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Design & Implementation of Fingerprint Biometrics based on Discretized Fingerprint Texture Descriptor

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ABSTRACT*:* Accurate automatic personal identification is critical in a variety of applications in our electronically interconnected society. So, this paper presents a fingerprint biometric system based on texture descriptors. For this, it requires an image of high PSNR value so that complete features must be extracted and all matching points will be obtained. For this, it uses an contrast based enhancement algorithm for improving PSNR value. We have considered the factors relating to obtaining high performance feature points detection algorithm, such as image quality, separation, image improvement and feature detection. Commonly used features for increasing fingerprint image quality are features vectors and local orientation. Accurate separation of fingerprint ridges from noisy background is necessary. A pre-processing method containing of field orientation, frequency estimation, filtering, segmentation and enhancement is performed. Image normalization is also done for equalizing the features values. Also area of interest is also found out. All simulations are done in MATLAB tool.

KEYWORDS: Fingerprint technique, Biometrics, Texture descriptors, minutia matching etc.

I. INTRODUCTION

Nowadays, there is an emerging interest in the application of biometric authentication and identification. Biometric identification is a growing and notorious field in which civil liberties groups express their concern over identity and privacy issues. Today, biometric laws and regulations are in process and biometric industry standard are being tested. This development has the great concern of security in the use of Internet application for consistent and automatic personal identification. Image processing is a rapidly growing area of computer science. Its growth has been fuelled by technological advances in digital imaging, computer processors and mass storage devices. Fields which traditionally used analog imaging are now switching to digital systems, for their flexibility and affordability. Important examples are medicine, film and video production, photography, remote sensing, and security monitoring. These and other sources produce huge volumes of digital image data every day, more than could ever be examined manually. Digital image processing is concerned primarily with extracting useful information from images. Ideally, this is done by computers, with little or no human intervention. Image processing algorithms may be placed at three levels:

At the lowest level are those techniques which deal directly with the raw, possibly noisy pixel values, with de-noising and edge detection being good examples. In the middle are algorithms which utilise low level results for further means, such as segmentation and edge linking. At the highest level are those methods which attempt to extract semantic meaning from the information provided by the lower levels, for example, handwriting recognition.

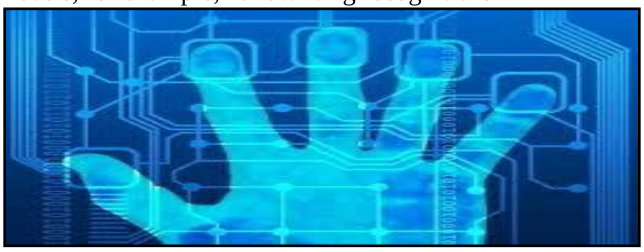

Figure 1: Fingerprint Image [17]

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Biometrics, which refers to identifying an individual based on his or her physiological or behavioural characteristics, has the capability to reliably distinguish between an authorized person and an imposter. Since biometric characteristics are distinctive, cannot be forgotten or lost, and the person to be authenticated needs to be physically present at the point of identification, biometrics is inherently more reliable and more capable than traditional knowledge-based and token-based techniques. Biometrics also has a number of disadvantages. For example, if a password or an ID card is compromised, it can be easily replaced [2].

The paper is organized as follows. In section II, it describes the related work of biometrics. In Section III, It describes introduction of image fingerprinting system. In Section IV, it describes the proposed fingerprinting image processing technique. The results are given in Section V. Finally, conclusion is explained in Section VI.

II. RELATED WORK

Fingerprint image quality improvement is proposed. The algorithm consisted of two stages. The first stage was decomposing the input fingerprint image into four sub-bands by applying two-dimensional discrete wavelet transform. At the second stage, the compensated image was produced by adaptively obtaining the compensation coefficient for each sub-band based on the referred Gaussian template. The method concluded an improved clarity, quality and continuity of ridge structures therefore accuracy was also increased. Background and the blurred region of fingerprint images were also removed.

