FUSION OF HOLISTIC AND LOCAL FEATURES FOR PALMPRINT RECOGNITION

by

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LIST OF ABBREVIATIONS

DCT	Discrete Cosine Transform
DOST	Discrete Orthonomal Stockwell Transform
EER	Equal Error Rate
FAR	False Acceptance Rate
FLD	Fisher's Linear Discriminant
FRR	False Rejection Rate
GWT	Gabor-Wigner Transform
ICA	Independent Component Analysis
LBP	Local Binary Pattern
LDA	Linear Discriminant Analysis
LPP	Locality Preserving Projections
LLDP	Local Line Directional Patterns
MFRT	Modified Finite Radon Transform
PCA	Principal Component Analysis
PSO	Particle Swarm Optimization
ROI	Region of Interest
SVM	Support Vector Machine
TPTSR	Two-phase Test Sample Sparse Representation

LIST OF SYMBOLS

λ	Eigenvalues Diagonal Matrix
θ	Orientation
ψ	Phase Offset
σ	Standard Deviation of Gaussian Envelope
γ	Spatial Aspect Ratio
C	Two-Dimensional Covariance Matrix
Di,j	Two-Dimensional Euclidean Distance Matrix
e	Two-Dimensional Eigenvectors Matrix
$e_{projected}$	Eigenvectors Matrix After Projection
E_i	Global Matching Score
m	Number of Image Vector
R	Feature Vector Matrix of the Training Data
$R_{i,k}$	Feature Vector Matrix for Training Data
S	Feature Vector Matrix of the Testing data
$S_{j,k}$	Feature Vector Matrix for Testing Data
S_w	Fused Weighted Sum Score
T_r	Averaged Palmprint Image Vector of the Training palmprint of a specific subject
T_s	Averaged Palmprint Image Vector of the Testing palmprint of a specific subject
X	Two-Dimensional Zero-Mean Testing Data Matrix
$\bar{X}$	Mean Value in Data Matrix

x_i	Values in Each Column of Feature Matrix
W_1	Weight for Holistic Feature
W_2	Weight for Local Feature
Z	Two-Dimensional Zero-Mean Training Data Matrix
Z^T	Transpose Matrix of the Two-Dimensional Zero-Mean Training Data Matrix

Gabungan Ciri Holistik dan Tempatan bagi Pengecaman Tapak Tangan

ABSTRAK

Pengecaman tapak tangan telah menjadi teknologi yang penting dan pantas berkembang dalam sistem biometrik sepanjang dekad yang lalu. Kejayaan pengenalan tapak tangan memerlukan padanan terbaik antara sampel ujian daripada data masukan dan pencontoh di dalam pangkalan data tapak tangan tersebut. Penggunaan ciri holistik dan tempatan secara berasingan akan mempunyai batasan dari segi geometri dan variasi. Gabungan maklumat biometrik tapak tangan dapat dikembangkan bagi menghasilkan prestasi pengecaman yang lebih baik. Oleh itu, kerja penyelidikan ini membentangkan gabungan ciri holistik dan tempatan bagi pengecaman tapak tangan. Keseluruhan kerja penyelidikan ini mengambil tiga langkah utama iaitu teknik pra-pemprosesan, pengekstrakan ciri dan proses pemadanan sebelum diteruskan dengan gabungan ciri holistik dan tempatan. Teknik pra-pemprosesan adalah peringkat permulaan untuk memastikan imej tapak tangan dari dataset dipotong dan diubah saiznya kepada saiz tertentu. Keseluruhan kaedah yang dicadangkan disahkan menggunakan penanda aras dataset PolyU bagi menganalisis pengecaman tapak tangan. Corak penapis Gabor digunakan untuk mengeluarkan maklumat penting dalam ciri holistik manakala Discrete Cosine Transform (DCT) digunakan untuk mengekstrak tenaga frekuensi rendah bagi ciri tempatan. Kemudian, pengiraan analisis komponen utama (PCA) digunakan untuk mengurangkan ruang ciri dimensi yang tinggi kepada ruang ciri dimensi rendah. Ruang ciri dimensi rendah mengekalkan maklumat frekuensi rendah. Klasifikasi adalah proses yang digunakan untuk membezakan dan mengklasifikasikan pemerhatian baru berdasarkan set latihan data. Tujuan pengelas jarak Euclidean adalah untuk mengukur nilai yang sepadan dan kedekatannya antara ciri vektor latihan dan ujian. Antara pelbagai tahap gabungan, tahap gabungan padanan yang hampir sama adalah pendekatan yang paling sesuai untuk menggabungkan skor padanan dari dua modul yang berbeza kerana tahap gabungan ini dapat meningkatkan ketepatan padanan tersebut. Ia berkembang dengan membentuk satu nilai untuk memproses keputusan dari pengeluaran yang sepadan dengan modul yang hampir sama. Dalam skim gabungan skor yang sepadan, peraturan jumlah tertimbang menghasilkan prestasi unggul. Kadar pengecaman terbaik sebanyak 97% dicapai menggunakan 100 subjek. Berdasarkan analisis pengecaman, terdapat tiga parameter penting yang mempengaruhi prestasi kajian iaitu saiz imej, kesan bilangan komponen utama, dan bilangan pekali DCT.

