two shortcomings (Jun et al. 2010). One of them is the incompetency of capturing global patterns which are important in pattern recognition. The other one is the insensitivity of noise as LBP only compares the gray values among pixels. These shortcomings result in missing of important global structures from an image.

Apart from that, (Zeng et al. 2004) has proposed a method that obtains features from a pattern map instead of multi-filtered image. This method is known as pixel-pattern-based texture feature (PPBTF) and has been successfully used in facial expression recognition (Lu, Huang & Chen 2007). PPBTF is claimed to be insensitive to variance of illumination and relatively simpler for computation. Motivated by both problems and advantages, this research will propose a new approach for finger vein recognition which uses pattern map based on PPBTF.

1.3 Research Objectives

- To implement and validate pattern map method on finger vein recognition.
- To compare the proposed algorithm with the existing algorithms which use Gabor Filter and Principal Component Analysis.

1.4 Scope of Work

In this research, a finger vein recognition algorithm is developed using pattern map which is based on pixel-pattern-based texture feature (PPBTF) (Zeng et al. 2004). Because of the vacancy of common finger vein database, the experiments are conducted on a finger vein database (Mahri, Suandi & Rosdi 2010) collected at Universiti Sains Malaysia. From the database, the region of interest (ROI) has already been extracted and the finger images are ready to be used as input images. The main focus of this research is the feature extraction using pattern map method and the new way of generating pattern templates for pattern map. Hence, vein images used in the experiments are pre-processed already. There is no image enhancement being employed during the experiments.

To test the discriminability of the extracted features, nearest neighbor classifier is adopted for classification. As for the experiments, parameters of generating the pattern maps are determined specifically for finger vein texture.

Finally, the proposed algorithm is implemented using the MATLAB. The performance of pattern map is evaluated to test its capability in finger vein biometrics in terms of its number of features extracted, identification rate and computational time. To further verify the proposed algorithm, comparisons with existing methods are conducted.

1.5 Research Contribution

The contributions of this research are:

- Implementation of pattern map as feature extraction in finger vein recognition for the first time
- A new way of generating pattern templates, which selecting small blocks from every class with an area of constraint

1.6 Thesis Outline

The remainder of this thesis is organized as follows:

In chapter 2, an overview of finger vein as biometric feature is presented. In addition, a brief survey on previously proposed finger vein recognition algorithms are given along with a method based on pattern map.

Next, a new approach for finger vein recognition which uses pattern map as a feature extraction is explained in Chapter 3. Pattern map method consists of two parts: pattern templates generation and pattern map generation. The principle of the proposed algorithm is explained in details.

Besides that, Chapter 4 focuses on the experimental results and analysis. Parameters are optimized via various experiments to ensure the best recognition rate of pattern map is achieved. Then, the performance of the proposed algorithm is evaluated to test its capability in finger vein classification by comparing with existing methods.

In Chapter 5, the subject is concluded and summarized. Conclusions are drawn from the experiment results and analysis. The work is summarized with recommendations for future work.

CHAPTER 2

LITERATURE REVIEW

Finger vein recognition is a fairly new technological advance in the field of biometrics. It can be used to identify individuals based on the finger vein patterns. The development of finger vein recognition technique has made a promising biometric technology for its advantages such as, contactless, live body identification and high security.

This chapter will discuss on the properties and the advantages of finger vein pattern as a biometric feature. In addition, a general framework of finger vein recognition is presented. The general framework consists of enrolment, live sample, template storage, identification process and decision making.

Besides that, various existing methods on finger vein recognition are reviewed. Apart from that, a method on texture representation based on pattern map is shown. The features and advantages of this method are briefly explained. Based on this pattern map method, a new approach for finger vein recognition is proposed.

2.1 Finger Vein for Biometrics

2.1.1 Properties of a Biometric Feature

Among the authentication systems, biometrics is emerging as the most efficient personal authentication and identification technique. The question comes to what biological measurements are qualified to be a biometric. According to Jain et .al (Jain, Bolle & S.; 1999), any human physiological or behavioral characteristic can be used as a biometric feature as long as it fulfills the following properties:

- *Universality*: everyone should have the biometric characteristic.
- *Distinctiveness*: the biometric characteristic should be distinctive to each person. Any two should be different enough in terms of characteristic.
- *Permanence*: the characteristic should be time-invariant with respect to the matching criterion.
- *Collectability*: the characteristic should be quantitatively measurable.

