PALMPRINT RECOGNITION USING EIGEN-PALM IMAGE IMPLEMENTED ON DSP PROCESSOR

by

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LIST OF SYMBOLS

EU	Euclidean distance
pp	point in Euclidean *n*-space
qp	point in Euclidean *n*-space
MD	Mahalanobis distance
S	Two-Dimensional Covariance Matrix
$D_{Chebyshev}$	Chebyshev distance
T	2D Matrix of stacked training or testing images vectors
A	images vectors
γ	sample palmprint image
y	feature vector
μ	mean vector
$\boldsymbol{S}_T$	scatter matrix
$\overline{X}$	mean value
Z	Two-Dimensional Zero-Mean Training Data Matrix
m	vector number
λ	eigenvalue diagonal matrix
e	2D eigenvector matrix
$e_{projected}$	eigenvector matrix after projection
F	feature vector matrix of the training data
g	length of the leg of the right triangle
h	length of the leg of the right triangle
j	length of the hypotenuse
FAR	False Accept Rate

FRR	False Rejection Rate

LIST OF ABBREVIATIONS

1D	One Dimensional
2D	Two Dimensional
3D	Three Dimensional
ADC	Analogue to Digital Signal Converter
ALU	Arithmetic-Logic Unit
CASIA	Chinese Academy of Sciences, Institute of Automation
CCS	Code Composer Studio
CMC	Cumulative Match Characteristic
CMOS	Complementary Metal Oxide Semiconductor
DAC	Digital to Analogue Signal Converter
DCT	Discrete Cosine Transform
DIP	Dual In-Line Package
DSK	Digital Signal Processing Starter Kit
DSP	Digital Signal Processing
DSP*	Digital Signal Processor
ED	Euclidean Distance
EER	Equal Error Rate
FAR	False Accept Rate
FRR	False Rejection Rate
FT	Fourier Transform
GAR	Genuine Accept Rate
GT	Gabor Transform
GWT	Gabor-Wigner transform

ICA	Independent Component Analysis
ICP	Iterative Closest Point
IDE	Integrated Development Environment
IITDelhi	Indian Institute of Technology Delhi
IITK	Indian Institute of Technology Kanpur
JTAG	Joint Team Action Group
LDA	Linear Discriminant Analysis
MAC	Multiply-And-Accumulate
MD	Mahalanobis distance
NN	Nearest Neighborhood
PC	Principal Components
PC*	Personal Computer
PCA	Principle Component Analysis
PCAC	Principle Component Analysis Coefficient
PHOG	Pyramidal Histograms of Oriented Gradients
PolyU	Hong Kong Polytechnic University
POP	Principal Orientation Pattern
PPI	Pixels Per Inch
PSO	Particle Swarm Optimization
RLOC	Robust Line Orientation Code
ROI	Region of Interest
SDRAM	Synchronous Dynamic Random Access Memory
SIFT	Scale Invariant Feature Transform
SVM	Support Vector Machine
TI	Texas Instruments

TPTSR	Two-Phase Test Sample Representation
VLIW	Very Long Instruction Word
WT	Wavelet Transform

Pengecaman Tapak Tangan Menggunakan Imej Eigen-palm Dibangunkan Dengan Menggunakan Prosessor DSP

