LOG-GABOR FILTER BASED FINGER VEIN BIOMETRIC SYSTEM USING MODIFIED REPEATED LINE TRACKING ALGORITHM

by

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LIST OF ABBREVIATIONS

AHE	Adaptive Histogram Equalization
BBHE	Brightness Bi-Histogram Equalization
BR	Border Region
CCD	Charge-Coupled Device
CDF	Cumulative Density Function
CLAHE	Contrast Limited Adaptive Histogram Equalization
CR	Corner Region
CTP	Current Tracking Point
DNA	Dexoyribo Nucleic Acid
DSIHE	Dualistic Sub-image Histogram Equalization
EER	Error Equal Rate
et al.	(et alia): and others
FAR	False Acceptance Rate
FIR	Finite Impulse Response
FFT	Fast Fourier Transform
FRR	False Rejection Rate
GAR	Genuine Acceptance Rate
HE	Histogram Equalization
ID	Identity Document
IR	Inner Region
KPCA	Kernel Principal Component Analysis

LBP	Local Binary Pattern
LDA	Linear Discriminate Analysis
LDP	Local Direction Pattern
LED	Light Emitting Diodes
LLBP	Local Line Binary Pattern
MLP	Multilayer Perception
MRLT	Modified Repeated Line Tracking
MSE	Mean Square Error
MUM	Modified Un-sharp Mask
NIR	Near-Infrared Reflectance
PBBM	Personalized Best Bit Map
PCA	Principal Component Analysis
PSNR	Peak Signal Noise Ratio
PWM	Personalized Weight Maps
RLT	Repeated Line Tracking
RMSHE	Recursive Mean-Separate Histogram Equalization
ROC	Receiver Operation Characteristic
ROI	Region of Interest
RSWHE	Recursive Separated and Weighted Histogram Equalization
SVM	Support Vector Machine

LIST OF SYMBOLS

β	Clip limit value
σ_{ρ}	Angular bandwidth
σ_{θ}	Radial bandwidths
θ_{pk}	Frequency center of filter
D_{lr}	Dimension left to right
D_{du}	Dimension down to up
N_r	Neighbouring pixel
p_{new}	New pixel value
p_{old}	Old pixel value
R	Maximal signal power
T_r	Locus matrix
(x_c, y_c)	Current tracking point

SISTEM BIOMETRIK URAT JARI BERASASKAN PENURAS LOG-GABOR MENGGUNAKAN ALGORITMA PENJEJAKAN GARIS ULANGAN TERUBAHSUAI

ABSTRAK

Prestasi sistem pengecaman vena jari bergantung pada kualiti imej yang ditangkap. Walaupun topeng penyahtajaman lelurus klasik mampu mempertingkatkan bahagian gelap dan bayang-bayang imej urat jari, tetapi imej yang dipertingkatkan akan mengalami dua kekurangan. Pertama, kesan halo yang muncul di sekitar kawasan imej yang lebih tajam. Kedua, hingar yang wujud dalam imej juga akan dipertingkatkan. Kajian ini mengubah topeng penyahtajaman lelurus klasik dengan menggunakan penapis Log-Gabor. Topeng Penyahtajaman Diperbaiki (MUM) meningkatkan kontras dan ketajaman imej tanpa kelemahan yang disebutkan di atas. Kajian ini memperkenalkan peringkat pra-pemprosesan dalam sistem pengesahan vein jari yang mana, mulanya, kaedah penyamaan Histogram Pengesuaian Had (CLAHE) akan digunakan pada imej masukan dan kemudiannya teknik MUM digunakan untuk meningkatkan ketajaman dan kontras imej urat jari. Hasil daripada ciri yang diekstrak menunjukkan peningkatan yang cemerlang dalam mengenalpasti perincian vena dengan menggunakan kaedah prapemprosesan yang dicadangkan ini. Penjejakan Garis Ulangan Terubahsuai (MRLT) digunakan sebagai kaedah pengekstrakan ciri Manakala Mesin Vektor Sokongan (SVM) digunakan sebagai pengelas. Kadar Kesalahan Seimbang (EER) digunakan sebagai pengiraan prestasi dalam kajian ini. EER yang diperolehi untuk sistem pengesahan dengan meggunakan tiga data latihan ialah 16.66% untuk imej asal, 14.22% untuk imej CLAHE yang dipertingkatkan dan 6.28% untuk imej bagi kaedah yang dicadangkan (CLAHE kemudian MUM).