However, there are other issues that should be considered while applying a biometric feature in a practical biometric system (Jain, Bolle & S.; 1999). The requirements that one biometric system should fulfill includes:

- *Performance*: ability in achieving desired recognition accuracy and computational speed with operational and environmental factors that may affect the accuracy and speed.
- *Acceptability*: user-friendliness in terms of using the particular biometric characteristic in daily lives.

- *Circumvention*: indicates the robustness of the biometric system. It should not be fooled easily using fraudulent methods.

Therefore, a practical biometric system should achieve desired recognition accuracy, computational speed in addition to resource requirements. The method in getting the biometric feature should also be user-friendly, harmless to the user and robust to various fraudulent methods.

2.1.2 Finger Vein as a Biometric Feature

Among the biometric systems that have been proposed and implemented, finger vein biometrics appears to be a foolproof method of automated personal identification and it is a fairly recent technological advance in the field of biometrics (Lee & Park 2011; Lee et al. 2010; Liu et al. 2010). Besides, finger vein pattern also fulfill the properties of a biometric feature and practical requirement.

Finger vein pattern is a network of blood vessels underneath the finger skin which is invisible to human eyes. Hence, numbers, locations and length of finger veins have not been known about. With technologies, sharp vein images are obtained and made research possible. To use finger vein as a biometric feature, the finger vein pattern should be distinct in kind. Recently, Yanagawa et. al (Yanagawa, Aoki & Ohyama 2007) had investigated the diversity of human finger vein patterns by comparing both right and left index fingers and middle fingers of about 500 persons. The results indicate that two fingers are identical if and only if they are the same finger in the same hand of the same person, where all the other cases can be treated as unrelated. In addition, the diversity of finger vein pattern has also been proven to be similar to that of the iris pattern. Therefore, human finger vein patterns are valid to be utilized for personal identification.

Despite the uniqueness, universality, permanence and measurability, finger vein identification has some excellent advantages compared to other biometric authentication technology (Wu & Ye 2009). The advantages include:

- *Non-contact*: Vein patterns are captured by Near-Infrared rays LED. With the light-transmission technique, there is no need to have contact between users and sensing surface. This improves the hygiene concerns.
- *Live body identification*: Artificial veins unavailable in application as blood vessels only exist in a live body.
- *High security:* Vein patterns are networks of blood vessels underneath the skin which are internal features. Hence, it is difficult to be forged.

It is very important that a feature has all the required properties such as universalities, permanence, distinctiveness and collectability to be considered as a biometric feature. Therefore, with the additional advantages, finger vein recognition can be an even highly reliable authentication method.

2.1.3 General Framework of Finger Vein Recognition

Finger vein pattern has fulfilled the properties of a biometric feature and practical requirement. It also has some excellent advantages compared to other biometric authentication technology. Therefore, finger vein pattern can be used for personal authentication and identification. In identification, the general framework consists of enrolment, live sample, template storage, identification process and decision making as shown in Figure 2.1.

Before a biometric can be used, samples of the biometric must be captured and saved in a database. This process is called enrolment and template storage. The sample is also referred to user's biometric template. This is an important step as the samples are needed later in identification step.

