IMPLEMENTATION OF FINGERPRINT BIOMETRIC TEMPLATE SYSTEM IN EMBEDDED SOFTWARE DESIGN

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Specially dedicated to
dearest family and beloved husband

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ABSTRACT

Reliable personal identification is necessary due to the growing importance of information technology and the necessity of protection and access restriction. The key task is to verify the person is who they claim to be. A biometric security system verifies user identity by comparing the behavioral or physiological trait possessed by the user to a previously stored sample of the trait. Fingerprints are the oldest and most widely used form of biometric identification. Local characteristic called minutiae points represent fingerprints. This project proposed an embedded software design of fingerprint biometric authentication system that involved interface design and software development in an embedded processor. The system consists of two components; the Graphic User Interface (GUI) on a host PC and the Fingerprint Biometric Template system on the Field Programmable Gate Array (FPGA) development board. The GUI will access the image repository and display the output image at each processing steps. The Fingerprint Biometric Template System contains three stages; image processing, feature extraction and matching stage. The image processing stage will enhance and skeletonized the fingerprint image, the feature extraction stage will extract the valid minutiae points in template based, and the matching stage will match the template with a previously stored template. An embedded software system that can verify the minutiae templates extracted a fingerprint image is resulted from this project.

ABSTRAK

Perkembangan teknologi maklumat yang pesat pada waktu kini menjadikan keperluan untuk melindungi data dan maklumat daripada dicerobohi semakin penting. Secara tidak langsung, sistem pengecaman diri yang efektif menjadi satu keperluan utama. Kegunaan utama sistem pengecaman diri adalah untuk memastikan individu itu adalah seperti yang didakwanya. Sistem keselamatan biometrik mengenalpasti setiap individu dengan cara membandingkan perangai atau sifat fisiologi yang dimiliki oleh individu tersebut dengan contoh sifat yang telah sedia ada dalam simpanan data. Cap jari adalah cara terawal dan paling banyak digunakan sebagai pengecam biometrik. Cap jari diwakili oleh ciri-ciri terperinci yang dipanggil titik *minutiae*. Projek ini merangkumi satu rekabentuk perisian terbenam untuk satu sistem pengesahan biometrik berdasarkan cap jari yang mana melibatkan rekabentuk antaramuka dan pembangunan perisian di dalam satu pengawal terbenam. Sistem ini mengandungi dua komponen iaitu Antaramuka Pengguna Grafik (GUI) pada computer dan sistem pencontoh biometrik berdasarkan cap jari di dalam papan prototaip FPGA. GUI akan mendapatkan imej daripada gedung imej dan memaparkan imej keluaran untuk setiap proses. Sistem pencontoh biometrik berdasarkan cap jari ini mengandungi tiga proses; pemprosesan imej, pengenalpastian ciri, dan proses pemadanan. Pemprosesan imej akan membaikpulih dan menipiskan imej cap jari sehingga selebar satu pixel, proses pengenalpastian ciri mengestrak titik *minutiae* yang sah dalam bentuk pencontoh dan proses pemadanan akan memadankan pencontoh itu dengan pencontoh yang telah di simpan. Satu sistem perisian terbenam yang boleh mengesahkan pencontoh *minutiae* yang diestrak daripada imej cap jari terhasil daripada projek ini.

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LIST OF ABBREVIATIONS

ADO	-	ActiveX Data Object
AFIS	-	Automated Fingerprint Identification System
CN	-	Crossing Number
CPU	-	Central Processing Unit
DAO	-	Data Access Object
EDA	-	Electronic design Automation
FPGA	-	Field Programmable Gate Array
GUI	-	Graphic User Interface
ODBC	-	Open Database Connector
OLE DB	-	Object Linking and Embedding Database
PC	-	Personal Computer
PDA	-	Personal Digital Assistant
PIO	-	Parallel Input Output
PLD	-	Programmable Logic Device
RISC	-	Reduced Instruction Set Computer
SDK	-	System Development Kit
SoC	-	System-on-Chip
SOPC	-	System-on-a-Programmable-Chip
UART	-	Universal Asynchronous Receiver Transmitter
$\bullet$	-	Closing Operator
$\oplus$	-	Dilation Operator
Θ	-	Erosion Operator
$\circ$	-	Opening Operator

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CHAPTER 1

INTRODUCTION

This thesis proposes the FPGA implementation of an embedded fingerprint recognition system. The design applies the System-on-Chip (SoC) technology to produce a system that can perform fingerprint image processing, extraction of the biometric feature from the image and authenticate the template.