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ABSTRACT

The performance of finger vein recognition system relies on the quality of captured image. Although the classical linear Un-sharp mask can enhance the dark and shadowy parts of finger vein image, but the enhanced image suffers two drawbacks. First, the halo effects that appears around sharper areas of image. Second, the noises which exist in image are over enhanced. This study modifies the classical linear Un-sharp mask with use of Log-Gabor filter. This Modified Un-sharp Mask (MUM) enhances the contrast and sharpness of image without aforementioned drawbacks. This study, introduced a pre-processing stage in the finger vein verification system which first, applies Contrast Limit Adaptive Histogram Equalization (CLAHE) method on input image then use MUM technique in order to enhance the sharpness and contrast of finger vein image. The results of extracted feature show the excellent improvement in detection of vein details by using the proposed pre-processing method. The Modified Repeated Line Tracking (MRLT) is used as feature extraction method and Support Vector Machine (SVM) is used as classifier. The Equal Error Rate (EER) is used as performance evaluation in this study. The EERs for the verification system at three training data is observed to be 16.66% for original image, 14.22% for CLAHE enhanced image and 6.28% for proposed method (CLAHE then MUM).

CHAPTER ONE

INTRODUCTION

1.1 Overview of Biometric System

The biometric technology is defined as the science of identification/verification based on behavioural or physiological characteristic of a human such as handwriting, signature, voice, face, fingerprint, iris, and DNA (RavaleNerkar, 2015; Syazana-Itqan, Syafeeza, & Saad, 2016). Figure 1.1 shows some biometric modalities that are currently used by researchers.

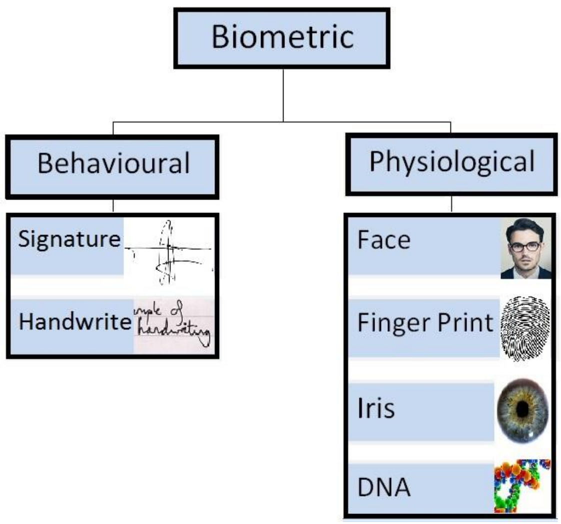

Figure 1.1: Samples of behavioural and physiological biometric modalities.

In recent decades, recognition systems which work based on biometric traits have been widely used and played an important role for individuals' identification/verification in systems and applications (Jain, Ross, & Prabhakar, 2004; Mir, Rubab, & Jhat, 2011). The conventional recognition systems such as pin code, password, and ID card are not reliable and jeopardize the security of the system. This is because the risk of being thieved by scammers is one of the reasons that is contributed to the unreliability of them (Battacharyya, Ranjan, Alisherov, & Choi, 2009). Furthermore, it is likely being accessed by an unauthorized person which adds cautious to these systems (Connie, Teoh, Goh, & Ngo, 2003). Hence in order to maintain the privacy, security and confidentially of systems, biometric traits can be a reliable solution.

A biometric trait of human has seven basic criteria such as universality, uniqueness, performance, permanence, acceptability, collectability and circumvention (Schuckers, 2001) that are shown in Figure 1.2.

- Uniqueness: A biometric trait needs to be unique for each person and can has the distinction between individuals.
- Universality: Every person must possess that kind of biometric trait.
- Performance: Considered as accuracy, robustness and process speed of the authentication system.
- Permanence: A biometric trait has to be constant in a certain period of time.
- Acceptability: A biometric trait must be accepted in people’s view.
- Collectability: A biometric trait should have the ability to quantitatively measure by the authentication system.
- Circumvention: Considered as how easily the biometric trait which is provided by a person, can lead to failure.