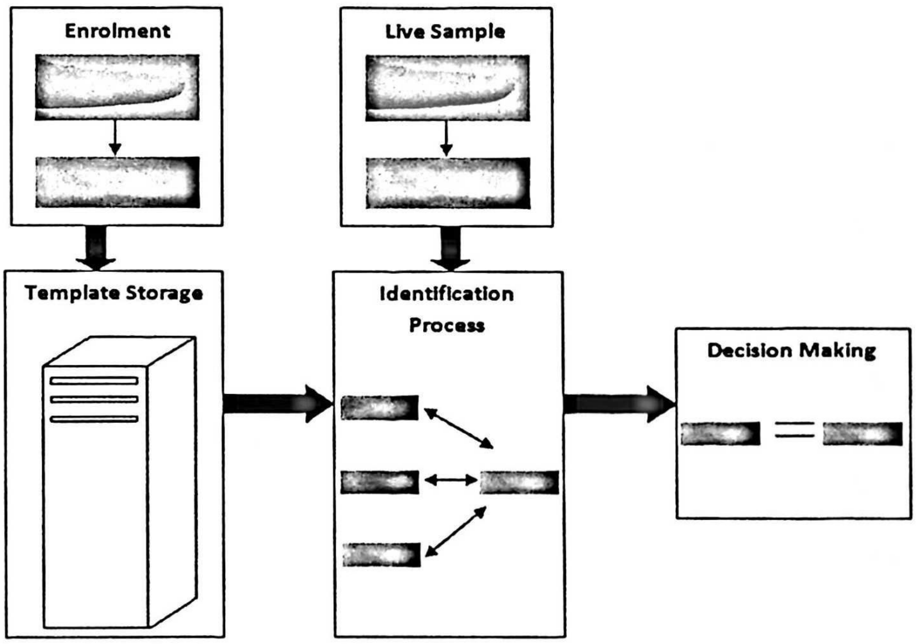

Figure 2.1: General framework of finger vein recognition.

In addition, the most complex part is the identification. Identification process can be subdivided into a few stages as shown in Figure 2.2.

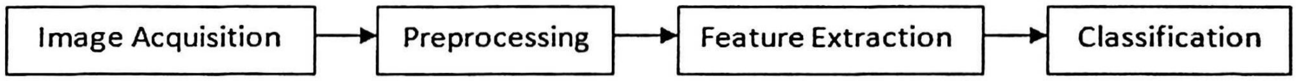

Figure 2.2: Identification Process.

First, live sample is acquired. Since our samples are the images of finger vein patterns, the vein images cannot be acquired by normal visible light. These vein images have to be acquired using infrared imaging technologies. Near-infrared (NIR) lights with 760-850nm rays are often used in medical applications in vein imaging because they can penetrate into the skin and the radiation of lights can be absorbed greatly by the deoxyhemoglobin (Zharov et al. 2004).

However, the images captured from the acquisition device come with black unwanted background. The background can potentially reduce the accuracy of the matching process. Hence, it is important to preprocess and extract the vein image from the undesired background by determining the region of interest (ROI) before feature extraction. Then, the image features are extracted. It is important to make sure that sufficient features are extracted to achieve higher accuracy of matching.

Lastly, the key procedure of decision stage is feature matching. Similarity between the query feature template and the templates from database are calculated one by one. The identification decision is made base on the maximum similarity score. Generally, the system would try to match the key features of the user's template against the database template.

In this thesis, the main focus is the feature extraction as mentioned in Scope of Work in Chapter 1, where pattern map based algorithm is used. Hence, image acquisition and preprocessing is not within the scope of work. Vein images used during the experiments are from a readily available database, which the images are pre-processed already.

2.2 Previously Proposed Finger Vein Recognition Algorithms

Today, finger vein recognition has become a popular biometric technology. It has attracted the attention of biometrics-based identification research community. Therefore, many studies have been done for finger vein based recognition. In order to achieve good performance, how to precisely extract and preserve the vein pattern is the critical step as the captured vein images may contain shading and noise that affect the accuracy. In this section, previously proposed finger vein recognition algorithms are discussed and the main focus would be the feature extraction.

2.2.1 A Novel Finger Vein Recognition Method with Feature Combination

Jinfeng et. al (Yang et al. 2009) has proposed a finger vein recognition method with feature combination. This method consists of image preprocessing and feature extraction and it is able to describe the diversity of the finger vein networks.

As for preprocessing, a circular Gabor filter is designed specifically to improve the quality of finger vein images. From the filtered images, image is implemented to extract finger vein network and thinning operation is performed to obtain the finger vein skeleton as shown in Figure 2.3. Then, the finger vein features on local moments, topological structure and statistic are exploited.

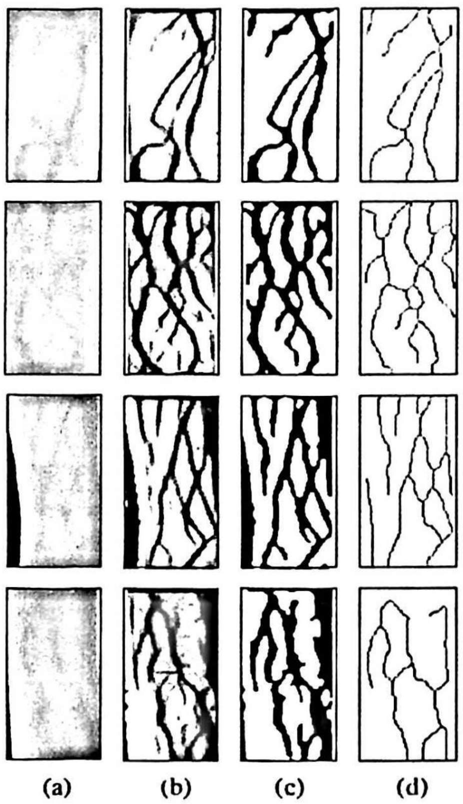

Figure 2.3: (a) Original Images. (b) Finger vein image enhancement. (c) Finger vein segmentation. (d) Finger vein skeleton.(Yang et al. 2009)

