A Novel Implementation of Fingerprint Recognition System using DSP Processor

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***Abstract* — Along with the rapid development of biometric recognition techniques, the fingerprint recognition is becoming a significant subject. Fingerprint recognition is a method to identify a person based on his finger physiological characteristics. Hence this technology has been already used in many special fields, such as criminal investigation and so on, which proves its practicability and reliability. However, many of today's recognition systems are still implemented on the PCs and servers, which has hardly mobility and high power consumption and uneasy to be used in some mobility environment. On the contrary, the embedded recognition system has high mobility, low power consumption, high speed and accuracy. In this paper, a practical and efficient DSP processor based system model is proposed for recognition purpose. The DSP processor and an improved algorithm can run smoothly to realize the recognition process.**

Keywords* — *Biometric; Fingerprint; Recognition; DSP Processor.

I. INTRODUCTION

The Biometrics are automated methods of recognizing an individual based on their physiological (e.g., fingerprints, face, retina, iris) or behavioral characteristics (e.g., gait, signature). Each biometric has its strengths and weaknesses and the choice typically depends on the application. A number of biometric characteristics are being used in various applications as Universality, Uniqueness, Permanence, Measurability, Performance and Acceptability. No single biometric is expected to effectively meet the requirements of all the applications. Various biometric technologies are fingerprint, face, iris, hand geometry, voice and signature recognition. Among all those, fingerprint technology is the oldest biometric technology, but still it is most widely used because it provides good levels of accuracy and simplicity. This technology is highly reliable for the recognition purpose because of their uniqueness and consistency over the time. Also, the fingerprint is fast biometric technique for more reliable and secure system [1].

A. Fingerprint – an Overview

A fingerprint, as the name suggests is the print or the impression made by our finger because of the patterns formed on the skin of our palms and fingers since birth. With age, these marks get prominent but the pattern and the structures present in those fine lines do not undergo any change. Because of their permanence and unique nature, they have been used in criminal and forensic cases for a long time [2]. The fingerprint image is shown in Fig.1

Fig. 1 Fingerprint image

A fingerprint is composed of many ridges and furrows. These ridges and furrows present good similarities in each small local window, like parallelism and average width. The fingerprints are not distinguished by their ridges and furrows (valleys), but by features called Minutia. The Minutia refers to some abnormalities in a ridge. Minutia is an important characteristic of a ridge. The most prominent two minutia points are

- Ridge termination means the sudden or abrupt ending of the ridge. Termination minutia is shown in Fig. 2

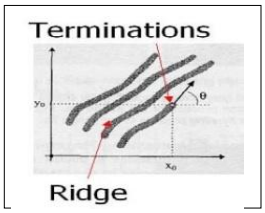

Fig. 2 Ridge termination minutia

- Ridge bifurcation is the point on the ridge where a ridge is divided into two separate ridges.

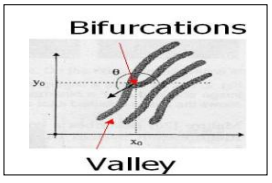

Fig. 3 Ridg3e bifurcation minutia

B. *Fingerprint Recognition*

The recognition procedure can be broadly sub grouped into two categories.

1) *Fingerprint Identification*: It refers to specifying one's identity based on his fingerprints. The fingerprints are captured without any information about the identity of the person. It is then matched across a database containing numerous fingerprints. The identity is only retrieved when a match is found with one existing in the database. So, this is a case of one-to-n matching where one capture is compared to several others. This is widely used for criminal cases [3].

2) *Fingerprint Verification*: It is different from identification in a way that the person's identity is stored along with the fingerprint in a database. On enrolling the fingerprint, the real time capture will retrieve back the identity of the person. This is however a one-to-one matching. This is used in offices like passport offices etc. where the identity of a person has to be checked with the one provided at previous stage [3].

C. *Approach to Fingerprint Recognition*

The approach that we have concentrated on in recognition of the fingerprints is the minutia based approach. In this approach the ridge bifurcations and terminations are taken into consideration for analysing each fingerprint. The representation is based on these local features [4].

The DSP processor uses highly complex algorithms to recognize and analyse the minutia. The basic idea is to measure the relative portion of minutia. Simply, it can be thought of as considering the various shapes formed by the minutia when straight lines are drawn between them or when the entire image is divided into matrix of square sized cells. If two fingerprints have the same set of ridge endings and bifurcations forming the same shape with the same dimension, there' s a huge likelihood that they are of the same fingerprint. So, to find a match, DSP processor has to find a sufficient number of minutia patterns that the two prints have in common, the exact number being decided by the DSP processor programming.

