THUMBPRINT PREPROCESSING USING ALTERA CYCLONE DE2 BOARD

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To my dearest mother who never stops loving…

ACKNOWLEDGEMENT

It is 0445, I have been anticipating for the past 36 hours for this moment. Here I am, completing the last piece of puzzle to my project report. I have definitely saved the best for last. At this very moment here, I am all humbled and grateful, and I have clearly in my mind him, to whom I feel that I owe a big giant thank-you, not because the faith of my project pretty much lies in his hands, instead it is his kindness and understanding along the way that always shed a light. It has been a rocky road to me, I fell down, and I hit the rock bottom. There were numerous times that I have disappointed myself; there were countless times that reality has rendered me helpless, and then doubt creeps in. Whenever I looked to him to check if I am such a let-down, he always let his positivity shine and brighten up the whole boulevard. He gave me words of encouragement and trust when I have doubted myself. He understood me when I expected that no one would have understood. From the bottom of my heart, I would like to extend my heartfelt gratitude to you, my supervisor, Dr. Syed. You have touched a person, and made a big difference in somebody else's live with a small gesture that you may not even notice. Thank you!

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ABSTRACT

Thumbprint has been by far the most reliable and acceptable form of biometric identification system. This project aims to implement the thumbprint preprocessing procedures from the software front with the utilization of Altera Cyclone DE2 board to improve raw thumbprint images up to a standard necessary to facilitate subsequent processing processes for thumbprint recognition. In order to realize this, the configurable FPGA hardware of the board has to be ready to enable the operation of the Nios II processor. The preprocessing procedures have to be defined in a description (ANSI-C++) that is understandable by the board. This project looks out for an implementation option that satisfies the requirements on flexibility and portability while trying to incorporate as much as possible the needs from multiple perspectives, namely computational cost, algorithm speed, and storage requirement. The pre-processing procedure generally comprises five main stages, namely filtering, contrast enhancement, adaptive segmentation, noise elimination and thinning. The project has proven that Altera Cyclone DE2 board is a feasible implementation option for thumbprint image preprocessing. Comparable image quality can be achieved with the thumbprint preprocessing procedures on the DE2 board which offers great flexibility and portability at the expense of slight penalty in processing time.

ABSTRAK

Cap ibu jari adalah bentuk identifikasi biometrik yang paling dipercayai sampai hari ini. Projek ini bertujuan untuk menerapkan prosedur pra-pemprosesan cap ibu jari dari segi perisian dengan menggunakan papan Cyclone DE2 dari Altera untuk memperbaiki imej cap ibu jari sehingga tahap yang bersesuaian untuk mempermudahkan proses pengiktirafan cap ibu jari yang seterusnya. Demi itu, peranti keras FPGA perlu dikonfigurasi untuk mengaktifkan penggunaan Nios II prosesor. Prosedur pra-pemprosesan juga perlu ditakrifkan dalam bentuk ANSI-C yang boleh difahami oleh papan itu. Projek ini berusaha untuk mencari kaedah pelaksanaan yang memenuhi keperluan dari segi fleksibiliti dan kemudahalihan sambil memenuhi sebanyak mungkin keperluan dari pelbagai perspektif, iaitu kos komputasi, kelajuan algoritma, dan keperluan simpanan. Prosedur pra-pemprosesan umumnya terdiri daripada lima tahap utama, iaitu penapisan, penambahan kontras, segmentasi adaptif, penghapusan hingar dan penipisan. Projek ini telah membuktikan bahawa papan Cyclone DE2 dari Altera adalah pilihan yang sesuai untuk pra-pemprosesan cap ibu jari. Prestasi yang sebanding dengan Matlab boleh dicapai melalui pelaksanaan prosedur pra-pemprosesan dengan menggunakan papan DE2 di samping menawarkan fleksibiliti dan portabilitas hanya dengan sedikit pengorbanan dari masa pemprosesan.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ANSI-C	American National Standards Institute for C Language
BMP	Bitmap
C2H	C-to-Hardware Acceleration
CAD	Computer Aided Design
FPGA	Field Programmable Gate Array
HAL	Hardware Abstraction Layer
IDE	Integrated Development Environment
JTAG	Joint Test Action Group
ROI	Region of Interest
SOPC	System on Programmable Chip
SRAM	Static Random Access Memory
UART	Universal Asynchronous Receiver/ Transmitter

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

This project aims to implement the thumbprint preprocessing procedures from the software front with the utilization of Altera DE2 board to improve raw thumbprint images up to a standard necessary to facilitate subsequent processing processes for thumbprint recognition. This chapter starts with a brief introduction to the background, and challenges which lead to the motivation of this project. Definition of scopes and organization of the report would be wrapped up in the later part of this chapter.