In local moments, a 70x150 window is used to slide over a finger vein image globally to obtain a region that contains the richest finger vein information. Then, a 70x70 window is used to slide along the height of the cropped region at a 20 pixel length step as shown in Figure 2.4 to obtain five subimages. Based on the seven moments of every subimage, a matrix is then generated to describe the finger vein variations in vessel diameters and networks along a finger.

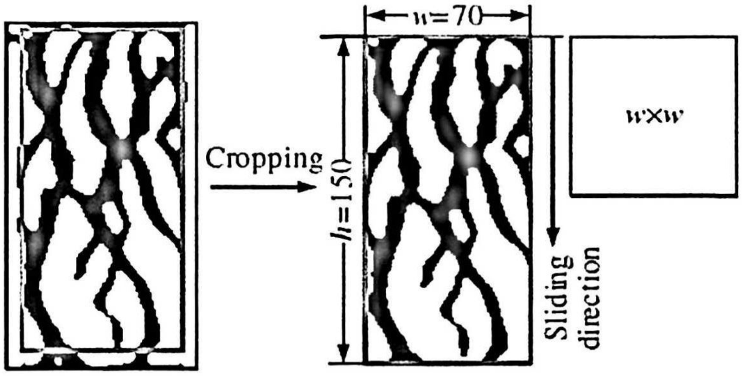

Figure 2.4: Subimage extraction through *wxw* window sliding. (Yang et al. 2009)

Moreover, the topological characteristic is analyzed based on the cross-points in a finger vein skeleton. First, the cross-points are detected and numbered clockwise. The connectivity between adjacent cross-points is then determined and angles related cross-points are calculated. From the angle features, a vector is formed to represent the topological information of the numbered cross points. Finally, vein shape feature is used to represent the statistical characteristic of the finger vein skeleton. Extracted finger vein features are then evaluated by nearest cosine classifier.

However, this method has a weakness. It is difficult to perform thinning process for good vein skeleton when the images are not clear. Since this algorithm extracts features based on the cross-points in a finger vein skeleton, the performance is greatly affected by conditions of finger vein images.

2.2.2 Personal Identification Based on Finger Vein Features

In a recent study, Jinfeng et. al (Yang, Shi & Yang 2011) has proposed a new method of personal identification based on finger vein pattern. It is a feature extraction method based on Gabor filters specific to finger vein images. A bank of Gabor filters is used to exploit the vein characteristic at different scales and orientation. In the proposed method, even-symmetric Gabor filter is used to exploit the vein features where the finger veins appear dark ridges in image plane. This is because even-symmetric Gabor filter is suitable for ridge detection in an image. Figure 2.5 illustrates a bank of even-symmetric Gabor filters with four scales and eight channels used for two dimensions of convolutions while Figure 2.6 shows the filtered finger vein images from a bank of even-symmetric Gabor filters.

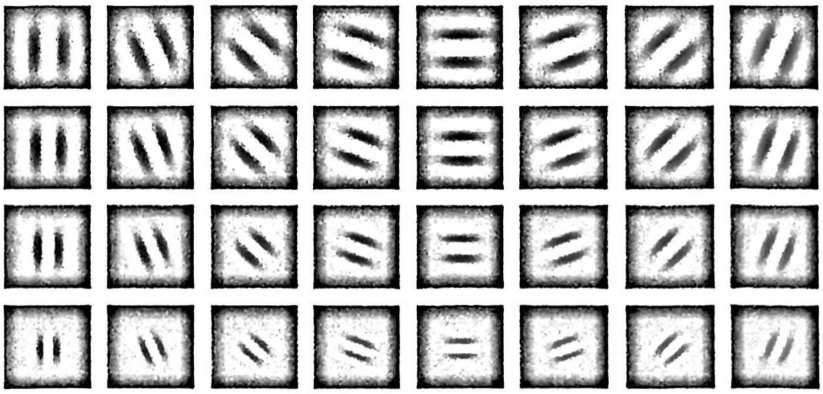

Figure 2.5: A bank of even-symmetric Gabor Filters with four scales and eight channels. (Yang, Shi & Yang 2011)

