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A Biometric System for Person Authentication Based on Finger Vein Patterns on FPGA

Mrunali Jadhav[1], Priya M. Ravale Nerkar[2]

PG Student [VLSI & ES], Dept. of E & TC, D. Y. Patil College of Engineering, Akurdi, Pune, India[1]

Assistant Professor, Dept. of E & TC, D. Y. Patil College of Engineering, Akurdi, Pune, India[2]

ABSTRACT: The personal verification is a critical key problem in today's society; also protection of personal information is very difficult because of different physical and software attacks. Due to this fact, the biometric authentication has gaining popularity as it provides a high security and reliable approach for personal authentication. Finger vein biometric is advantageous over other types of biometric systems because it has low forgery rate, aliveness detection as well as stable over long period of time. The paper presents the implementation of image processing algorithm and feature extraction processes in MATLAB, and for final authentication the template matching is carried out on Field Programmable Gate Array (FPGA) for fast recognition. The system is prototyped on Papilio one 500k FPGA board which has Xilinx Spartan 3E chip inside. The performance of the proposed system is evaluated by the time required to verify one input finger vein sample and Precision.

KEYWORDS: Biometric, finger vein recognition, FPGA, MATLAB, Precision.

I.INTRODUCTION

Biometrics is an automated recognition of an individual based on uniqueness of their biological or behavioural characteristics. The personal information can be protected in the form of biometrics. The traditional authentication systems like identity card or password can be easily stolen or acquired by unauthorized person [1]. All these traditional authentication systems are gradually replaced by biometric systems like fingerprints, iris recognition, palm print and veins. The biometric authentication system is chosen over conventional authentication system because of their distinctiveness and highly secured nature.

Out of these biometric systems, finger vein biometric is one of the emerging techniques. In this type of biometric system the vascular pattern under one's skin is utilized as a unique feature for authentication. Veins are hidden underneath the skin surface and are mostly invisible to human eye, they are not prone to external distortion and also the vein patterns are much harder to replicate as compared to other biometric traits. Vein patterns are unique for each individual and are stable over a long period of time. Because of its uniqueness, stability and high resistance to criminal attacks, vein pattern is more reliable biological feature for a secure biometric authentication system [5][2].

The Biometric system is often implemented in an untrusted environment that uses an insecure and non-reliable central server for the storage of the biometric templates [9]. This can be the source of biometric information leakage. The solution to this problems is given by recent development in vein authentication by hardware implementation of the system [12][7][11][18]. It provides secure information storage and tamper resistance, hence it provides the protection from physical and software attacks.

The finger-vein biometric pattern for personal authentication is promising in security and convenience point of view. The comparison between different biometric systems is as shown in Table 1 [4], I=insufficient, N=normal, G=good.

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Table 1 Comparison of Major Biometrics Method

Bio-metric	Anti-forgery	Accu racy	Speed	Enrolme nt rate	Resista nce	Cost
Finger print	I	N	N	I	I	G
Iris	N	G	N	N	I	I
Face	N	I	N	N	G	I
Voice	N	I	N	N	G	N
Vein	G	G	G	N	N	N

This paper presents preliminary requirement for the implementation of finger vein recognition system on FPGA. It includes image pre-processing and feature extraction processes on finger vein images in MATLAB which is required for developing Biometric recognition system on FPGA. According to best of our knowledge the implementation of the entire pre-processing module, feature extraction and matching on FPGA is very challenging and also it will be very time consuming process. The solution to this is proposed in this work by performing all pre-processing task and feature extraction in MATLAB and final template matching in FPGA. By doing this the speed of authentication is quite good. Also the system is cost effective.

The rest of this paper is organized as follows. Previous related work is provided in section 2. Section 3 gives overview of the system and description of the proposed work including flowchart of the system. Section 4 presents Methodology of the proposed work. Experimental results are given in section 5 and finally concluding remarks in section 6.

II.RELATED WORK

A lot of work has been carried out in this field of biometric using finger veins for authentication and also for variety of applications on different platforms. In this section review of some prior work on finger vein biometric security system is discussed.

David Mulyono et al. in [2] introduced a preliminary process to enhance the image quality that worsen by the light effect and some noise produced by the web camera while acquisition, then vein pattern segmentation by adaptive thresholding and matched using improved template matching algorithm. The final result shows that by applying some appropriate process the vein image with not that much good quality can be used for personal identification as long as the veins are clear.