1.1 Background

As our everyday life is getting more and more computerized, automated security systems are getting more and more important. Today, most of the banking transactions can be performed over the Internet and soon they can also be performed on mobile devices such as cell phones and PDAs. This rapid progress in wireless communication system, personal communication system and smart card technology in our society makes information more susceptible to abuse. Due to the growing importance of the information technology and the necessity of the protection and access restriction, reliable personal identification is necessary.

The key task of an automated security system is to verify that the users are in fact who they claim to be. There are three main methodologies when performing this verification. The security system could ask the user to provide some information known only to the user, it could ask the user to provide something only the user has access to or it could identify some sort of trait that is unique for the user. Identifying some trait that is unique for the user is known as biometric security. A biometrics system is a pattern recognition system that establishes the authenticity of a specific physiological or behavioral characteristic possessed by a user.

Nowaday, embedded systems have become increasingly popular as advances in IC-technology and processor architecture allow for flexible computational parts and high-performance modules integrated on a single carrier. Embedded system interacts with the physical world. It executes on machines that are not, first and foremost, computers. They are cars, airplanes, telephones, audio equipment, robots, appliances, toys, security systems, pacemakers, heart monitors, weapons, television sets, printers, scanners, climate control systems, manufacturing systems, and so on. They performed function carefully partitioned in software and hardware to strike the balance between flexibility, reusability, performance and cost.

1.2 Problem Statement

As mention earlier, it is important to have reliable personal identification due to growing importance of information technology. A biometric security system is the key task to the automated security system that use a specific physiological or behavioral characteristic possessed by a user.

Of all the biometric techniques being used today, fingerprint-based identification is the oldest method, which has been successfully used in numerous applications. Every one is known to possess a unique fingerprint and it does not change throughout his lifetime and so the fingerprint matching is considered one of the most reliable techniques of people identification. A fingerprint is formed from an impression of the pattern of ridges on a finger. A ridge is defined as a single curved segment, and a valley is the region between two adjacent ridges.

There are two types of fingerprint representations: local and global. Local representations predominantly based on ridge endings or bifurcations (collectively known as minutiae (see Figure 1.1)) are the most common, primarily due to the following reasons:

- Minutiae capture much of the individual information
- Minutiae-based representations are storage efficient
- Minutiae detection is relatively robust to various sources of fingerprint degradation.

Typically, minutiae-based representations rely on locations of the minutiae and the directions of ridges at the minutiae location. Cores and deltas are global representation of the fingerprint.

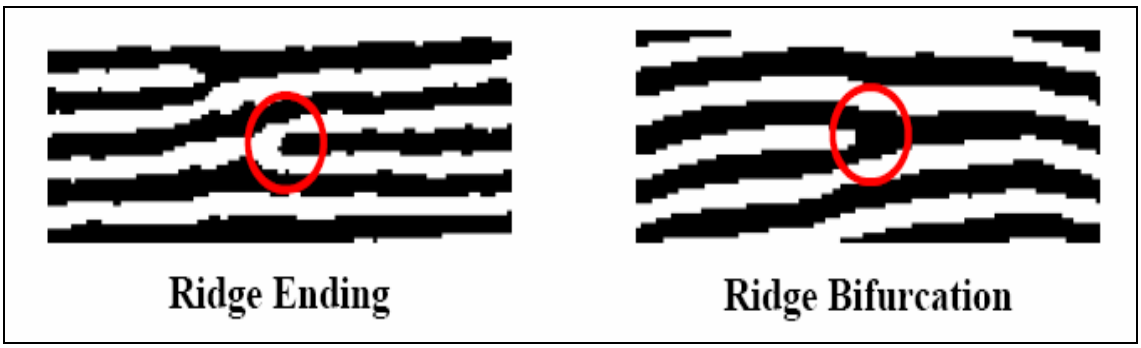

Figure 1.1 : Ridge ending and ridge bifurcation

1.3 Objective

From the discussion above, this project has set two objectives.