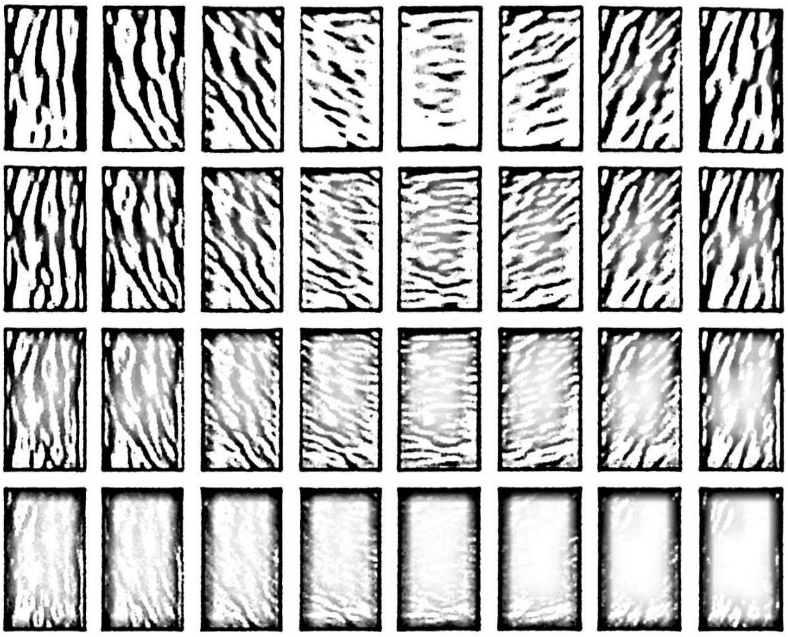

Figure 2.6: Filtered finger vein images from a bank of even-symmetric Gabor Filters. (Yang, Shi & Yang 2011)

Each scale generates eight outputs from the Gabor filters. These outputs are then stacked up to form a 8-dimentional vector. A new vector matrix is then constructed based on 10x10 small blocks of the 8-dimentional vector. From the new vector matrix, a feature matrix (FVCode) is formed through a specific extraction and is able to represent the local and global features of a finger vein pattern. Based on these feature vectors (FVCode), the cosine similarity measure classifier is adopted for classification. Cosine similarity is a method of measuring the similarity between two vectors by measuring the cosine of the angle between them. The cosine of the angle between two vectors can be used to determine if the two vectors are in the same class or not.

Lastly to improve the reliability of identification, Jinfeng et. al has implemented Dempster-Shafer (D-S) algorithm in decision level for finger vein identification. According to the paper, the D-S evidence theory works better in integrating multiple evidences for decision making. It is also known as the theory of belief functions where the decision is made based on the properties of probability.

One weakness of this method is that Gabor filter is computationally expensive. For example, number of Gabor filter banks chosen affects the recognition accuracy. It is expensive to convolve images with multi-banks of Gabor filters to extract multiscale and orientational coefficients.

2.2.3 Finger Vein Pattern Identification Using Principal Component Analysis and the Neural Network Technique

In addition, Jian-Da et. al (Wu & Liu 2011) have presented a finger vein pattern identification using principal component analysis (PCA) and the neural network technique as shown in Figure 2.7. In this paper, PCA is used for feature extraction to generate a set of distinguishing set of training features while adaptive neuro-fuzzy inference system (ANFIS) is used for pattern classification. ANFIS is a kind of neural network which is based on Takagi-Sugeno fuzzy interference system and it integrates both neural networks and fuzzy logic principles. To verify the effectiveness of the proposed ANFIS, back-propagation neural network (BPNN) is compared with ANFIS. Back-propagation is a common method of training artificial neural networks and it is able to adjust the weights to solve particular problem.