In [16] D. Wang et al. and M. Subramani et al. in [4] presented highly secured and reliable user identification mechanism using vein biometric technology for consumer electronics devices. Radon transforms and singular value decomposition method is used for feature extraction process and classification using a normalized distance measure.

N. Mahri et al. in [17] presented an algorithm for vein recognition with less complexity in the image pre-processing phase, where vein pattern extraction is not included in the authentication process. Phase only correlation is applied at the matching stage. In this technique, matching is by using phase component of 2D-DFT of an image. This technique is reliable, robust and doing less job in pattern extraction.

V. Ramya et al. in [8] introduced a novel design for personal authentication and for vehicle security using finger vein recognition system. Wavelet transform is used for feature point extraction using HAAR mother wavelet. The attracting feature of HAAR transform includes fast implementation and able to analyze the local features. The authors have presented hardware implementation of finger vein recognition system for vehicle security application, a vehicle set up consist of embedded main board module which has AT89C51 microcontroller and communication module consisting of LCD display, alarm and GSM. Purpose of this module is to alert the authorized vehicle user.

Zhi Liu et al. in [12] proposed a real-time embedded finger vein recognition system for authentication on mobile devices. The system is implemented on a DSP platform. The results proved that the system has low computational complexity and low power consumption, thus qualified for authentication on mobile devices.

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M. Khalil-Hani et al. in [18] proposed an embedded system implementation of finger vein biometric on FPGA. The system is prototyped on Altera Stratix-II FPGA hardware board with Nios2-Linux operating system running at 100 MHz. In this authentication system, feature extraction is based on minutiae extracted from vein pattern images while biometric matching is based on modified Hausdorff distance technique. The system gives high performance and optimum accuracy by an embedded system implementation on FPGA.

III.OVERVIEW OF THE SYSTEM

The proposed system consists of three modules: Image acquisition module, human communication module (PC) and FPGA board. The figure 1 shows the functional block diagram of the proposed work. The image acquisition module is used to collect the finger vein images for processing. The human communication module (PC) is used to perform basic image processing algorithms like RGB to gray scaling, edge detection and also feature extraction process in MATLAB. This preprocessing is required to prepare finger vein images for further processing. This human communication module (PC) is used to display the recognition results and also to receive inputs from image acquisition module. After pre-processing and feature extraction processes, the template matching is done on FPGA for final authentication.

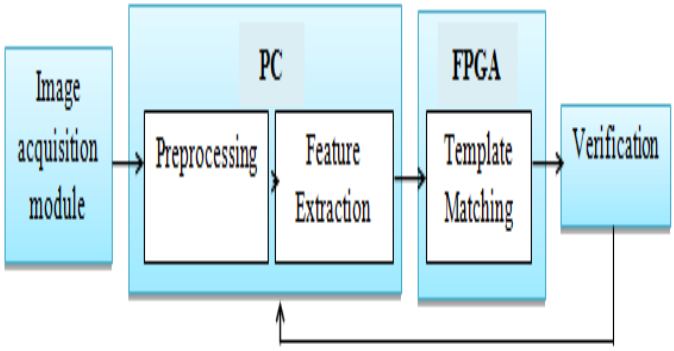

Figure 1 Functional block diagram of proposed work

The proposed finger vein recognition system consists of two stages: enrollment stage and verification stage[12]. The enrollment stage starts with pre-processing of the input finger vein images. For the verification stage after pre-processing and feature extraction process feature templates are generated. The input finger-vein image is matched with the corresponding template after its features are extracted and authentication is done for genuine or imposter user. Figure 2 shows the flowchart of the proposed system as discussed above.

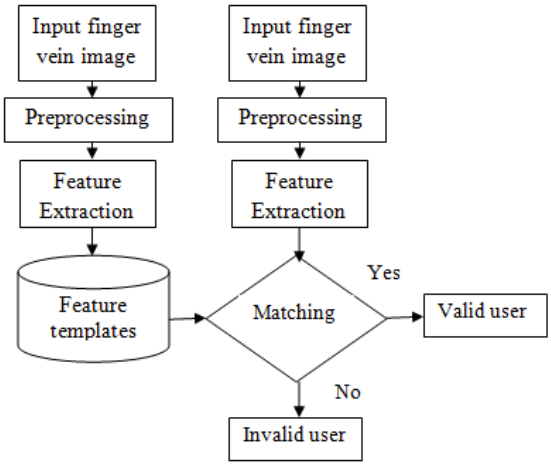

Figure 2 Flowchart of finger-vein authentication system

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IV.METHODOLOGY

In this section the methodology for the proposed work is discussed, which includes image acquisition of finger vein image, different pre-processing techniques on vein image, feature extraction and template matching process for final authentication.