Fusion of Holistic and Local Features for Palmprint Recognition

ABSTRACT

Palmprint recognition has become an important and rapidly developing technology in biometric system over the past decade. The success of palmprint identification requires the best matching of the test sample from input data and the templates in the palmprint database. The used of holistic and local features separately will have limitations in geometry and variations. Information fusion of palmprint biometric is developed in order to produce a better recognition performance. Thus, this research work presented the fusion of holistic and local features for palmprint recognition. The overall structure of the study takes the form of three major steps includes pre-processing techniques, feature extraction and matching process before proceeds with fusion to combine the holistic and local features. Pre-processing technique is the initial stage to make sure the palmprint image from dataset is cropped and resized into the specific size. The entire proposed method is validated using benchmark PolyU dataset for palmprint recognition analysis. Gabor filter pattern is used to extract important information in holistic features while Discrete Cosine Transform (DCT) is used to extract low frequency energy of local features. Then, the computation of Principal Component Analysis (PCA) is applied to reduce the high dimensional feature space to low dimensional feature space. Low dimensional feature space preserved low frequency information. Classification is the process used to distinguish and classify a new observation based on the training set of data. The purpose of Euclidean distance classifier is to measure the matching value and its closeness between the training and testing feature vectors. Among various fusion levels, matching score level fusion is the most suitable approach in combining the match score from two different matchers because this fusion rule can increase matching accuracy. It is developed by forming a single value for decision process from the matching output of different matching module. In the matching score fusion scheme, weighted sum rule produced superior performance. The best recognition rate of 97% is achieved using 100 subjects. Based on the recognition analysis, there are three important parameters that affect the performance which is the size of input image, the effect of principal components number, and the number of DCT coefficient.

CHAPTER 1 : INTRODUCTION

1.1 Background study

In few years back, many types of research have broadly studied biometric recognition system to advance the well-being of personal identification. In comparison with the traditional method, biometric technology nowadays has made a major improvement because traditional methods, which are based on token, password and user identifier, give several limitations such as it is easily forgotten and it may be easy to be copied (Palma, Montessoro, Giordano, & Blanchini, 2017). By using biometric features, all of the limitation can be overcomed because those features are not disposed to theft and it also does not depend on the memory of human. Besides, the human can never imitate others biometric features.

Human biometric features can be divided into two types which are physiological and behavioral features. For physiological features or physical appearance, there are fingerprints, palmprints, hand geometry, face, iris and retina that have been studied in biometric technology (Li, Zhang, Zhang, & Yan, 2012). Each individual has unique biometric features and it remains unchanged during a person's lifetime. While in behavioral features there are voice, signature, gait and keystroke (Chakraborty, Bhattacharya, & Chatterjee, 2013). Several biometric processing techniques have been proposed to process both behavioral and physiological characteristics. Fusion of biometric is one of the approaches that can be applied to heighten the performance of system and security level.

In recent time, biometric palmprint has caught wide attention from researchers. Among of the physiological features, palmprint recognition is counted as one of the trustworthy technique in the biometric system. In general human palms are similar to fingerprints because they contain valley and ridge patterns. However, the unique features that contained in palmprints such as principal line, minutiae points, ridges, texture and singular point are expected to be more distinguishable than a fingerprint (Krishneswari & Arumugam, 2010). The research that has been conducted onto right palmprint image shows that the principal line consists of three lines named heart line, head line and life line respectively as showed in Figure 1.1 (Huang, Jia, & David, 2008). All of the lines are clear and barely change throughout the human existence. Palmprint is considered to be more distinctive than fingerprints because the area of the palm is wider than that of a finger.