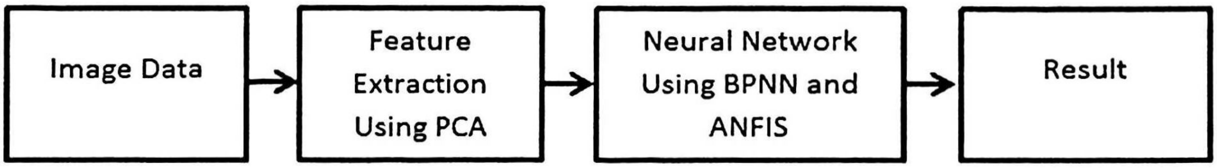

Figure 2.7: Block diagram of the method which uses PCA and Neural Network. (Wu & Liu 2011)

PCA is a powerful tool for data analysis, pattern recognition and data discrimination. Each principal component describes a percentage of total variance of a set of data (Kirby & Sirvoich, 1990). Here, PCA is able to describe patterns by reducing the feature dimensions without losing much of information. Once the pattern features are extracted, an artificial neural network (Tamrakar & Khanna 2011) is used as classifier to identify the images of the finger vein. The neural network for classification used in this method is back-propagation (BP) network and adaptive neuro-fuzzy interference system.

One advantage of the feature extraction method used is that it is simple and requires lesser steps unlike Gabor filter. PCA not only can extract the most distinguishing features but also able to reduce the feature dimension without losing much information. However, PCA method has disadvantages too. The PCA used in this algorithm is one-dimensional (1D) PCA, which does not represent two-dimensional (2D) structure of a finger vein image. This is because the data is being transformed into a single dimension during the calculation of eigenvein. Another disadvantage is that PCA does not consider the structure of finger vein, where it does not extract the vein lines.

2.2.4 Finger Vein Recognition Using Local Line Binary Pattern (LLBP)

Bakhtiar et .al (Rosdi, Shing & Suandi 2011) has proposed a new method called Local Line Binary Pattern (LLBP) as a feature extraction in finger vein recognition. Unlike in local binary pattern (LBP) (Lee, Park & Lee 2009) which the neighbourhood is a square shape, LLBP uses a straight line shape. From the proposed method, the straight line shape in LLBP is more suitable in extracting vein pattern from finger vein image. Moreover, LLBP has an advantage in emphasizing the change in image intensity such as vertices, edges and corners. The illustration of LLBP images is as shown in Figure 2.8. It is observed that the vein patterns can be clearly seen in LLBP images.

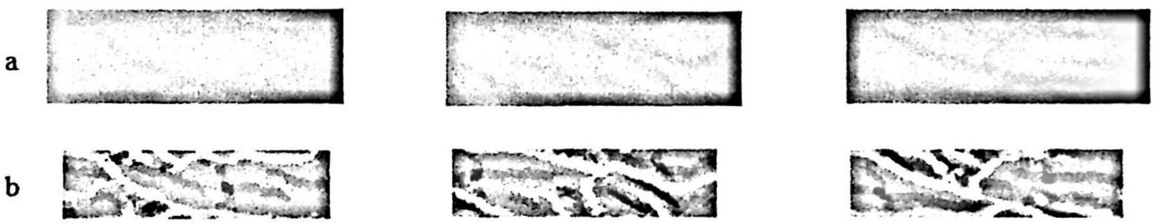

Figure 2.8: (a) Cropped Finger Vein Images. (b) LLBP Images. (Rosdi, Shing & Suandi 2011)

One weakness of this method is that LLBP is incompetent of capturing global patterns which are important. The reason is that LLBP is a statistical texture descriptor in terms of the characteristics of the local structure. LLBP divides image into blocks and the features are extracted based on local blocks. This helps to eliminate the noise, but it neglects the global feature.

2.3 Texture Representation Based on Pattern Map

The proposed finger vein recognition algorithm in this thesis is based on pixel-pattern-based texture feature (PPBTF) (Zeng et al. 2004). PPBTF is motivated by multichannel filtering techniques which are often used in texture analysis to enhance edges and lines of different orientations in each feature component. However, multichannel filtering techniques are computationally expensive. For example, number of Gabor filter banks chosen affects the recognition accuracy. It is expensive to convolve images with multi-banks of Gabor filters to extract multiscale and orientational coefficients.

Therefore, Xiang et.al (Zeng et al. 2004) has recently proposed a new method for texture analysis called pixel-pattern-based texture feature (PPBTF). Compared to the multichannel filtering, the proposed method is much simpler to calculate and is free of influence of illumination. In PPBTF, a grey scale image is first transformed into a pattern map in which edge, line and background pixels are classified by pattern matching. Basis functions obtained from PCA are used as templates for pattern matching. The pixel values are ranging from one to the number of pattern templates and have two advantages:

- Not affected by illuminations conditions
- Pixel values are related to orientation and scale pattern, having more texture information than gray scale values.