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Implementation of Vhdl/Fpga for Fingerprint Verification with Optimal Computation

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ABSTRACT

The concept of fingerprint verification is being used very vastly in the market and the current technology. Here we use the fingerprint verification system, and we are trying to get optimal computation using the addition of two extra features being the GFPU and the HWco-processor.We primarily use the step of fingerprint extraction from the fingerprint capturing unit and the fingerprint extraction using the MINDTCT algorithm of the NIST in the NFIS2. The fingerprint that is extracted is divided into minutiae and the minutiae extracted is made to pass through several steps for quality assessment and false minutiae removal and other steps.The obtained minutiae is again passed through the matching algorithm that is the BOZORTH3 of the NIST in the NFIS2. The algorithm matches the obtained minutiae with the pre-existing template set and the result is obtained.For optimal computation we attach the GRFPU and the HW co-processor to the integer unit of the Leon 2 soft core processor of the Spartan 3 family FPGA which gives 97.89 % execution time reduction is estimated (at 40MHz/4KB cache).

Keywords : sparten3 family FPGA, MINDTCT, BOZORTH3, HW co-processor, floating point unit

INTRODUCTION

Many systems require trusted mechanism for identification purpose in order to confirm or to identify person who requests for a specific service. This mechanism is used to ensure that provided a right person accesses service. One of the mechanisms is the biometric recognition system that used human biometric features to provide personal identification.

Biometric technologies are automated methods of verifying or recognizing the identity of a living person based on a physiological or behavioural characteristic. Typical biometric systems use pattern recognition that takes biometric data from specific individual and then extracts the features of these biometric data, which so called template, and comparing it with other features from the database as reference.

Fingerprint matching can be separated into two categories, which are verification and identification. It is the comparison of a claimant fingerprint against an enrolled fingerprint, where the intention is that the claimant fingerprint matches the enrolled fingerprint.

In order to prepare for verification, a person initially enrolls his or her fingerprint into the verification system. A representation of that fingerprint is stored along with the person's name or other identity. The person identifying him or her, and then applying the fingerprint to the system such that the identity can be verified authenticates each access. Verification is also termed, one- to-one matching. On the other hand, identification is a fingerprint matching where fingerprint of unknown ownership is matched against a database of known fingerprints to associate with an identity. Identification is also termed, one-to-many matching. In other ways, the objective of identification is to search that owns the current biometric data, while the verification is to make sure that biometric data belongs to specific person.

LITERATURE SURVEY

Raimond Thai uses crossing number method for pixel value representation '1' as presented in Raimond Thai, (2003), "Fingerprint Image Enhancement and Minutiae Extraction", Master's thesis, University of Western Australia. In his research, a post processing technique to remove false minutiae points was introduced. However, there were no clear explanations of how to obtain minutiae point parameters.

Sharat Cikkerur uses chain co de contour processing to detect minutiae points, which is translation variant. It can be made rotation invariant if relative direction is used.

This method also uses trigonometry calculation and works with floating point calculation as it was described in SharatChikkerur, 2005. "Online Fingerprint Verification System", Master's thesis, State University of New York at Buffalo.

Tsai-Yang Jea utilizes crossing number to determine and to detect minutiae points. However, pixel pattern is used instead of mathematical calculation. In this method, a window of pixel pattern is scanned into fingerprint image and if the block of image is match with this pattern, a minutiae point is detected. It is still unclear of how to detect minutiae points parameter, as it was described in Tsai-Yang Jea, (2005), "Minutiae-Based Partial Fingerprint Recognition", Ph.D. thesis, State University of New York at Buffalo.

Josef Str¨omBartunek introduces neural networks method to detect and to determine minutiae points from fingerprint image as published in Josef Strom Bartunek, (2005), "Minutiae Extraction from Fingerprint with Neural Network and Minutiae based Fingerprint Verification",. Master's thesis, Blekinge TekniskaHogskola. The problem with this method is the need of training process every time the data is changed or grown. In this technique, 3 windows in different size are used for the training data. There is not enough explanation of how to obtain the direction of the minutiae points.