II. HARDWARE IMPLEMENTATION

A. *Hardware Implementation possibilities*

Hardware implementation of the fingerprint recognition system [1] is a method to obtain a system that responds to the following requirements: real time, portability, embedded, small size and low power consumption. In order to reach these previous constraints, there are several choices in hardware implementation of the system, such as:

1) *Micro Controller*: It is a single integrated circuit, commonly with the following features: central processing unit - ranging from small and simple 4-bit processors to sophisticated 32- or 64-bit processors, input/output interfaces such as serial ports, peripherals such as timers and watchdog circuits and signal conversion circuits, RAM for data storage, ROM, EPROM, EEPROM or Flash memory for program storage.

2) *DSP Processor*: It is a specialized microprocessor designed specifically for digital signal processing, generally in real-time with the following main characteristics: designed for real-time processing, optimum performance with streaming data, separated program and data memories (Harvard architecture), special Instructions for SIMD (Single Instruction, Multiple Data) operations, the ability to act as a direct memory access device if in a host environment.

3) *ASIC*: Application-Specific Integrated Circuit (ASIC) is an integrated circuit (IC) customized for a particular use, rather than intended for general-purpose use. The general term application specific integrated circuit includes FPGAs, but most designers use ASIC only for non field programmable devices (e.g. standard cell or sea of gates) and differ between ASIC and FPGAs.

4) *FPGA*: Field Programmable Gate Array (FPGA) is a semiconductor device containing programmable logic components and programmable interconnects. These logic blocks and interconnects can be programmed after the manufacturing process by the customer/designer (hence the term field programmable, i.e. programmable in the field) so that the FPGA can perform whatever logical function is needed. FPGAs are generally slower than their application-specific integrated circuit (ASIC) counterparts, can't handle as complex a design, and draw more power.

Among all the hardware implementation possibilities, DSP is selected for the implementation of proposed fingerprint recognition system because it has so many advantages.

- It is well suited for real time applications.
- It supports Harvard architecture.
- It supports single instruction execution cycle.
- DSP Processor is very fast when compared to micro processor and others.
- DSP processor consumes less processor.
- DSP supports image processing applications.

B. *Proposed Hardware Implementation*

In this paper we proposed the implementation of fingerprint recognition system using DSP processor. The block diagram of proposed system is shown in Fig. 4. This system can collect real-time fingerprint image signals, extract finger minutiae, and then match the input fingerprint with one existing in a database to perform fingerprint recognition. The whole system includes fingerprint sensor, DSP processor, memory (database), keyboard and a LCD display.

Fingerprint sensors can use capacitive, optical, pressure, or thermal technologies to obtain an image of a finger's features. The most common fingerprint sensor solution first illuminates the print with a laser or LED light and then captures the image using a CCD or less expensive CMOS sensor. Fingerprint sensors are typically self contained modules that include an analog to digital converter to translate the analog information into a digital data stream. Resolution, dynamic range and pixel density are factors that contribute to the image quality and influence the accuracy of the sensor. *Tooan OP-100N optical sensor is best* for the implementation because it provides high resolution.

Once the image is captured the digital information is transferred to a digital signal processor for the recognition process. The DSP processor run the recognition algorithm and then match or compare the input fingerprint with one stored in the database. The database is maintained in the flash memory.

- If fingerprint matching is successful, DSP processor sends a signal to LCD so that it displays the "MATCH FOUND".
- If fingerprint matching fails, DSP processor sends a signal to LCD so that it displays the "MATCH NOT FOUND".