ABSTRAK

Kajian ini memberi tumpuan kepada pembangunan sistem pengecaman manusia menggunakan imej-eigen tapak tangan. Pengecaman manusia berasaskan teknologi biometrik digunakan dengan meluas di dalam beberapa aplikasi seperti system kawalan akses dan penyiasatan kes jenayah. Kaedah yang dibangunkan terdiri daripada tiga peringkat utama. Peringkat pra-pemprosesan untuk memproses imej tapak tangan untuk menghasilkan maklumat penting dan menghasilkan paparan yang lebih jelas daripada imej asal. Peringkat kedua, ciri-ciri penting diekstrak dari imej tapak tangan dan pengurangan dimensi data dilakukan dengan menggunakan teknik analisis komponen utama (PCA). Satu kaedah unjuran linear digunakan di peringkat ini untuk mengurangkan maklumat berulangan dan keluarkan hingar dari imej tapak tangan. Tambahan pula, pendekatan ini meningkatkan kuasa diskriminasi dalam ruang taburan ciri tersebut. Taburan ciri dimensi rendah dalam ruang ciri diandaikan Gaussian. Oleh itu, Euclidean Classifier boleh digunakan di peringkat klasifikasi, yang merupakan peringkat ketiga. Kaedah yang dibangunkan diuji menggunakan PolyU dataset. Hasil analisis menunjukkan kadar terbaik pengecaman yang dicapai adalah 97.5 % apabila imej tapak tangan dikurangkan saiz kepada skala 0.2 dan diwakili oleh 34 pekali PCA. Penjujuran data dan Euclidean Classifier dibangunkan dengan menggunakan prosessor pemproses isyarat digital (DSP). Perlaksanaan algoritma yang dicadangkan dengan menggunakan prosessor DSP dapat mencapai prestasi yang lebih baik kepada masa pengiraan jika dibandingkan dengan sistem yang berasaskan komputer dimana 47.2% lebih pantas.

Palmprint Recognition Using Eigen-palm Image Implemented on DSP Processor

ABSTRACT

This study focuses on the development of a human identification system using eigen-palm images. Human identification based on biometric technology is extensively used in several applications, such as access control and criminal investigation. The proposed method consists of three main stages. The preprocessing stage computes the palmprint images to capture important information and produce a better representation of palmprint image data. The second stage extracts significant features from palmprint images and reduces the dimension of the palmprint image data by applying the principal component analysis (PCA) technique. A linear projection method is used in this stage to reduce redundant features and remove noise from the palmprint image. Furthermore, this approach increases discrimination power in the feature space. The Euclidean distance classifier is used in the classification stage, which is the third stage. The proposed method is tested using a benchmark PolyU dataset. Experimental results show that the best achieved recognition rate is 97.5% when the palmprint image is resized with 0.2 resizing scale and represented using 34 PCA coefficients. The raw data projection and Euclidean distance classifier can be implemented on a digital signal processor (DSP) board. Implementing the proposed algorithm using the DSP board achieves better performance in computation time compared with a personal computer-based system which make the system 47.2% faster.

CHAPTER 1

INTRODUCTION

1.1 Background

Humans have used individual characteristics, such as fingerprint, gait, and face, to identify one another. A biometric system is a modern and powerful tool used to recognize a person by using biological and behavioral characteristics. In a biometric framework, verification is a process that validates a claim user and identification is a process that determines identity from the given biometric traits. Traditional methods based on tokens, passwords, and user identifiers have several limitations, such as being difficult to remember and easy to forge. Biometric technology has also been applied in criminal investigation, automatic access control, and security system. Various biometric traits have been proposed, such as face, fingerprint, palmprint, and iris, and all of these traits have their own advantages. Several biometric processing techniques have been proposed to process behavioral or physiological characteristics (Jain et al., 2004). The biometric recognition framework consists of several parts that implement subsequent steps, which leads to recognition of the person. A basic block diagram of a biometric recognition system is shown in Fig. 1.1.