Some [2] proposed a biometrics-based authentication scheme for multi-server environment using elliptic curve cryptography. To the best of our knowledge, the proposed scheme is the first truly three-factor authenticated scheme for multi-server environment. They also demonstrated the completeness of the proposed scheme using the Burrows Abadi–Needham logic.
Authors [3] presented the several improvements to an adaptive fingerprint enhancement method that was based on contextual filtering. In the global analysis and matched filtering blocks, different forms of order statistical filters were applied. These processing blocks yield an improved and new adaptive fingerprint image processing method.

Some [4] proposed a novel and effective two-stage enhancement scheme in both the spatial domain and the frequency domain by learning from the underlying images. They first enhanced the fingerprint image in the spatial domain with a spatial ridge-compensation filter by learning from the images. With the help of the first step, the second stage filter, i.e., a frequency band-pass filter that was separable in the radial- and angular-frequency domains was employed. An experimental result showed that our proposed algorithm was able to handle various input image contexts and achieves better results compared with some state-of-the-art algorithms over public databases, and to improve the performances of fingerprint-authentication systems Some [5] proposed a high-resolution palm print recognition system based on minutiae. The proposed system followed the typical sequence of steps used in fingerprint recognition, but each step had been specifically designed and optimized to process large palm print images with a good trade-off between accuracy and speed. A sequence of robust feature extraction steps allowed to reliably detecting minutiae; moreover, the matching algorithm was very efficient and robust to skin distortion, being based on a local matching strategy and an efficient and compact representation of the minutiae. Experimental results showed that the proposed system compares very favorably with the state of the art.

III. IMAGE FINGERPRINTING SYSTEM

Fingerprints are the patterns formed on the epidermis of the fingertip. The fingerprints are of three types: arch, loop and whorl. The fingerprint is composed of ridges and valleys. The interleaved pattern of ridges and valleys are the most evident structural characteristic of a fingerprint. The fingerprint of every individual is considered to be unique. No two persons have the same set of fingerprints.

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Figure 2: Fingerprint Sample [17]

1. Fingerprint Features

There are three main fingerprint features

a) Global Ridge Pattern b) Local Ridge Detail c) Intra Ridge Detail

A) Global Ridge Detail

There are two types of ridge flows: the pseudo-parallel ridge flows and high-curvature ridge flows which are located around the core point and/or delta point(s). This representation relies on the ridge structure, global landmarks and ridge pattern characteristics [4].

The commonly used global fingerprint features are:

1. Singular Points – They are discontinuities in the orientation field. There are two types of singular points- core and delta. A core is the uppermost of a curving ridge, and a delta point is the point where three ridge flows meet. They are used for fingerprint registration and classification.
2. Ridge Orientation Map – They are local direction of the ridge-valley structure. It is helpful in classification, image enhancement, and feature verification and filtering.

B) Local Ridge Detail

This is the most widely used and studied fingerprint representation. Local ridge details are the discontinuities of local ridge structure referred to as minutiae. They are used by forensic experts to match two fingerprints. There are about 150 different types of minutiae. Among these minutiae types, ridge ending and ridge bifurcation are the most commonly used as all the other types of minutiae are combinations of ridge endings and ridge bifurcations.

C) Intra Ridge Detail

On every ridge of the finger epidermis, there are many tiny sweat pores and other permanent details. Pores are distinctive in terms of their number, position, and shape. However, extracting pores is feasible only in high-resolution fingerprint images and with very high image quality. Thus the cost is very high. Therefore, this kind of representation is not adopted

2. Fingerprint Sensors

The fingerprint images may be acquired either by an offline or an online process. The fingerprint images acquired by the offline process are known as the “inked” fingerprints while the images acquired by the online process are known as “live-scan” fingerprints. Inked fingerprints are of three types: (i) rolled, (ii) dab, and (ii) latent. In the rolled method of fingerprint acquisition, ink is applied to the finger and then rolled on a paper from one side of the nail to the other to form an impression. This paper is then scanned at 500dpiresolution by a standard grayscale scanner. The rolled fingerprints have a larger ridge and furrow area due to the rolling process but have larger deformations due to the inherent nature of the rolling process. In the dab method of fingerprint acquisition, ink is applied to the finger and then pressed onto a paper without rolling. The paper is then scanned into a digital image. Typically, dab inked fingerprints have less nonlinear deformation but smaller area than the rolled inked fingerprints. Latent fingerprints are formed when the fingers leave a thin layer of sweat and grease on the surfaces that they touch due to the presence of sweat pores in our fingertips.