In order to reduce time calculations, many researches in hardware implementation of fingerprint recognition systems have been conducted and proposed. N.K. Ratha et al N. Ratha, D. Rover, and Anil.K. Jain, (1995), "An FPGA-Based Point Pattern Matching Processor with Application to Fingerprint Matching", CAMP '95 Italy, pages 394–401 and N. Ratha, D. Rover, and Anil.K. Jain, (1996), "Fingerprint Matching on Splash 2", In J. Arnold D. Buell and W. Kleinfolder (eds.), editors, Splash 2: FPGAS in a Custom Computing Machine, IEEE Computer So ciety Press, pages 117–140 proposed a sequential and parallel fingerprint-matching algorithm based on FPGA especially for Splash 2 architecture. The system consists of an array of Xilinx 4010 FPGAs connected to the host through an interface board. The Sun host realizes the query of database fingerprint and the matching process is executed on FPGA. Focusing on point pattern matching algorithm they obtained matching speed of the order of 105 matches per second for rolled fingerprint. In this system, matching process is performed without fingerprint feature extraction and overall performance of this design depends on communication between FPGA and Sun host trough interface board.

Gwo-Cheng Chao, et al Gwo-Cheng Chao, Shung-Shing Lee, Hung-Chuan Lai, and Shi-Jinn Horng, (2005), "Embedded Fingerprint Verification System", In Proceedings of the 2005 11th IEEE International Conference on Parallel and Distributed Systems (ICPADS'05) proposed fingerprint verification on System on Chips (SoC). This system uses a Nios CPU, memory, sensor controller, gradient fields, Gab or Redundancy Circuit (GRC), thinning hardware, Avalon bus and Infineon Finger TIP sensor. Image acquisition, extracting feature and matching are implemented on this hardware system and this gives an acceleration of 10 times in comparison with a full software solution. This article explains that developing system in SOC environments is difficult for customizations and modification in the future.

Madhuri and Richa Mishr (2012) [1] have proposed a paper on "Fingerprint Recognition using Robust Local Features", they say that there are many existinghuman recognition techniques which are based on fingerprints. Most of these techniques use minutiae points for fingerprint representation and matching. These techniques are not rotation invariant and fail when enrolled image of a person is matched with a rotated test image and such techniques fail when partial fingerprint images are matched. This paper proposes a fingerprint recognition technique which uses local robust features for fingerprint representation and matching.

Manisha Redhu and Dr.Balkishan (2013) [2] have proposed a paper on Fingerprint Recognition Using Minutiae Extractor", they say thatthe popular biometrics areused to authenticate a person's fingerprint which is unique and permanent throughout the person life.Fingerprint Recognition refers to the automated methods of verifying a match between two human fingerprints. Fingerprints are widely used in daily life for more than 100 years due to its feasibility, distinctiveness, permanence, accuracy, reliability, and acceptability. In this paper they projected Fingerprint Recognition using Minutia Score matching method.

Sangram Bana and Dr.Davinder Kaur [3]have proposed a paper on "Fingerprint Recognition using Image Segmentation", which specifies a study and implementation of a fingerprint recognition system based onMinutiae based matching techniques. This approach mainly involves extraction of minutiae points from the sample fingerprint images and then performing fingerprint matching based on the number of minutiae pairings among two fingerprints in question.

Ritu and MatishGarg(2014)[4] have proposed a paper on "A Review on Fingerprint-Based Identification System",this paper saysthat biometricfingerprints are the personal identification tool because of their individuality, uniqueness and reliability. A fingerprint image consists of valleys& ridges on human fingertips. Fingerprint authentication is possibly the

most sophisticated method of all biometric techniques. Fingerprint authentication has been thoroughly verified through various applications. All human recognition techniques using fingerprints are based on one of the following three methods: Minutiae-based, correlationbased, and hybrid. This paper provides a review of various fingerprint recognition techniques and then discusses a general minutiae-based fingerprint identification system.