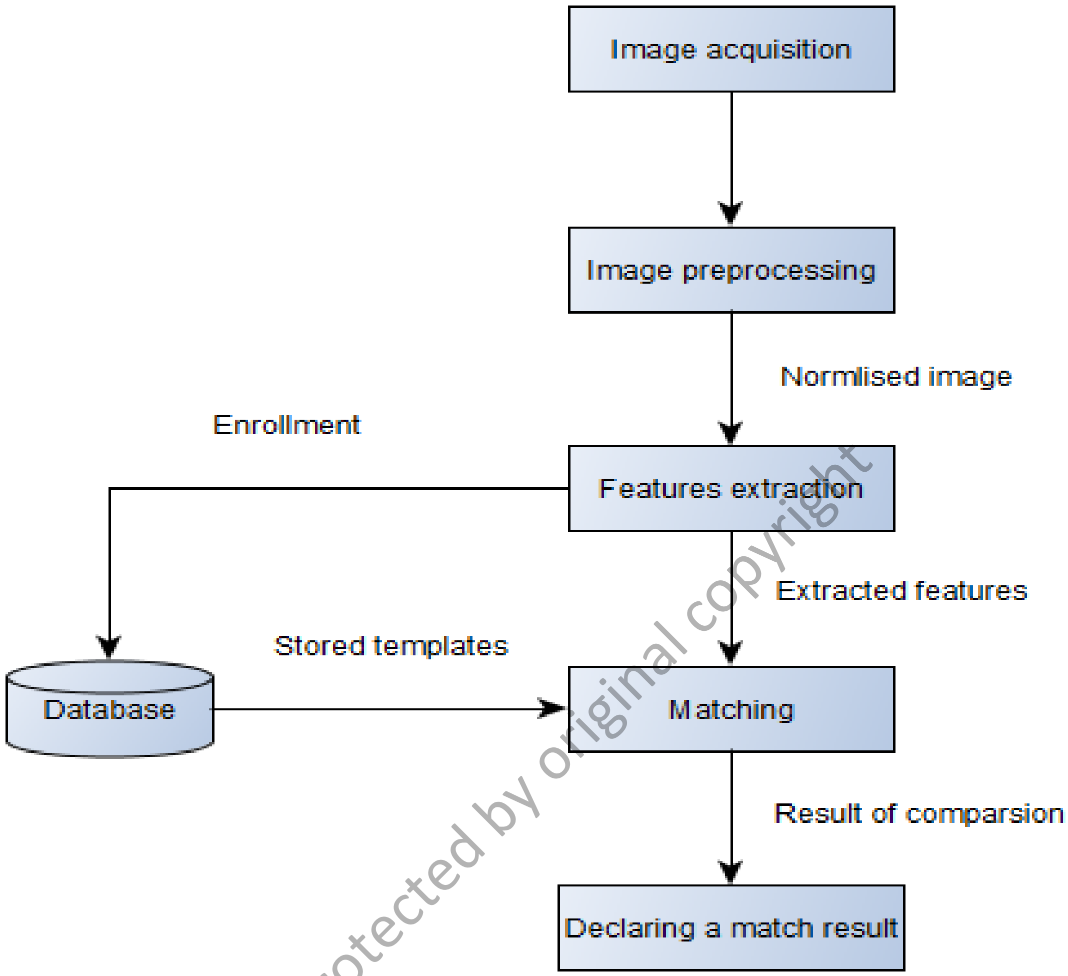

Figure 1.1: Main Steps in a Biometric Recognition System.

1. Image acquisition

Image acquisition is a process that captures the raw data of the physical or behavioral characteristics of a subject using image sensors, such as cameras and scanners (Jain et al., 2004). An example of physical image acquisition is a facial image captured by a CCTV camera, a palmprint image captured by a scanner, and a fingerprint image captured by a fingerprint sensor. An example of image acquisition of behavioral characteristics is using a camera to capture gait sequences. A raw image contains noise information, redundant features, and high dimensionality. Thus, processing tools are required to process the image. Several linear and nonlinear processing tools are extensively used to produce low-dimensional features. Appropriate selection of processing tool is required to analyze various biometric traits because all of these traits provide different information. For example, a palmprint image requires a tool that is able to capture its texture and a fingerprint image needs an algorithm that is able to boost the line and shape of the finger pattern.