3. Fingerprint Representation

The popular fingerprint representation schemes have evolved from an intuitive system developed by forensic experts who visually match the fingerprints. These schemes are either based on predominantly local landmarks (e.g., minutiae-based fingerprint matching systems or exclusively global information (fingerprint classification based on the Henry system. The minutiae-based automatic identification techniques first locate the minutiae points and then match their relative placement in a

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given finger and the stored template. A good quality inked fingerprint image contains between 60 to80 minutiae, but different fingerprints and different acquisitions of the same finger have different numbers of minutiae.
The global representation of fingerprints (e.g., whorl, left loop, right loop, arch, and tented arch) is typically used for indexing, and does not offer good individual discrimination. Further, the indexing efficacy of existing global representations is poor due to a small number of categories (typically five) that can be effectively identified automatically and a highly skewed distribution of the population in each category. The global representation schemes of the fingerprint used for classification can be broadly categorized into four main categories:
(i) knowledge-based (ii) structure-based, (iii) frequency-based, and (iv) syntactic.

4. Fingerprint Classification
Large volumes of fingerprints are collected and stored every day in a wide range of applications, including forensics, access control, and driver license registration. Automatic identity recognition based on fingerprints requires that the input fingerprint be matched with a large number of fingerprints stored in a database (the FBI database currently contains more than 630 million fingerprints!). To reduce the search time and computational complexity, it is desirable to classify these fingerprints in an accurate and consistent manner such that the input fingerprint needs to be matched only with a subset of the fingerprints in the database. Fingerprint classification is a technique used to assign a fingerprint into one of the several pre-specified types already established in the literature (and used in forensic applications) which can provide an indexing mechanism. Fingerprint classification can be viewed as a coarse level matching of the fingerprints.

5. Fingerprint Verification
A biometric system can be operated in two modes: 1) verification mode and 2) identification mode. In the verification mode, a biometric system either accepts or rejects a user's claimed identity while a biometric system operating in the identification mode establishes the identity of the user without a claimed identity. Fingerprint identification is a more difficult problem than fingerprint verification because a huge number of comparisons need to be performed in identification. A number of civilian applications operate in verification mode on a regular basis and perform identification only at the time of the user registration to check the integrity of the database.

IV. PROPOSED FINGERPRINTING BIOMETRICS SYSTEM

Fingerprint technique is one of the most popular applications in identification & verification as it develops a low-cost fast computing system. Applications include accessing buildings or facilities withdrawing money or using a credit card, gaining contact to electronic info on a local computer or over the internet. There are various approaches for fingerprint recognition among which Pixel based is mostly preferred nowadays due to its pixel based localization [10].

A. Image Acquisition
Image acquisition is first step in the approach. It is very important as quality of fingerprint image must be good and free from any noise. A good fingerprint image is desirable for better performance of fingerprint algorithms. Based on the mode of acquisition, a fingerprint image may be divided into off-line or live-scan. An off-line image is obtained by smearing ink on fingertip and creating an inked impression of fingertip on paper. A live-scan image, on other hand, is acquired by sensing tip of finger directly, using a sensor that is accomplished of digitizing the fingerprint on contact. Live-scan is done using sensors. There are three types of sensors used. They are optical sensors, ultrasonic sensors and capacitance sensors [15]

B. Fingerprint Image Enhancement
Fingerprint image quality is an important factor in performance of minutiae extraction and matching algorithms. A good quality fingerprint image has high contrast between ridges and valleys. A poor quality fingerprint image is low in divergence, noisy, exhausted, or smudgy, causing spurious and missing minutiae. Poor quality can be due to cuts, crinkles, or bruises on surface of fingertip, excessively wet or dry skin condition, uncooperative attitude of subjects, broken and impure scanner devices, little quality fingers (elderly people, manual worker), and other factors [11].

Fingerprint Image enhancement is to make image clearer for easy further operations. Since fingerprint images acquired from sensors or other Medias are not assured with perfect excellence, those enhancement methods, for increasing contrast between ridges and furrows and for connecting the false broken points of ridges due to insufficient amount of ink, are very valuable for

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keep a higher accuracy to fingerprint recognition. Two Methods are adopted for image enhancement stage: the first one is Histogram Equalization; the next one is Fourier Transform [14].