Priyanka rani,Pinki Sharma(2014) [5]have proposed a paper on "Fingerprint Identification System", they say that the Fingerprint authentication is the most sophisticated method of all biometric techniques and has been thoroughly verified through variousapplications. Even features such as person's face or signature can change with changing in time and may be fabricated or imitated. But a fingerprint occurs uniquely to an individual and remains unchanged for lifetime. This paper defines the various aspects and methods to be used for the fingerprint-based identification system.

Gurpreet Singh and Vinod Kumar (2014)[6] have proposed a paper on "Fingerprint Recognition: Minutiae Extraction and Matching Technique", they say that the recent advancement in fingerprint identification and authenticationhas encouraged many people to conduct researches in Fingerprint Identification and Authentication (AFIA). The fingerprint identification system is becoming a new domain for user authentication. Fingerprint classification plays an important role in large organizations where fingerprint identification systems are deployed. Fingerprint identification is very helpful in authentication when two fingerprints do not match and also it reduces the time used for identification. This paper presents a thorough review on the existing classification approaches that have applied to fingerprint recognition problems. The explanation in this paper covers the various evaluation parameters used by AFIS classification approaches.

Table 1: Comparison Table

NAME OF THE AUTHOR	TITLE OF PAPER	YEAR	LIMITATIONS
RaimondTha	Fingerprint Image Enhancement and Minutiae Extraction	2003	No clear explanations of how to obtain minutiae point parameters.
Tsai-Yang Jea	Minutiae-Based Partial Fingerprint Recognition	2005	Unclear of how to detect minutiae points parameter.
Josef Strom Bartunek	Minutiae Extraction from Fingerprint with Neural Network and Minutiae based Fingerprint Verification	2005	The problem with this method is the need of training process every time the data is changed or grown.
Gwo-Cheng Chao Shung-Shing Lee Hung-Chuan Lai Shi-Jinn Horng	Embedded Fingerprint Verification System	2005	Developing system in SOC environments is difficult for customizations and modification in the future.
Madhuri Richa Mishr	Fingerprint Recognition using Robust Local Features	2012	Techniques are not rotation invariant and fail when enrolled image of a person is matched with a rotated test image and such techniques fail when partial fingerprint images are matched.
Manisha Redhu Dr.Balkishan	Fingerprint Recognition Using Minutiae Extractor	2013	Does not specify about the matching technique and the technology used for matching of the minutiae extracted.
Sangram Bana Dr.Davinder Kaur	Fingerprint Recognition using Image Segmentation	2013	Extracts minutiae from fingerprint and matches but doesn't assess the quality of the fingerprint or perform mapping on the fingerprint.
Ritu Matish Garg	A Review on Fingerprint-Based Identification System	2014	Discusses only the general minutiae based fingerprint identification systems but does not speak about the efficiency of the particular system used.
Priyanka rani Pinki Sharma	Fingerprint Identification System	2014	Speaks about the general and standard identification systems but fail to

			increase the speed of the system.
Gurpreet Singh Vinod Kumar	Fingerprint Recognition: Minutiae Extraction and Matching Technique	2014	Uses the existing sources for extraction/matching but does not enhance speed.

COMPARISON TABLE

The above comparison table gives us a gist as to how the concept we use can overcome the limitations of the existing papers. Raimond Thai in ”Fingerprint Image Enhancement and Minutiae Extraction” [2003] gives the ideas about fingerprint image enhancement and minutiae extraction but has no clear explanations of how to obtain minutiae point parameters.

Tsai-Yang Jea in “Minutiae-Based Partial Fingerprint Recognition” [2005] speaks about extracting minutiae and recognising the fingerprint partially with respect to the extracted minutiae but it is unclear of how to detect minutiae points parameter.