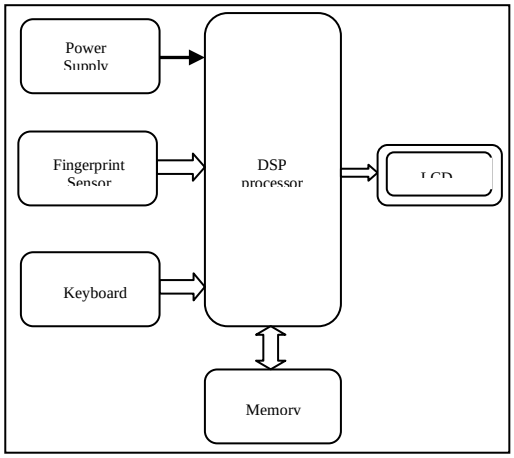

Fig. 4 Block diagram of proposed fingerprint recognition system

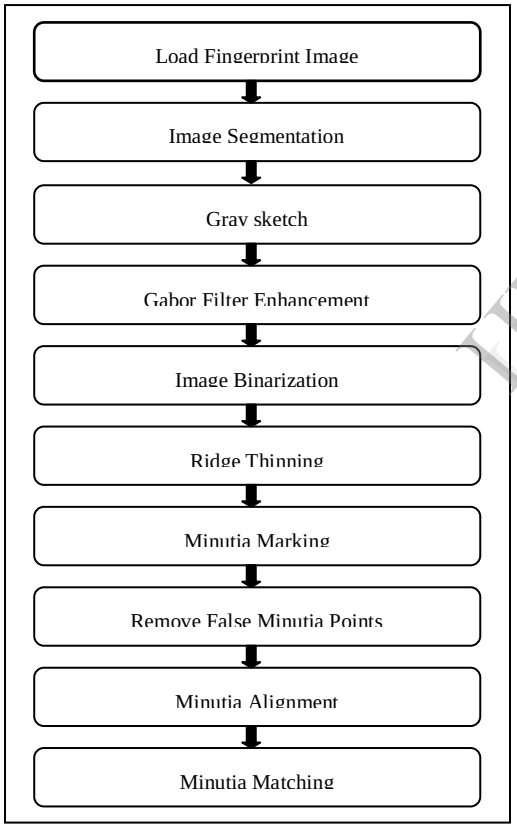

Fig. 5 Proposed algorithm overview

III. SOFTWARE IMPLEMENTATION

A major challenge in Fingerprint recognition lies in the pre processing of the bad quality of fingerprint images. In [2] the low percentage of verification rate is due to poor quality of images in the database and it lead to incorrect matches. Image enhancement is an essential preprocessing step in fingerprint recognition applications. The previous fingerprint image enhancement methods [2] are FFT formula based and has a drawback of poor image quality which results in low verification rate or performance.

In this paper, some modifications have been introduced to the original algorithms [2] in order to improve the matching performance results. In this paper, we will use a novel Gabor filter design method for fingerprint image enhancement. This Gabor filter enhancement increases the overall performance of the recognition process. The proposed algorithm overview is shown in Fig. 5. The algorithm steps are discussed below.

A. Image Segmentation

For a fingerprint image, only a certain portion is important which can provide the required information and can be useful for further processing. This portion is called the ROI or the region of interest. In this process, the area without important ridges and furrows is discarded as it holds only background information.

B. Gray sketch

The image after segmentation is subjected to Gray Stretch to increase the global contrast of the image. Gray Stretch is performed by means of Histogram Equalization, resulting in an even distribution of gray scale intensities in the image.

C. Image Enhancement

The fingerprint images obtained from sensors are not likely to be of perfect quality. Image enhancement is necessary to make the image clearer for further operations. Hence, enhancement methods are used for making the contrast between ridges and furrows higher.

D. Image Binarization

The original image is an 8-bit greyscale image. This process transforms the original gray scale image into a binary image. The Binarization process assigns values 0 for ridges and 1 for furrows. After Binarization, the ridges appear black while the furrows appear white.

E. Ridge Thinning

Ridge Thinning is to eliminate the redundant pixels of ridges till the ridges are just one pixel wide. For the easy identification of minutiae points, this thinning process is must and should. This thinning operation is done with the help of built-in Morphological thinning function in MATLAB.

F. Minutia Marking

After the fingerprint ridge thinning, identify where the marking minutia points are located and mark those points with cross marks [5]. In general, for each 3x3 window in the fingerprint image.

- If the central pixel is 1 and has exactly 3 one-value neighbors, then the central pixel is a ridge branch.
- If the central pixel is 1 and has only 1 one-value neighbor, then the central pixel is a ridge ending.

Together with the minutia marking, all thinned ridges in the fingerprint image are labeled with a unique ID for further operation.

G. False Minutia Removal

The preprocessing & minutia-extraction stage does not yield the final processed fingerprint image. False minutia such as false ridge breaks because of lack of ink and also ridge cross-connections from ink spill are still present along with genuine minutia [6]. Also the earlier steps in processing

themselves allow some errors. False minutiae can significantly affect accuracy of matching.

H. Minutia Match

Given two set of minutia of two fingerprint images (input and database), the minutia match algorithm determines whether the two minutia sets are from the same finger or not. We use an iterative ridge alignment algorithm to first align one set of minutiae w.r.t other set and then carryout an elastic match algorithm to count the number of matched minutia pairs.

- Alignment stage: Given two fingerprint images to be matched, choose any one minutia from each image; calculate the similarity of the two ridges associated with the two referenced minutia points. If the similarity is larger than a threshold, transform each set of minutia to a new coordination system whose origin is at the referenced point and whose x-axis is coincident with the direction of the referenced point.
- Match stage: After we get two set of transformed minutia points, we use the elastic match algorithm to count the matched minutia pairs by assuming two minutia having nearly the same position and direction are identical.

IV. EXPECTED RESULTS

Two metrics are mainly used to determine the performance of a biometric recognition system. They are False Acceptance Rate (FAR) and False Reject Rate (FRR) [9] [10].

1) *False Accept Rate or False Match Mate (FAR or FMR)*: FAR is a measure of biometric accuracy. It represents the probability that a given biometric system will accept an incorrect input as a positive match.
2) *False Reject Rate or False Non-Match Rate (FRR or FNMR)*: FRR is a measure of the probability that a biometric system will incorrectly reject an input as a negative match.