C. Fingerprint Image Binarization

Fingerprint Image Binarization is to alter 8-bit Gray fingerprint image to a 1-bit image with 0-value for ridges and 1-value for furrows. After operation, ridges in fingerprint are highlighted with black color while furrows are white. A nearby binarization method is performed to binarize fingerprint image. Such a named method comes from mechanism of converting a pixel value to 1 if value is larger than mean intensity value of current block (16x16) to which pixel belongs [12].

D. Thinning of Image

Thinning is a morphological operation that is used to remove selected foreground pixels from binary images. It is used to eliminate redundant pixels of ridges till ridges are just one pixel wide. Thinning is normally only applied to binary images, and creates another binary image as output. It is final step prior to minutiae extraction. It uses an iterative, parallel thinning algorithm. All pixels on boundaries of fore ground regions that have at least one background neighbour are taken. Any point that has more than one foreground neighbour is deleted as long as doing so does not locally disconnect the region containing that pixel [15].

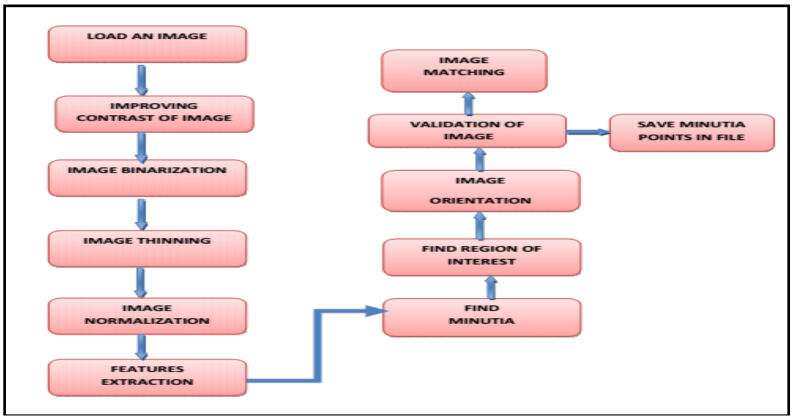

Figure 3: Functional Block Diagram of Proposed Approach

E. Fingerprint Image Segmentation

In general, only a Region of Interest is useful to be recognized for each fingerprint image. The image area without operative ridges and furrows is first discarded since it only holds background information. Then bound of remaining effective area is sketched out since the minutia in bound region are confusing with those spurious minutia that are generated when the ridges are out of the sensor [9].

Local segmentation can be seen to belong to a continuum of approaches to image understanding. At a higher level is global segmentation which attempts to group together related pixels from throughout image. The highest level is object recognition, whereby global segments are combined into logical units representing real world objects of interest. The fundamental component of local segmentation approach is segmentation algorithm itself. Most segmentation algorithms are designed to operate upon a whole image, or a large portion thereof. Local segmentation can only utilise a small number of pixels belonging to fragments of larger segments. Thus a local segmentation algorithm differs in that it has less data and fewer contexts to work with.

F. Minutiae Extraction

After enhancement of fingerprint image, image is ready for minutiae extraction. For proper extraction, however, a thinning algorithm is applied to enhanced image. It produces a skeletonised representation of image.

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G. False Features Removal

The pre-processing stage does not totally heal fingerprint image. For instance, false ridge breaks due to insufficient amount of ink and ridge cross-connections due to over inking are not totally eliminated. Actually all earlier stages themselves occasionally introduce some artefacts which later lead to spurious minutia. This false minutia will expressively affect accuracy of matching if they are simply regarded as genuine minutia. So some mechanisms of eliminating false minutia are essential to keep the fingerprint verification system effective [16].

H. Fingerprint Matching

Given two set of features of two fingerprint images, minutia match algorithm determines whether two minutia sets are from same finger or not. An alignment-based match procedure is used. It includes two consecutive stages: one is alignment stage and second is match stage [16].