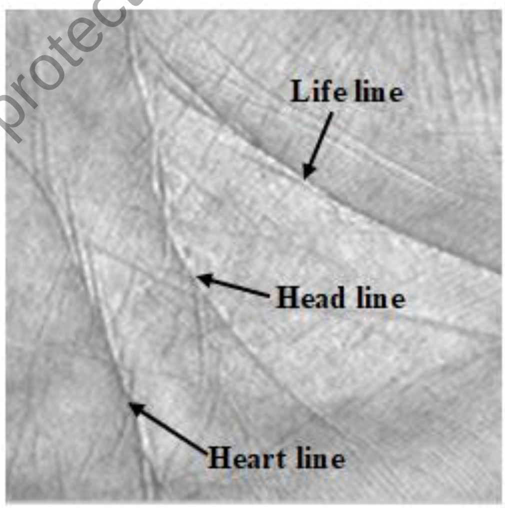

Figure 1.1: Three principal lines exist on a palm (Huang, Jia, & David, 2008)

Palmprint acts as a reliable human identifier because each individual has a different print pattern of features even in monozygotic twins (Kong, Zhang, & Lu, 2006). The details of the patterns are lastingly located in each individual. There are many other features associated in a palmprint, such as geometry features, wrinkles features and delta point features that are still open for investigation. Moreover, the recognition rate can increase significantly, which makes palmprint images more suitable for forensic applications that typically require high-resolution images, with at least 500 dpi. Palmprint is suitable to be used in forensic, commercial, and security applications.

Unlike face recognition, palmprint recognition is barely affected by age and accessories. In contrast to fingerprint recognition, palmprint images have more information and require only low-resolution image-capturing devices, which result in a more cost-effective system. It has rich information thus it is believed to give a better recognition rate compared to the other biometrics traits. Palmprint images differ from iris images in that the former can be captured without intrusiveness. Thus, palmprint recognition has become important and promptly going up in biometric technology over the past decade.

There are two types of features that can be extracted from palmprint image named as holistic feature and local feature. In palmprint recognition, these two features perform different roles yet can support each other. Holistic feature presents all the information such as the shape and contents of the image. It refers to the entire area of palm image. Meanwhile, local feature only focuses on small part of the palm image because it is divided into sub regions. Holistic feature and local feature capture the existing information in the palm image and both of the features are data independent (Kumar & Premalatha, 2014). These two features take advantages of each other because holistic feature have limitations in geometry and illumination such as the shift and rotation of the palm. Local feature can cover the limitations of holistic as it produce better features when the image has variations in geometry and illuminations.

Palmprint recognition modules mainly involve three main steps that are started with pre-processing, feature extraction, and matching as shown in Figure 1.2. Feature extraction is a key technique for palmprint recognition. The purpose of feature extraction is to extract structural information that exists in palmprint. The precious structures of the palmprint offer a large number of useful information for recognition. Apparently, there are many suitable approaches for feature extraction such as subspace-based approaches, statistical-based approaches, structural-based approaches and some other approaches that can support a certain scale of identification (Kong, Zhang, & Kamel, 2009).

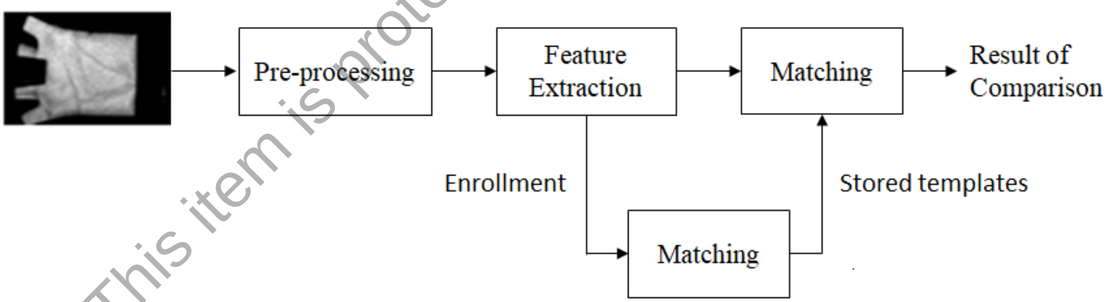

Figure 1.2: Overall structure of Palmprint Recognition System (Kong, Zhang, & Kamel, 2009)