FAR and FRR rates have an inverse relationship with one another. In other words, the more selective the biometric system is (better FAR rate), the more likely that the system will also begin to occasionally reject the correct fingerprint.

In [1] the authors Sunny Arief Sudiro and Rudi Trisno Yuwono describe about the implementation of fingerprint recognition using FPGA. It is observed that the False Acceptance Rate and False Reject Rate of this FPGA implementation is 14.05 %.

We expected that overall performance of proposed system (DSP implementation) is slightly better than FPGA implementation. Also we expect that this DSP implementation will reduce the False Acceptance Rate and False Reject Rate to around 10 %.

V. CONCLUSION

In this paper we proposed the implementation of fingerprint recognition system using DSP processor. This implementation was an effort to understand how Fingerprint Recognition is used as a form of biometric to recognize identities of human beings. This system can collect real-time fingerprint image signals, extract finger minutiae, and then match the input fingerprint with one existing in a database to perform fingerprint recognition. The LCD displays the results of recognition process. A computer program will be coded in MATLAB and C to implement algorithms for enhancement, minutiae extraction and matching processing. We expect that this proposed system will give better results when compared to the existing methods due to some modifications made in existing algorithm [2].

REFERENCES

[1] Sunny Arief and Rudi Trisno, *"Adaptable Fingerprint Minutiae Extraction algorithm based – on crossing number method for hardware implementation using FPGA",* International Journal of Computer Science, Engineering and Information Technology (IJCSEIT), Volume 2. Issue 3, June 2012.

[2] Sangram Bana and Dr. Davinder Kaur, *"Fingerprint recognition using image segmentation"*. International journal of advanced engineering sciences and technologies vol no. 5, issue no.1, 2011.

[3] Davide Maltoni, Dario Maio, Anil K. Jain & Salil Prabhakar, "Handbook of Fingerprint Recognition", Springer, second edition, 2009.

[4] A. K. Jain, F. Patrick, A. Arun, *"Handbook of Biometrics",* Springer science+Business Media, LLC, 1st edition, pp. 1-42, 2008.

[5] Maitane Barrenechea, Jon Altuna, and Miguel San Miguel, *"A Low Cost FPGA-Based Embedded Fingerprint Verification Embedded Fingerprint Verification and Matching System",* Fifth Workshop on Intelligent Solutions in Embedded Systems (WISES 07), 2007.

[6] Tsai-Yang Jea, "Minutiae-Based Partial Fingerprint Recognition, Ph.D. thesis", 2005, State University of New York at Buffalo.

[7] Salil Prabhakar, "*Fingerprint Classification and Matching Using a Filter bank",* Ph.D. thesis, (2001), Department of Computer Science and Engineering, Michigan State University.

[8] Lin Hong, "Automatic Personal Identification Using Fingerprints", Ph.D. Thesis, 1998.

[9] Jianwei Yang, Lifeng Liu, Tianzi Jiang, Yong Fan, *"A Modified Gabor Filter Design Method for Fingerprint Image Enhancement",* Pattern Recognition Letters, 2003.

[10] Antonio R. C. Paiva and Tolga Tasdizen, *"Fingerprint image segmentation using data Manifold characteristic features",* International journal of pattern recognition and artificial intelligence, vol. 26, no. 4 (2012), pages 1-23, Aug 29. 2012.

[11] Vishaveet Jindal and Prof. Manoj Ramaiya , *"Fingerprint Recognition based on Minutiae Extraction Principle".* International Journal of Management. IT and Engineering (IJMIE), Volume 2, Issue 9, September 2012.

[12] Kuntal Barua, Samayita Bhattacharya and Dr. Kalyani Mali, "Fingerprint Identification", Global Journal of Computer Science & Technology (USA), Volume II, Issue Version 1.0, April 2011.

[13] Ravi. J, K. B. Raja and Venugopal. K. R. *"Fingerprint Recognition using Minutia Score Matching",* International Journal of Engineering Science and Technology, Volume 2, 2009.

[14] Manvjeet Kaur, Mukhwinder Singh, Akshay Girdhar and Parvinder S. Sandhu, *"Fingerprint Verification System using Minutiae Extraction Technique",* World Academy of Science, Engineering and Technology 22 2008.

[15] Yongqiang Zhang and Ji Liu, *"Wireless Fingerprint Attendance Management System",* Proceedings of the 2007 WSEAS International Conference on Computer Engineering and Applications, Gold Coast, Australia, January 17-19, 2007.

[16] Wikipedia link – http://en.wikipedia.org/wiki/Biometrics.

[17] Wikipedia link – http://en.wikipedia.org/wiki/Finger_recognition.