1. Alignment stage. Given two fingerprint images to be matched, any one feature from each image is chosen, and similarity of feature points is calculated. If similarity is larger than a threshold, each set of features is changed to a new coordination system whose origin is at referenced point and whose x-axis is coincident with direction of referenced point.

2. Match stage: After obtaining two set of transformed minutia points, elastic match algorithm is used to count matched minutia pairs by assuming two minutia having nearly same position and direction are identical.

V. RESULTS

In proposed case, firstly both images are different. Here different functions are used for browsing the images one by one. Firstly, both images are assigned in MATLAB so that they may compare to each other and provide useful results. One is sample image for comparison and other is victim image.

Spatial domain represents an important enhancement technique that can effectively be used to remove various types of noise in digital images. Mean filters are the most commonly spatial filters used as a simple method for reducing noise in an image, particularly Gaussian noise. The idea of mean filtering is simply to replace each pixel value in an image with the mean 'average' value of its neighbours, including itself. The extracted average values are the result of the convolution process. Segmentation involves partitioning an image into groups of pixels which are homogeneous with respect to some criterion. Different groups must not intersect each other and adjacent groups must be heterogeneous. Thinning process removes the boundary of image as shown in results. Thinning was done using morphological algorithms. After thinning process, features of image are required to be extracted. So region props are used for feature extraction process. After all operations, both images are applied to fingerprinting matching system which matches images pixel by pixel. For this, it calculates the difference of the images. If both are matched, then difference image shows no error. But if both are different, then it shows error image.

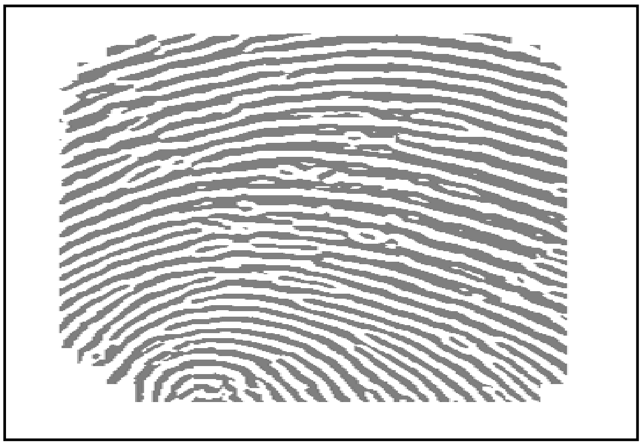

Figure 4: Input Original Image

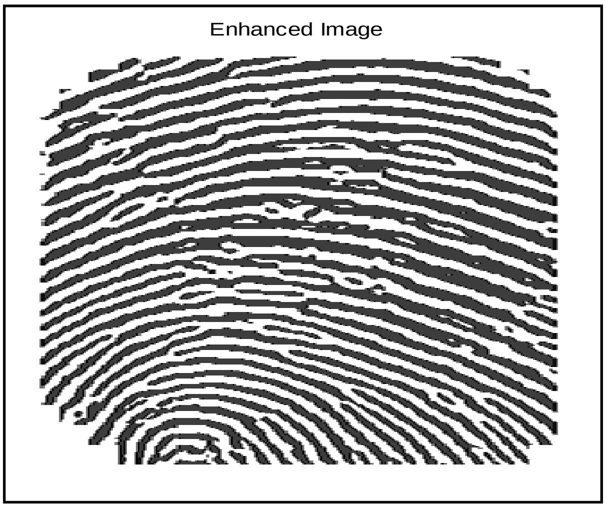

Figure 5: Enhanced Image

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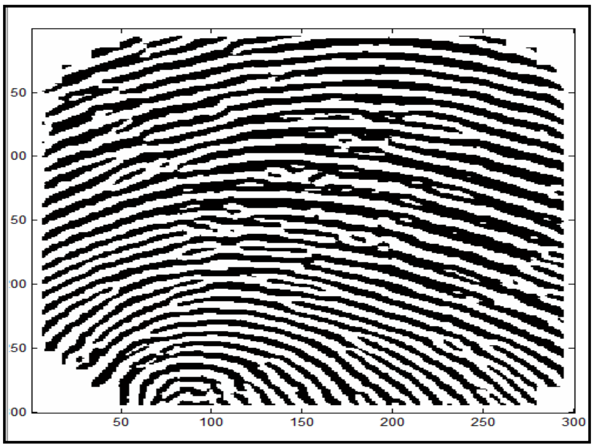