To overcome the limitation of a single feature, fusion of biometrics is one of the techniques that can boost the discrimination power. The purpose of fusion is to increase the matching accuracy of a biometric system. Features are the core characteristics of palmprint recognition methods. Line features based on location, orientation, and position are used relative to the other features, with data presented in the local structure format. The acquired local structure is invariant to rotation. Moreover, the acquired local structure can tolerate reasonable distortion because it was obtained from only a small area of the palmprint. Information fusion extracted from the local region and holistic information of palm image is able to enhance the discrimination power.

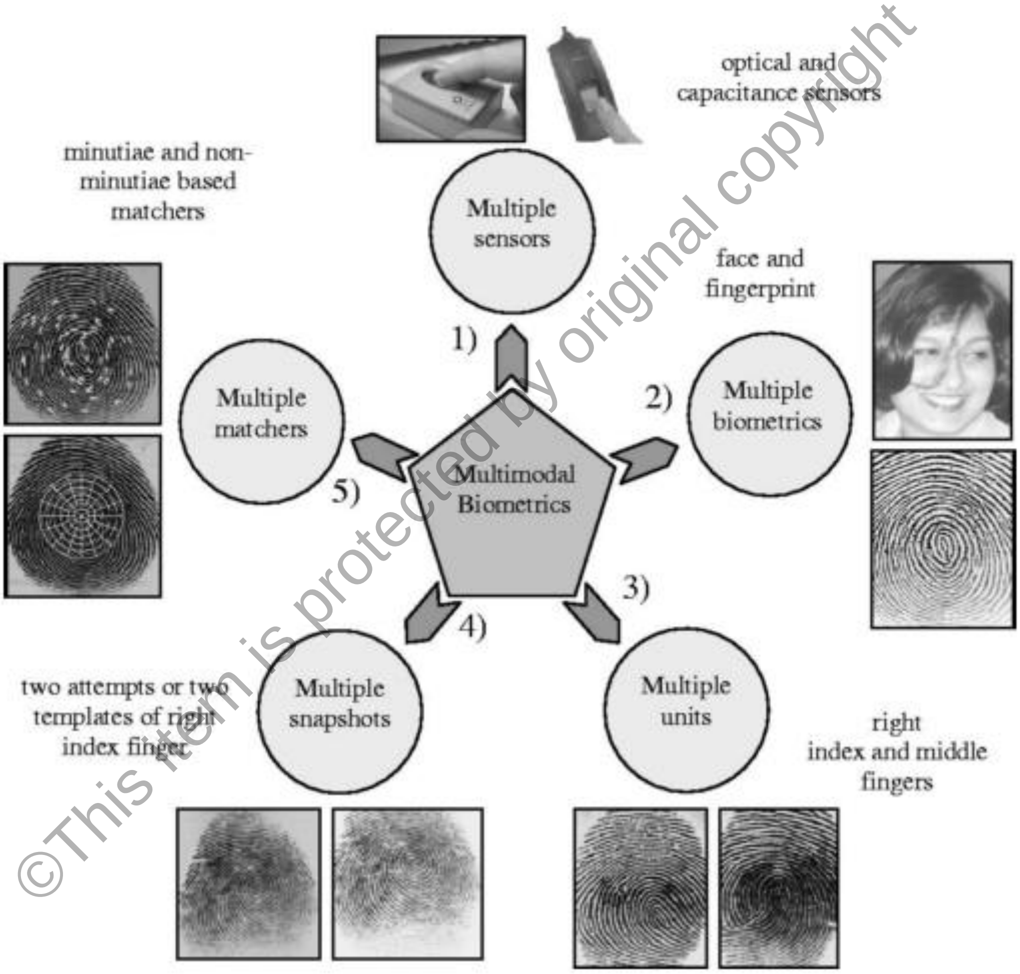

Figure 1.3: Multimodal biometrics system (Jain, Ross, & Prabhakar, 2004)

However, there is also fusion that involves multi-modal biometric (Jain, Ross, & Prabhakar, 2004). Some of the researchers combine different types of biometric features such as face and palmprint images for a satisfactory recognition performance (Farmanbar & Toygar, 2015). Figure 1.3 shows the multimodal biometric system that consists of multiple sensors, multiple biometric, multiple units, multiple snapshots and matchers.