1.1 Background

"In the mid-19th century, it was established that no two fingerprints from different fingers have the same ridge pattern and that fingerprint ridge patterns remain the same throughout a person's life (Quit Gao *et al*., 2001)." Since then, fingerprints have been widely used and remains until today a reliable means for personal identification. Until now, fingerprints were usually employed in forensic applications for identification of criminals. Thanks to the increasing power of

computers and to better scanners, research on fingerprint-based recognition systems for civilian applications, such as banking security and physical access control, is becoming more and more attractive.

Image Preprocessing is an important step in the area of image processing and pattern recognition to improve the interpretability and quality of information in the raw thumbprint images up to a satisfactory level to facilitate the subsequent processing steps.

1.2 Challenges and Motivations

Fingerprint has been by far the most reliable and acceptable form of biometric identification system. The image processing algorithms used in present-day fingerprint-based recognition systems are usually digital and operate pixel-wise and sequentially. Accordingly, they are rather time-consuming. Another major issue is how to improve the recognition rate to satisfy the practical requirements for a given application. "Furthermore, efforts still need to be made to further reduce the size and the power consumption of the systems in order to make them suitable for portable applications (Eun-Kyung Yun *et al.*, 2005)."

Most of fingerprint processing are done using PC-Based system or dedicated DSP boards. PC-Based system lacks portability and mobility since it would be inconvenient to transport to different places. DSP based system, on the other hand, would probably lack the flexibility as it is somewhat difficult to be customized later on. Hence, the goal of this project is to utilize the flexibility and portability of the FPGA in implementing thumbprint pre-processing.

In order to widen the use of fingerprints, especially for portable applications, such as weapon control or ownership verification of a credit card, newly designed systems have to take into consideration the following crucial factors: computational cost, algorithm speed, storage requirement, flexibility and portability.

1.3 Objectives

From the discussion from the sections, the project is set up to achieve these main objectives:-

- to implement the preprocessing procedures of raw thumbprint images from the software front with the utilization of Altera DE2 board to improve thumbprint images up to a standard necessary to facilitate subsequent processes in the thumbprint recognition stage later.

- to look for an implementation option to meet the requirement of flexibility and portability.

1.4 Scope of Work

Since this is an initial work, the project will concentrate on utilizing the Altera Cyclone DE2 board just for preprocessing the thumbprint image. Recognition and verification would not be part of this project and this will require some hardware attachment to the existing board for storing database of thumbprint images. In a similar manner this project would not indulge into optimization using the hardware design of the FPGA but rather on the software implementation of the processing.

Based on available resources, limited time frame and expertise, the project is narrowed down to focus on the following scopes of work:

- to improve the interpretability and perception of information in the raw thumbprint images to facilitate the subsequent processing steps

- to research on the existing algorithms and procedures that are currently in use in the field for the pros and cons of each technique

- to look out for an implementation option from multiple perspectives: computational cost, algorithm speed, storage requirement, flexibility and portability

- to familiarize with the board to enable the utilization of the board for software/ code implementation

- to implement all these procedures from the software front with optimized algorithms/techniques which meet the design requirements

The subject of interest is the thumbprint pre-processing procedures, and thus the following items would not be included as part of the scope of the project:-

- Fingerprint Acquisition/ Input Scanning

- Fingerprint Matching/ Recognition

1.5 Report Outline

The report opens with a brief introduction to the background of the thumbprint identification and thumbprint preprocessing in particular, and also challenges which lead to the motivation of this project. Definition of scopes and organization of the report is included in the later part of the same chapter. It then goes on to the literature review which is essential for the implementation of the project in Chapter 2.

Next, methodology for implementation of the project is explored in Chapter 3. Chapter 4 then dives into the actual implementation of the project. This is then expanded to the following chapter with detailed discussions about the results and outcome of the project. A general summary and recommendation for future work is put forward as a conclusion to the report.

This report is organized into six chapters:-

Chapter 1 includes an introduction to the background and motivation that leads to this project. Objective and scope of the project are also clearly defined in this introductory chapter.

Chapter 2 starts off with the basic terminology, and reports the literature review of the fingerprint identification pre-processing steps, namely filtering, contrast enhancement, segmentation, noise elimination and thinning processes.

Chapter 3 explains the methodology and implementation plan of the project, and also algorithms, approaches and techniques to achieve the project goal.

Chapter 4 details the actual implementation of the project from both the hardware and software fronts.

Chapter 5 reports the results and the outcomes of the project and it is then accompanied by discussions on the corresponding results.

Chapter 6 summarizes the work that has been completed throughout the project, and proposes the future enhancement to the project.

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