2. Image Preprocessing

The purpose of preprocessing is to enhance some image features, increase image intensity, remove noise data, and increase brightness. Image preprocessing emphasizes details that are disturbed during image acquisition or highlights particular features of interest in an image. Image preprocessing improves the recognition rate of the biometric recognition system (Jain et al., 2004). Preprocessing is an unsupervised method where labeling of a certain class is not required. Preprocessing algorithm emphasizes different biometric data. For instance, a palmprint image requires region of interest (ROI) cropping where the most important features. A small area for preprocessing also affects recognition performance because of less information available in the area. Meanwhile, a large ROI increases processing time and memory cost. When the algorithm is implemented in hardware, such as a digital signal processing (DSP) processor, a suitable ROI size must be identified to guarantee good performance.

3. Feature Extraction

Feature extraction produces low-dimensional feature vectors that are sufficient to represent the important features of biometric traits. Feature extraction in biometric images has two main categories, namely, local features category and global features (holistic features) category. The local features category extracts information from a small region of image texture by dividing the image into several sub-block windows and processing them independently. Meanwhile, the holistic features category captures information from the entire image texture to produce a single feature vector. Several linear and nonlinear methods have been used in feature extraction, such as principal component analysis (PCA), kernel PCA, linear discriminant analysis (LDA), kernel LDA, and independent component analysis (ICA). All of these approaches produce a lower-dimensional feature vector, which is suitable for hardware implementation. However, the linear method has less computational cost.

The most well-known method used to extract the important features of a biometric image is the PCA, which is extensively used in face, palmprint, iris, and fingerprint recognition. Another supervised method used for feature extraction is the LDA. The PCA and LDA algorithms are classified under the holistic features category, where the raw images are projected to a most dominant eigenvector to produce a low-dimensional feature vector called template. The template represents the unique features of an enrolled individual biometric in a reduced set form of raw data. The template is stored in the system database or used directly in the matching process (Jain et al., 2004).

4. Matching Process

The final stage in the biometric recognition system is the comparison of the test pattern with a template stored in the database. In the identification process, the captured sample is compared with every template in the database. This process returns a match score that represents how close the captured sample is to the templates in the database. Matching scores are obtained by using classifier algorithms, such as Euclidean and Mahalanobis distances, which compute the distance between two data points in a feature space. In verification systems, a test feature is compared with a specific template in a database that is assumed to belong to the same person, which makes it faster than identification (Jain et al., 2004). This process is a one-to-one matching process. The verification process requires a certain threshold value to be set for each of the matching processes. The decision is to accept if the matching value is less than a threshold; otherwise, it is rejected.

1.2 Biometric Traits

Several biometric traits contain important information that is suitable for representing an identity. Several of these traits can be classified as physiological and behavioral traits, as shown in Fig. 1.2, which can be grouped as contact and contactless biometrics. Different biometric traits have different information. For instance, a face image has abundant information related to image texture, keystore data have abundant information related to speed dialing, and a fingerprint image has abundant information related to line texture.