1.2 Problem Statement

The success of palmprint recognition requires the search for the best matching of the test sample from the input and the templates in the palmprint database. In order to achieve the best matching between test and template, a good feature must be extracted from palm texture image and a good classifier must be designed to deal with feature space. Most of the existing work in feature extraction in palmprint recognition use holistic and local features separately. Using holistic features alone will have a limitation when the palm image has variations in the geometry and illumination. Meanwhile, local features is a better features when the image has variations in geometry and illumination (Choge, Oyama, & Karungaru, 2009). However, by using local features alone some important information is discarded during feature extraction process because of its small region. To overcome this problem, the important information can be preserved by integrating the information extracted from holistic and local features.

The single feature of biometric has limitations in uniqueness, non-universality and contains some noisy data. Hence, it may not be able to achieve the desired performance requirements of real-world application. So, to overcome all of the limitations, fusion of multimodal features can provide a higher performance in terms of recognition rates (Zhang, Zuo, & Yue, 2012). Although there are various levels of information fusion in a biometric system, integration at the matching score level is the most general approach due to the ease in combining the matching scores generated by different matchers.

1.3 Research Objectives

The aim of this project is to develop feature extraction and information fusion techniques for palmprint images used for a biometric recognition system. The objectives of the projects are as follows:

1) To enhance feature extraction method for palmprint image by using both holistic and local approach.

2) To design fusion rule at matching score level to combine holistic and local matching score.

1.4 Research Scope

This research project used palmprint image for person identification. The scope of this project is to extract features from holistic and local features using Gabor filter bank and Discrete Cosine Transform (DCT) respectively. To perform the matching process, Euclidean distance classifier is needed to achieve maximum accuracy. The proposed algorithms are implemented using MATLAB software. The algorithm is modelled using m code. The entire algorithms are tested using the benchmark PolyU palmprint dataset developed by Hong Kong Polytechnic University that is widely used in many palmprint recognition (Younesi & Amirami, 2017).

1.5 Thesis Organization

This thesis is organized into five chapters to cover all the research works about fusion of holistic and local features for palmprint recognition.

Chapter 1 presents the background study about human biometric features and palmprint recognition system. This chapter also presents the problem statement, research objective and research scope.

Chapter 2 discussed the related study about palmprint feature extraction algorithm and some existing works for palmprint recognition system. This chapter also explained some of the classifiers that are used in palmprint recognition method. The information about different levels of fusion is also discussed.

Chapter 3 presents research methodology of the research work. This chapter discusses about methodology in palmprint recognition system and overall block diagram of proposed method that focuses on holistic feature extraction using Gabor filter bank and local feature extraction using Discrete Cosine Transform (DCT). The computation of Principal Component Analysis (PCA) and the classification using Euclidean Distance classifier are explained in this chapter.

Chapter 4 evaluates the experimental setup and the results of the proposed method. All the finding data on pre-processing technique, holistic features extraction, local feature extraction and fusion rule are distinctly discussed in this chapter.

Chapter 5 concludes all the research work and the outcomes of the fusion of holistic and local features. Some recommendations for future work are also provided in this chapter.

CHAPTER 2 : LITERATURE REVIEW

2.1 Introduction

This chapter presents the literature review of palmprint recognition method. It starts with the feature extraction algorithm that followed by distance measurement and information fusion. The last part is the existing work of fusion of holistic and local feature. More recently, literature has emerged that offers contradictory findings of palmprint recognition method. Palmprint recognition has become an important and rapidly developing biometric technology over the past decade. One major theoretical issue that has dominated the field for many years' concerns is about feature extraction. Generally, feature extraction is the stage that considers the extensive variety of techniques and can be classified into holistic (Yan et al., 2004) and local features (Hammami, Ben Jemaa, & Ben-abdallah, 2012). Furthermore, information fusion of palmprint biometric is also popular in order to produce a better recognition performance. The overall structure of the study takes the form of three major steps includes pre-processing techniques, feature extraction, and matching process before proceeds with fusion for a better recognition rate. Pre-processing is used to align palmprint images and to segment important region of palmprint image for feature extraction. Feature extraction obtains low dimensional features from the pre-processed palmprints. A matcher compares two palmprint features during classification process and a database stores the registered templates.