A. Image acquisition

Image acquisition is of two types off-line and online. On-line images are the images which are taken in real time and off-line images means the images which are taken from already created database. The images in real time can be obtained by normal web camera or by designing a finger-vein imaging device based on light transmission for more distinct imaging.

In the proposed work the off-line finger vein images are used for human identification.

B. Pre-processing

In image-based biometric systems like finger vein system, a number of pre-processing tasks are required prior to enhance the image quality, some of these tasks are contrast, brightness, edge information, noise removal, sharpen image, etc., furthermore, to produce a better quality of image that will be used for later stage as an input image and assuring that more relevant information can be detected for authentication. A finger vein based authentication system mainly consists of following pre-processing stages and they are RGB to grayscale conversion, Gaussian blurring and edge detection.

1) RGB to grayscale

In RGB to grayscale conversion color image is converted into grayscale. In the grayscale digital image the value of each pixel is a single sample means it carries only intensity information. Images of this sort are known as black-and-white, which are composed of shades of gray, varying from black at the weakest intensity to white at the strongest.
The formula for RGB to grayscale conversion is as stated below:

$$GRAY = 0.299*r + 0.587*g + 0.114*b \qquad (1)$$

2) Edge detection

After this noise removal, the edges are detected by using canny operator in MATLAB. A canny operator with locally adaptive threshold is used to get the single pixel edge of the finger.

C. Feature extraction

Feature extraction is most important step in this authentication process. It is a special form of dimensionality reduction. It is a transformation of input data into the set of features. In the proposed work for this feature extraction process the canny edge detection method is used for feature extraction process. Extraction of features such as edges and curves from an image is useful for final authentication. Edges are important features in an image, they represents significant local intensity changes.

An image is viewed as a function. For a given pixel values i, j; we have an intensity I (i,j). While extracting features there may be chance that operator will return non-zero values in regions where there is no edge. So, thresholding can be used which minimizes false positives and only pick local maxima. Final edges are determined by suppressing all edges that are not connected to a very strong edge. After this feature extraction process, the template database is generated which is used for final authentication in matching process.

This algorithm for feature extraction process runs in following steps as shown in figure 3, which basically consists of four main steps: a) smoothing b) gradient calculations c) non-maximum suppression and finally d) thresholding.

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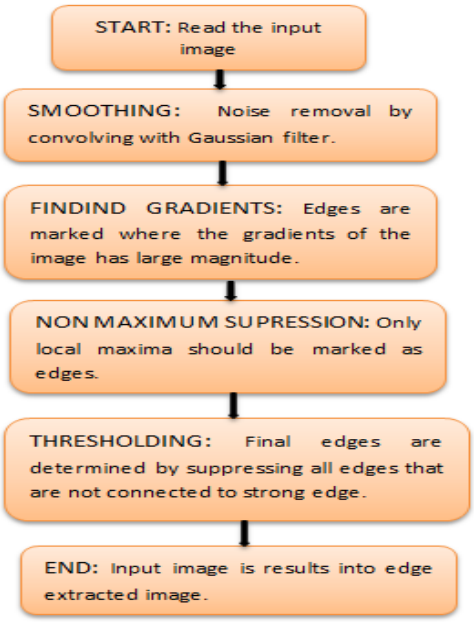
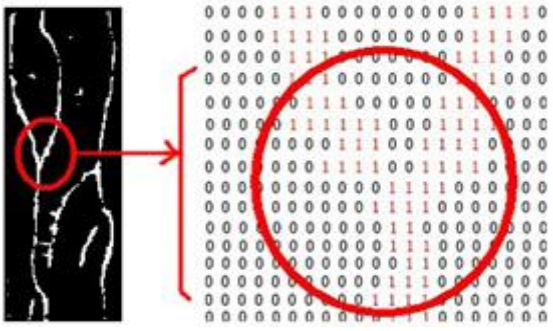


Figure 3Canny edge detection Algorithm

D. Matching

After features are extracted from the vein image the matching stage measures the similarity or dissimilarity between the input finger vein image features and the previously enrolled ones in the database. Template matching is performed on FPGA, where input image and the image in the database which is generated after extracting features are compared. A standard threshold value is set for authentication purpose.