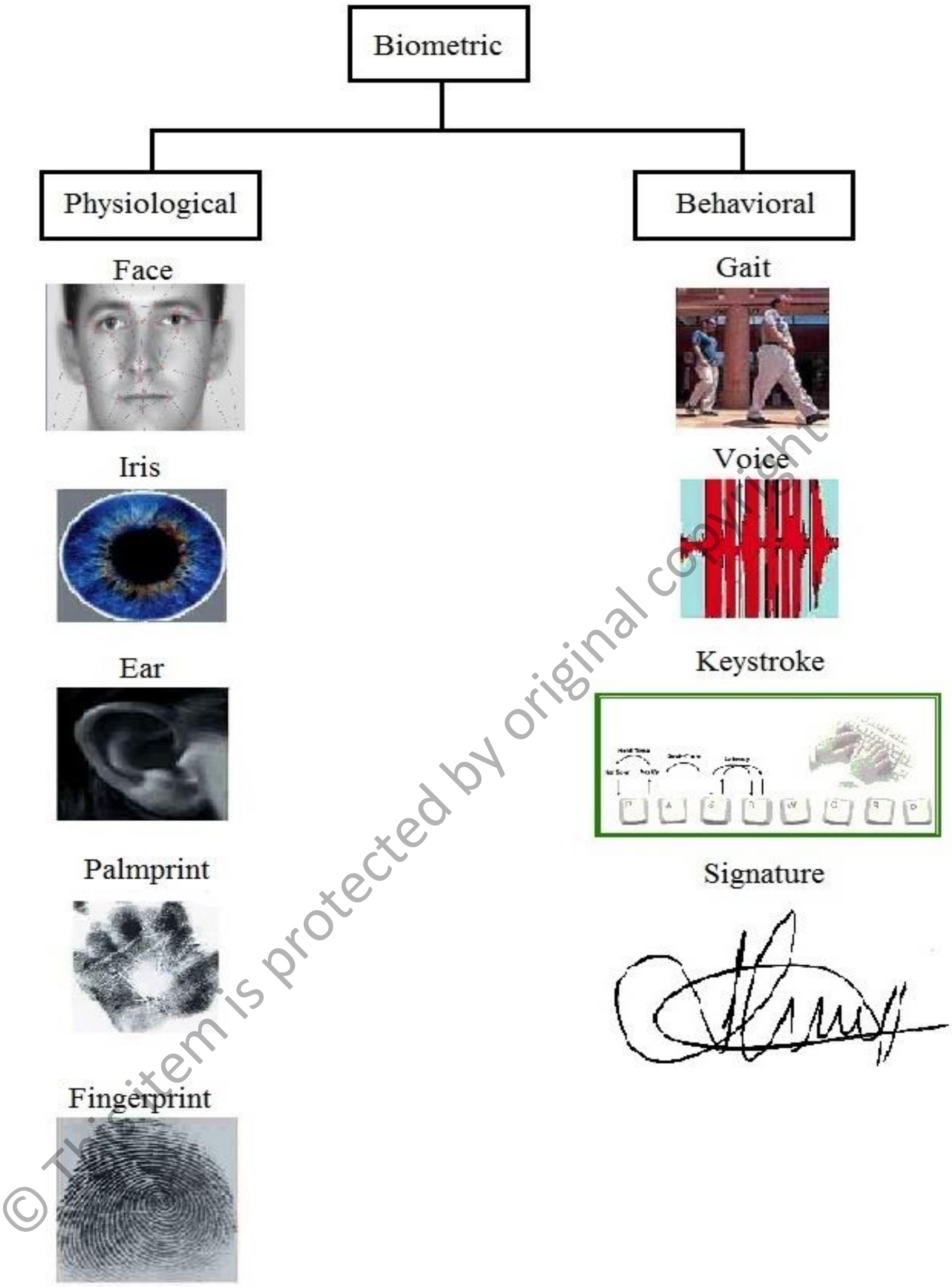

Figure 1.2: Biometric Recognition Methods.

1. Gait Recognition

Gait is a behavioral biometric used in biometric recognition systems. Gait may change over time because of the change in body weight and/or brain or major injuries. Gait acquisition is similar to acquiring a facial picture such that an acceptable biometric is obtained. A gait recognition system is considered to be expensive in terms of computation power because gait-based biometric systems use the video sequence footage of a walking person to measure several different movements in each articulate joint (Jain et al., 2004).

2. Keystroke or Typing Recognition

The typing patterns of an individual, such as the time spacing of words, can be used to determine the identity of an individual. Keystroke recognition can be used for identifying persons, who, for example, send inappropriate e-mail or do fraudulent activity on the Internet. Keystroke recognition is executed by a keystroke recognition software installed on the computer of a person. However, the effectiveness of the keystroke recognition software may change when the user changes the keyboard because of physical problems, such as difficulty in pressing the keys (Jain et al., 2004).

3. Voice Recognition

Voice recognition is used to determine the identity of an unknown speaker by using the speech style and patterns of voice pitch. Voice behavioral patterns differ with every individual. In criminal investigation, voice is used to identify the criminal by