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Fingerprint Identification System based on Minutiae Extraction

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ABSTRACT

This paper consists of *fingerprint recognition by minutiae extraction technique*. This technology has suffering from problem which is associated with the poor quality images. In recognition, fingerprint matching is takes place with distortion. Distortion in geometric position of finger image and its orientation leads to difficulties in matching and recognition from multiple impressions acquired from the same device. Considering minutiae accurately as well as rejecting false minutiae is major issue under research. This work has combination of many methods to build a minutiae extractor with the help of bifurcation which is used for minutiae matcher. This method provides more accuracy.

Keywords: minutiae extraction, segmentation, thinning, matching

I. INTRODUCTION

Today's life recognition of persons using biometric characteristics is recent trends. There are various biometric identifiers such as finger, face, signature and voice. Fingerprints are the highest levels of uniqueness with more accuracy and performance. As compare with most other biometric techniques, a fingerprint recognition system has more advantages cause of use and cost effective. Fingerprint recognition has a very good balance of all the properties. Therefore, a fingerprint recognition system plays a vital role in such situations. Human beings are easily accessible as identity cards. Fingerprint has a unique design which represents at their fingertips. In general there is no chance of the same exact pattern of the fingerprint. Even if there are twins may look similar but pattern never matched. A trained investigator can find out clear differences in the pattern. In general fingerprints are not distinguished by their ridges and furrows but by minutiae. There are some abnormal points on the ridges as shown in figure 1.

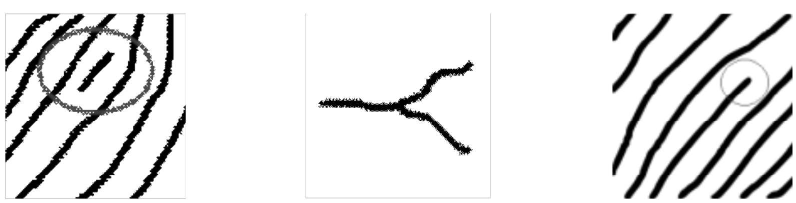

Figure 1: Basic Fingerprint Features

A fingerprint is distinguished by features called as minutiae. Minutiae are points at the ending ridges and at the bifurcation when one ridge splits up in two ridges. There are two types of minutiae features used extensively in the identification are termination and bifurcation. Termination is the immediate ending of a ridge. Bifurcation is the point on the ridge from which two branches derive [1]. Fingerprints cannot be forging and it is practically impossible. Therefore it is used in crime investigation and security. Minutiae features are used in biometrics and forensic science.

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The fingerprint recognition system consists of three categories such as fingerprint enrollment, verification and identification. Enrollment is the process of the assignment. Verification is the process of recognition from multiple people with same identity [2] [3] [4]. Fingerprint verification is nothing but authenticity of the person. In identification system individual recognition carried out through searching in the database for ideal match. In general fingerprint recognition carried out in three ways image preprocessing, fingerprint verification and identification. Fingerprint is one of the unique identifications of the personnel, in which the identity is checked through the fingerprint feature. The involvement of two minutiae features strengthens matching efficiency and reality extraction and minutiae matching based pairing. From thinned image extract minutiae for accuracy purpose. This paper deals with introduction in chapter 1, chapter 2 consists of the minutiae extraction technique, chapter 3 describes minutiae matching and chapter 4 elaborates results and discussion.

II. FINGERPRINT RECOGNITION USING MINUTIAE EXTRACTION TECHNIQUE

Various stages are involved in fingerprint recognition system to obtain accurate results. These stages are fingerprint image pre-processing, minutiae extraction or feature extraction and fingerprint image post-processing.

2.1. Fingerprint image pre-processing:

The matching performance mostly depends on the pre-processing of the fingerprint image due to sensors, physics and environment. The deficiency in the preprocessing system decreases the false rejection rate (FRR) and increases false acceptance rate (FAR). The efficient pre-processing is also a time issue for the real time application. Pre-processing steps involved in the system are shown in the Figure 2.

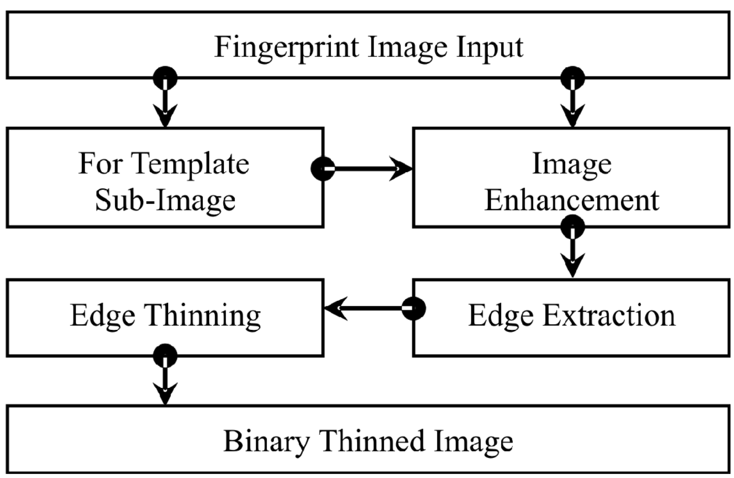

Figure 2: Image Pre-Processing Steps

There are a lot of methods for these processing of images, already established earlier. For a better thinned image, image enhancement is done using histogram equalization [5] [6]. There are few steps to be followed while performing the fingerprint image pre-processing that are fingerprint image enhancement, fingerprint image segmentation, fingerprint image binarization and fingerprint image thinning