1. To design and develop a fingerprint biometric template system that can process every fingerprint image inserted by the user and extracted the minutiae points from the image in template based.

2. To implement the fingerprint biometric template system in an embedded processor on a FPGA development board.

1.4 Scope of Work

1. Input fingerprint images are stored in an image repository on the host pc. In software development, this project uses 256 gray-sales bitmap images with sizes of 128 pixels x 128 pixels as a test vector. In embedded system, this project uses 256 gray-sales bitmap images with sizes of 80 pixels x 80 pixels as test vector.

2. Although many types of minutiae points exist, this project only extracts the most prominent type, which is ridge ending and ridge bifurcation.

3. The Fingerprint Biometric Template system is implemented on an Altera Nios APEX EP20K200EFC484-2X development board.

4. The Fingerprint Biometric Template will process and enhance the image at the image processing stage.

5. The enhanced image will be sent to feature extraction stage to extract the biometric template.

6. A simple matching system using point matching is designed to validate the system.

A fingerprint recognition system involves many process and stages. Figure 1.2 shows the general process to recognize a fingerprint. For this project, the scope is shown by dashed box in Figure 1.2.

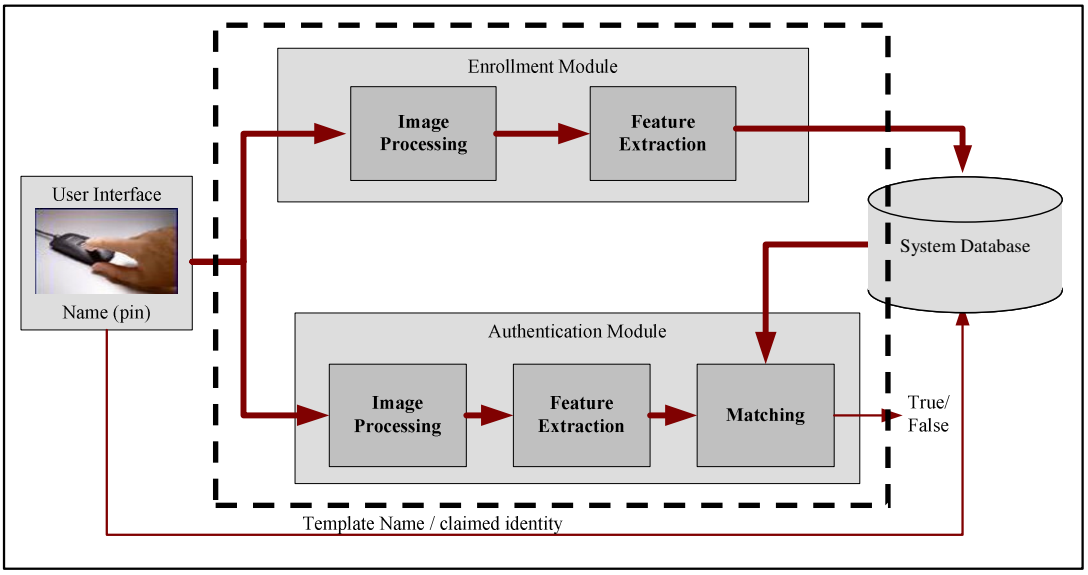

Figure 1.2 : General process in identifying a fingerprint

1.5 Project Contribution

A prototype of the fingerprint recognition system implemented in embedded system. The fingerprint recognition system, which is called Fingerprint Biometric Template system extract the minutiae points in template based.

A systematic design approach to design an embedded system in a SoC environment based around Altera Nios embedded processor using software embedded design techniques has been introduced.

1.6 Thesis Organization

This thesis is organized into six chapters. The first chapter introduced the motivation, research objectives, scope of work and contribution of this project.

Chapter 2 reviews the background of the project. Algorithms used in developing the system are also explained in this chapter.

Chapter 3 presents the research methodology, system design procedures and application tool that have been used in this project.

Chapter 4 described the software development of the system and implementation of the software in embedded system.

Chapter 5 presents the result for each stage in the system and discussion of the overall result.

In the final chapter, the research work is summarized and the potential future works are given.

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