Figure 6: Binarized Image

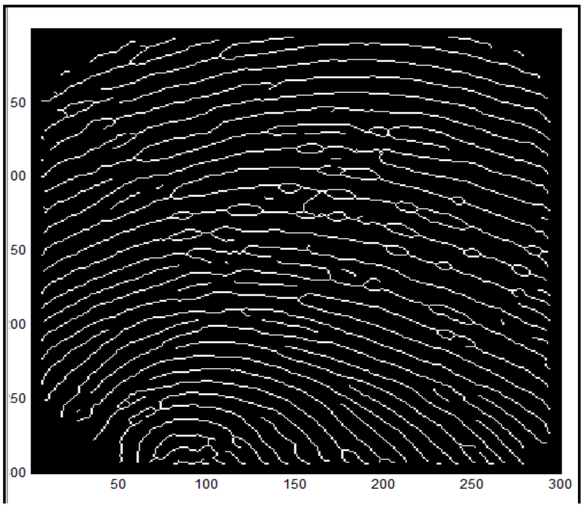

Figure 7: Thinning Image

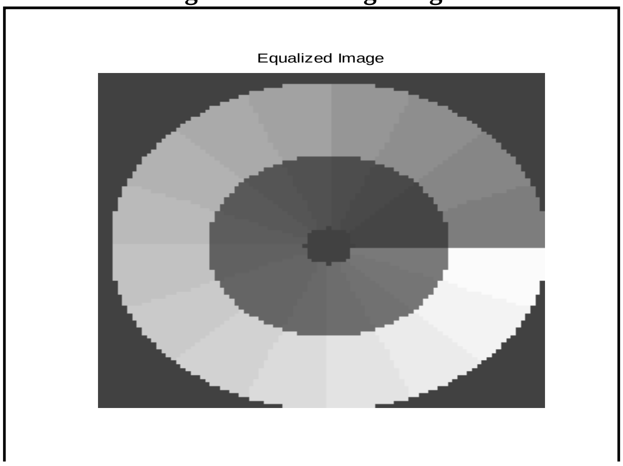

Figure 8: Normalized Image

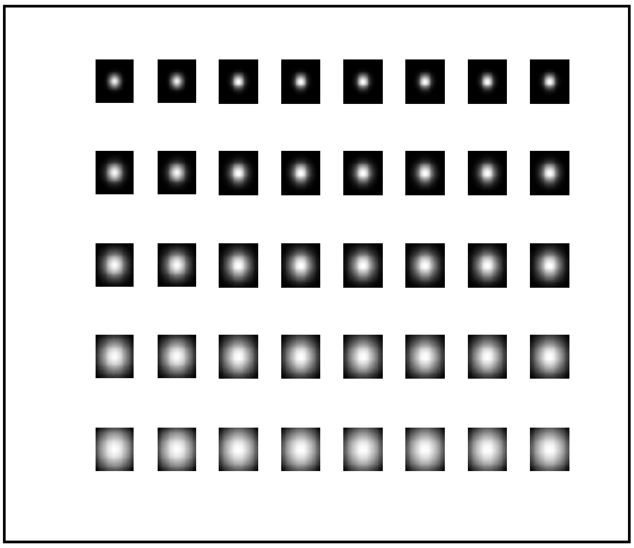

Figure 9: Features Vectors

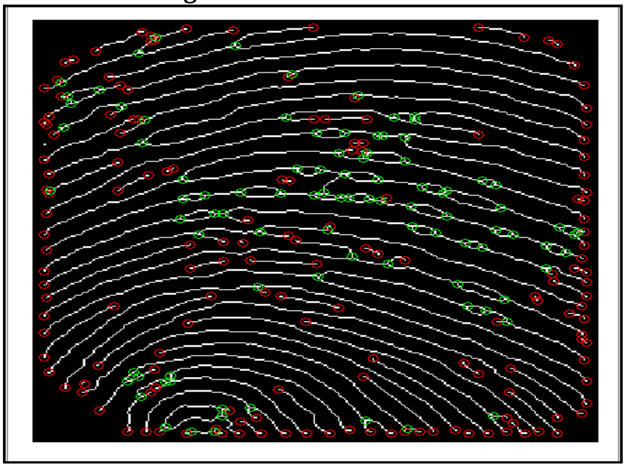

Figure 10: Minutia Extraction

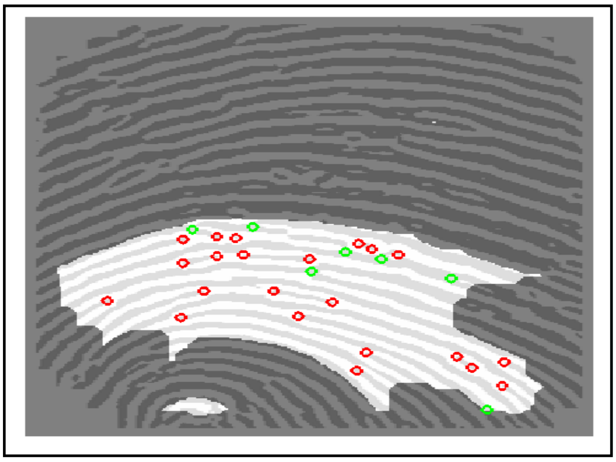

Figure 11: Region of Interest

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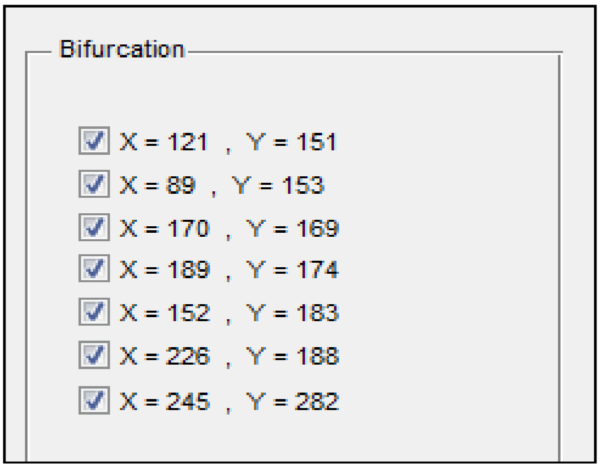

Figure 12: Bifurcation Points

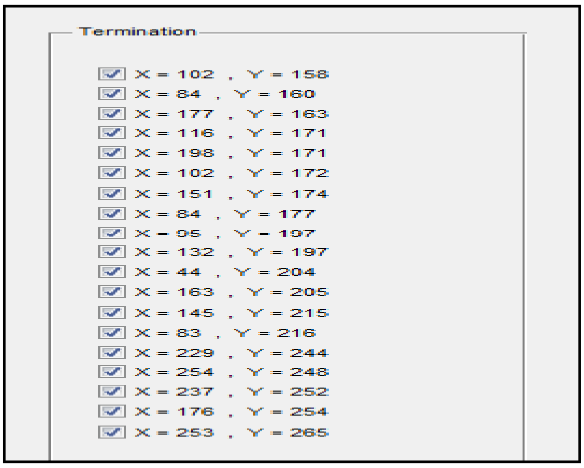

Figure 13: Termination Points

VI. CONCLUSIONS

The goal of this thesis is to design a fingerprint biometric system based on feature extractors. It is used in the application of fingerprint matching system. It is used to study the security impact of partial fingerprints on automatic fingerprint recognition systems and to develop an automatic system that can overcome the challenges presented by partial fingerprint matching.The proposed algorithm is implemented in MATLAB. The reliability of any automatic fingerprint system strongly relies on the precision obtained in the minutia extraction process. A number of factors are detrimental to the correct location of minutia. Among them, poor image quality is the most serious one. This proposed enhanced algorithm is able to overcome the drawbacks of spatial domain methods like thresholding, histogram equalization and frequency domain methods. The number of processes is used to match these images. This algorithm is able to get good contrasted image which increases the brightness of the low contrasted images. Also image gets equalized by normalization technique. In this, a region of interest is also found out to find minutia points. In last, image is validated and all points are save in a file.

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