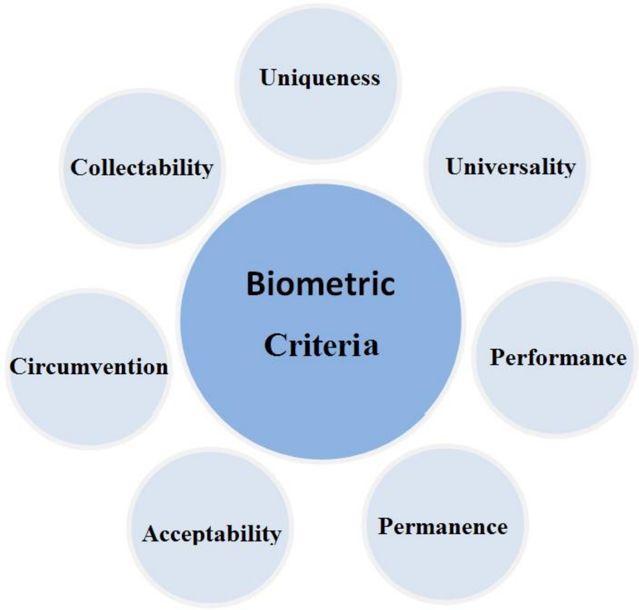

Figure 1.2: Seven basic criteria of a biometric trait

A biometric recognition system is essentially a pattern recognition system which senses a biometric trait, extraction a feature and compares it with stored template of system. In reality, the typical biometric recognition system operates in two modes of verification or identification that are shown in Figure1.3 and Figure 1.4 respectively.

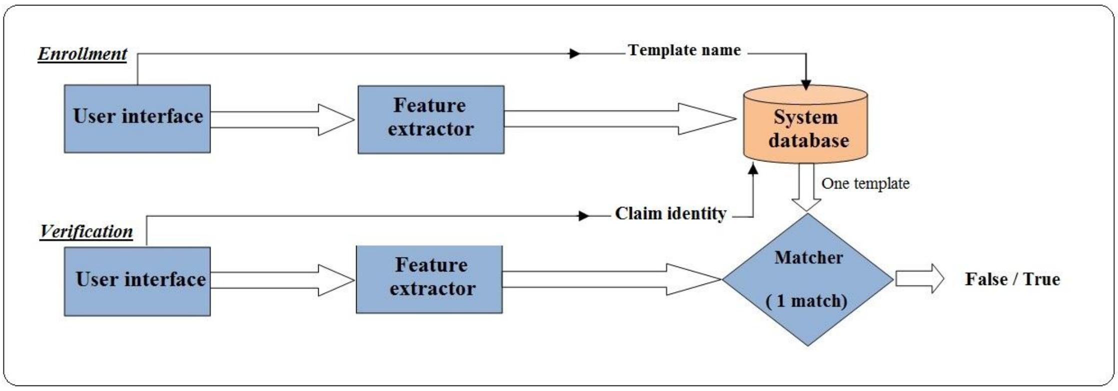

Figure 1.3: Block diagram of verification mode of a biometric system

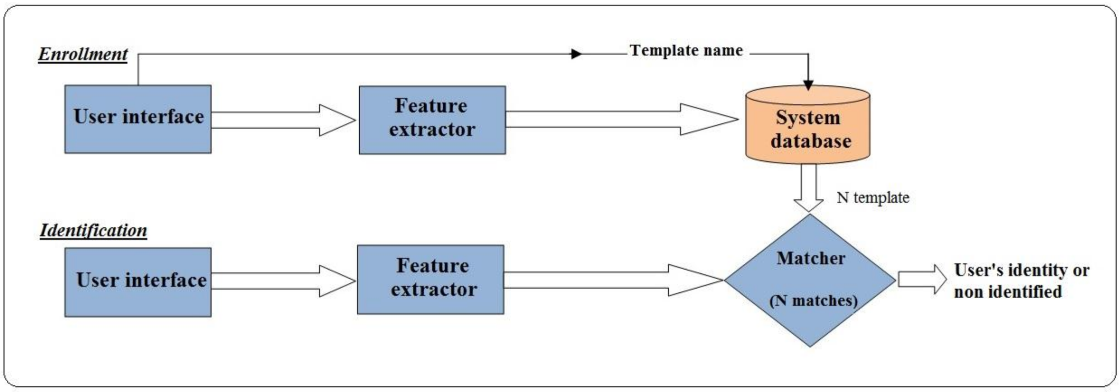

Figure 1.4: Block diagram of identification mode of a biometric system

The duty of enrolment stage is for collecting the information of users from their biometric traits and save the information in the database of the system. The identification or verification phase (recognition is the general term of both) is for extracting the feature of a biometric trait from an examination image, then compare it with the reference database of the system (Mu, 2013).