Josef Strom Bartunek in “Minutiae Extraction from Fingerprint with Neural Network and Minutiae based Fingerprint Verification” [2005] includes the concept of minutiae extraction from neural networks and verification of the same. The problem with this method is the need of training process every time the data is changed or grown as the use of neural networks is adopted.

Gwo-Cheng Chao, Shung-Shing Lee, Hung-Chuan Lai and Shi-Jinn Horng in “Embedded Fingerprint Verification System” [2005] adapts the concept of SoC design and uses the same for fingerprint verification system. The problem is that developing system in SOC environments is difficult for customizations and modification in the future.

Madhuri and Richa Mishr in “Fingerprint Recognition using Robust Local Features” [2012] explains the verification of fingerprint using local features such as ridge endings and bifurcations and does not specify on the quality assessment and the mapping. Techniques are not rotation invariant and fail when enrolled image of a person is matched with a rotated test image and such techniques fail when partial fingerprint images are matched.

Manisha Redhu and Dr.Balkishan in “Fingerprint Recognition Using Minutiae Extractor” specifies the extraction of the minutiae and usage of the same for recognition of the fingerprint. Does not specify about the matching technique and the technology used for matching of the minutiae extracted.

Sangram Bana and Dr.Davinder Kaur in “Fingerprint Recognition using Image Segmentation” [2013] speaks of recognition of the fingerprint using image segmentation which is not a standard procedure for recognizing and extracts minutiae from fingerprint and matches but doesn’t assess the quality of the fingerprint or perform mapping on the fingerprint.

Ritu and Matish Garg in “A Review on Fingerprint-Based Identification System” [2014] discusses only the general minutiae based fingerprint identification systems but does not speak about the efficiency of the particular system used.

Priyanka rani and Pinki Sharma in “Fingerprint Identification System” [2014] speaks about the general and standard identification systems but fail to increase the speed of the system.

Gurpreet Singh and Vinod Kumar in “Fingerprint Recognition: Minutiae Extraction and Matching Technique” [2014] uses the existing sources for extraction/matching but doen’t enhance speed.

METHODOLOGY

The Finger Print that has been kept on the Finger Print module will be captured and primarily saved in the image format and transferred to the PC via the UART interface. Now this Finger Print has to undergo series of image processing techniques which will be done using the MATLAB software. This block makes sure that the minute details of the Finger Print are then gathered and this small details called the minutiae are stored and using the Modelsim software we convert this small details into the respective hexadecimal codes and then dumped into the FPGA module. Then the verification part is being carried out.Once the user keeps his fingerprint on the finger print sensor if his finger print details are updated and enrolled in the database then it will be shown as match. If the user’s fingerprint isn’t stored in the database then the seven segment display on the FPGA board is going to display the message as mismatch or error. The finger print module is interfaced to the PC via the UART and the FPGA is also interfaced to the PC via the UART.

RESULTS

The verification of the fingerprint speeds up with the use of an external controller and another HW co processor. The addition of these two features makes sure the process of matching the finger print speeds up and as the minute details of the finger print is being captured with the help of the image processing techniques which we conduct with the help of MATLAB software. So there are minute chances that the finger print verification shows an error if the same authentic person places his finger. The main aim was to build a custom application where we can conduct the finger print verification process that happens in the inbuilt DSP chip of the sensor. With the followed methodology we have achieved the goal of writing the custom code for feature extraction and matching the Finger Print.

CONCLUSION AND FUTURE SCOPE

Implementation of a fingerprint minutiae extraction and matching algorithm. Uses a SPARTAN3 family FPGA based low-cost system which makes it economically feasible and available and can be implemented everywhere for general and daily use. Uses anEmbedded Leon2 soft-processor. Minutiae extraction process has been accelerated in a 94.14% with the process of quality assessment and mapping and removing of false minutiae which helps the matching algorithm. HW co-processor is estimated to speed-up the extraction algorithm up to a 97.89%. With fingerprint verification system being in the top notch list of the existing technologies this low cost system can be adapted easily in any particular place and the people can be educated regarding the use of it which makes technology reach all doors of every village in India.

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