After feature extraction, a binary vein pattern is generated as shown by figure 4 (a), in which white part denotes the vein patterns and black part shows the background. Figure 4 (b) shows the store matrix, in which vein patterns and background is represented by 1 and 0 respectively. In this way, during this template matching process, two such store matrices for two vein images that we want to match for authentication are compared pixel by pixel and the error sum is generated. When this error sum is above the threshold value then the message will be displayed that the user is invalid; and if this error sum is less than threshold value then it is a valid user.



(a) ***(b)***

Figure 4 A binary finger vein pattern and its store format in a matrix

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V. RESULT AND DISCUSSION

In this section the information regarding the database of finger vein images that we have used is given. The results of pre-processing steps and feature extraction process in MATLAB and also the results for matching module are given.

A. Database

In the proposed work we have used off-line finger vein images from already created database. This database contains images of size 320X240 and subject number is 20 and these images are acquired by light transmission method.

Some of the finger vein images in this database are as shown in figure 5.

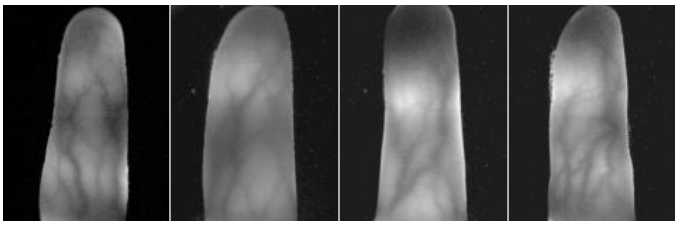


Figure 5 Database images

B. Result of feature extraction process

After applying canny edge detection algorithm for feature extraction process the features are as shown in figure 6.

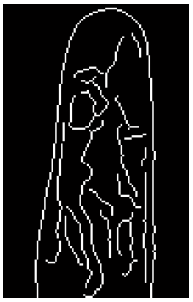
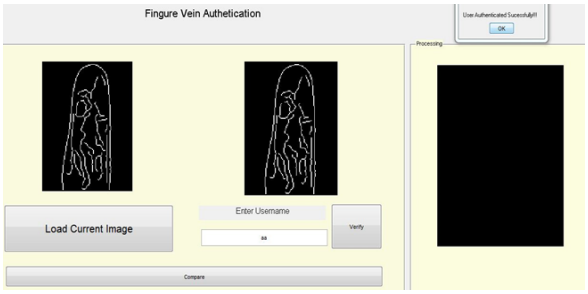


Figure 6 Feature extraction

C. Result for Template matching

Here, the final authentication of the valid or invalid user is given. Figure 7 (a) shows final authentication for valid user when sum is less than the standard threshold value. And figure 7 (b) shows authentication of invalid user when sum is greater than the standard threshold.



(a)

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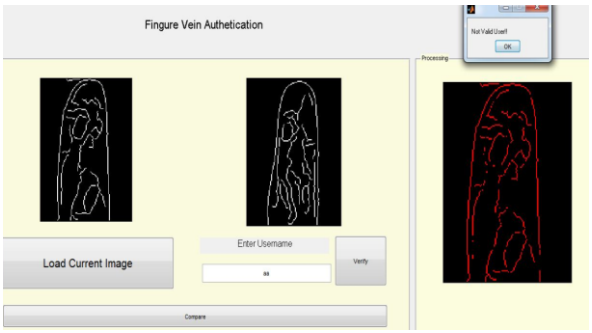

(b)

Figure 7: Authentication for (a) Valid user (b) Invalid user

VI.CONCLUSION

In this paper, the algorithms required to process the finger vein images for authentication is discussed in details with the experimental results. These processes are required to prepare image for further processing of authentication system on FPGA. This authentication process uses predefined vein images from the database. This hardware system of finger vein authentication system on FPGA can be used for variety of application. The results for feature extraction and matching process are also discussed. From the analysis, it is observed that the recognition time means the time taken to match one sample of finger vein is about 41 seconds.

Also for performance evaluation of the proposed system, precision is one of the parameter considered. Precision is a probability that randomly selected input images are matched perfectly. For the proposed system the precision we get is about 87.5%.

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