Identification and verification blocks work differently in the database comparison. The system output of identification is an identity and it is described as a one-to-many comparison. In other words, the system attempts to answer the question “ Who is the person?’’. While in the verification mode, the identity of the user is authenticated and it is described as a one-to-one comparison. In other words, the system tries to answer the question “ Is this person who they say they are?’’ (Kornelije & Miroslav, 2007) .

1.2 Finger Vein Biometric System

Among different biometric modalities such as the face, voice, iris, fingerprint and so on, finger vein trait has more advantages. Table 1.1 shows the comparison among different biometric modalities in terms of advantage, disadvantage, security level and cost of the system (Syazana-Itqan et al., 2016).

Table 1.1 *Comparisons of Different Biometric Traits*

Biometric Trait	**Main Advantage**	**Disadvantage**	**Security Level**	**Sensor**	**Cost**
Voice	Natural and Convenient	Noise	Normal	Non-contact	Low
Face	Remote Capture	Lighting Conditions	Normal	Non-contact	Low
Fingerprint	Widely Applied	Skin	Good	Contact	Low
Iris	High Precision	Glasses	Excellent	Non-contact	High
Finger Vein	High-Security Level	Quality of Captured Image	Excellent	Non-contact	Low

As it is shown in Table 1.1, the finger vein biometric method has the highest security compared to other methods. Besides, it has low cost and the minimum disadvantage. Some other advantages of the finger vein biometric method are presented as follows:

- Finger vein sample can only capture from living body, therefore it is impossible to steal it from a dead person (Yang, Yang, Yin, & Zhou, 2014).
- Every person generally has ten fingers; hence if an unforeseen incident happens to any of the fingers, other fingers are available for replacement in authentication process (Xuebing , Jiangwei , & Xuezhang 2010; Yang , Shi , & Yang, 2011).
- As vein is located underneath of human's skin, it is invisible to eyes, so the risk of steal or forgery is lower than other biometric traits.
- As finger vein acquisition process is contactless, ensuring hygiene and convenience for users.

Since the finger vein modality has many advantages such as the highest security and user convenience compared other biometric modalities, this study develops a recognition system based on finger vein modality and tries to improve the extracted feature of finger in order to get higher accuracy rate.

1.3 Problem Statement

In order to have a recognition system with higher accuracy and lower identification error rate, the pattern of finger vascular has to be extracted precisely from the captured image. The captured finger image by a charge-coupled device (CCD) camera is not clear and it contains noise and irregular shadows since it was produced by different thickness of finger muscles and bones. Therefore, precise extraction of finger vein pattern becomes a challenge (Perez Vega , Travieso , & Alonso 2014).

Since the illumination of a digital image often need to be corrected, many scholars worked on the improvement of capturing devices in order to tune the environmental illumination as the out-coming images of the devices are either too dark or too bright (Ton & Veldhuis 2013; Yin , Liu , & Sun 2011; Yu, Shan, Sook, Zhihui, & Dong, 2013). Besides, many researchers introduced various methods of feature extraction in order to improve the precious of the extracted pattern (Kumar & Zhou 2012; Liu , Xie , Yan , Li , & Lu 2013; Miura & Nagasaka, 2004; Miura, Nagasaka, & Miyatake, 2007; Qin, Yu, & Qin, 2011; Song et al., 2011).Yet, there is still more works to do to achieve more accurate extracted pattern of finger vein.

Scholars have proposed various image enhancement methods based on different concepts of feature extraction techniques. Since the extraction method of the current study is based on Modified Repeated Line Tracking (MRLT) method which operates according to cross-sectional profile of the finger image, hence the modifications of sharpness and contrast of finger image leads to better performance of vein detection