2.1.1. Fingerprint Image Enhancement

The enhancement of fingerprint image is to accentuate certain image features for sub-sequent analysis or for image display. Image enhancement is needed for feature extraction, image analysis and visual information display. The enhancement process increases the inherent information content in the data. It simply emphasizes certain specified & desired features or image characteristics for easy detection. These algorithms are interactive and depend on application. Image enhancement techniques useful for contrast stretching and mapping to a pre-determined transformation [7][8]. An example is histogram equalization method, where the input gray levels are mapped therefore the output gray level distribution is uniform. This method is found to be powerful technique for low contrast images [9].

2.1.2. Fingerprint image segmentation

Image segmentation separates the desired region of interest (ROI) from the acquired image. To recognize fingerprint image the ROI is useful [10]. The ROI of the fingerprint image is the only region where all the required minutiae or features are present. Image segmentation decompose image into its components.

2.1.3. Fingerprint image binarization

Binarization is the process in which the gray scale image (i.e. all the gray levels in the image) is converted (mapped) into a binary image by thresholding and is defined as

$$Binarized\ \ pixel\,value = \begin{cases} 1; if\ \ pixel\ value > 1 \\ 0; \quad\ otherwise \end{cases}$$

2.1.4. Fingerprint image thinning

The binarized image thinning is used to reduce the complexity in processing. This process reduces the width of the ridges of the fingerprint image to into one pixel wide (skeleton image) by morphological thinning operation. In fingerprint image thinning process, thickness of each ridge line is reduced to such an extent that entire ridge line is represented by a single pixel wide line [8][11][12]. The requirements of thinning process are as follows

i) The thinned fingerprint image has single pixel width ridge line
ii) Ridge should be approximated to its centre pixel
iii) No breakage of ridge lines at thinning process
iv) Elimination of noise and singular pixels

By using these thinning rules, generate a one pixel wide skeleton image. Ridge thinning is used to eliminate the redundant pixels of ridges up to getting ridge of one pixel wide. It is difficult to obtain one pixel wide ridge. There are some locations in which skeleton have a two pixel wide. An erroneous pixel is defined as the one with more than two 4 connected neighbors. The erroneous pixels can destroy the integrity of spurious bridges and spurs. It can exchange the type of minutiae points. It can miss detects true bifurcations. Before proceeding to minutiae extraction, it is required to develop an algorithm to eliminate the erroneous pixels with preserving the skeleton connectivity at the fork regions [1].

$$\begin{bmatrix} a8 & a7 & a6 \\ a1 & a0 & a5 \\ a2 & a3 & a4 \end{bmatrix}$$ If a0 & a6 =1 then make a7 & a5=0. If a0 & a8 =1 then make a7 & a1= 0

2.2. Minutiae Extraction or Feature Extraction

There are two process of minutiae extraction and feature extraction is minutiae marking or detection and minutiae post-processing

2.2.1. Minutiae marking or detection

The fingerprint image thinning process is followed by marking the minutiae in the thinned binary image. The minutiae marking must be carried out after the thinning process [13] [14]. If the number of minutiae detected are more than the accuracy probability increases. In general, for each 3x3 window, for central pixel has value 1 and it has 3 one value neighbors, then ridge branch along with center pixel as shown in figure 3. If the central pixel is 1 and it has 1 one value neighbor therefore the ridge ending is to be considered with central pixel as shown in figure 3. Figure 3 demonstrate special case in which genuine branch is triple counted. If both the uppermost pixel with value 1 and the rightmost pixel with value 1 have another neighbor outside the window therefore the two pixels are marked as branches. In general one branch is located in the small region. Algorithmic check routine is required to verify neighbors of branches are added.

$$\begin{bmatrix} 0 & 1 & 0 \\ 0 & 1 & 0 \\ 1 & 0 & 1 \end{bmatrix} \begin{bmatrix} 0 & 1 & 0 \\ 1 & 1 & 1 \\ 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Figure 3: (a) bifurcation (b) triple counting branch (c) termination

The average inter ridge width is estimated at this stage. The average inter ridge width is the average distance between two neighboring ridges. To approximate the ridge width scan thinned ridge image row and make sum of pixels in the row has value one. The obtained summation is used to divide the row length to obtain inter ridge width. To get more accurate result these row scan is performed on other rows and column scans to get averaged inter ridge widths. The minutiae marking and thinned ridges in the fingerprint image are named with unique identifier for future processing[15].

2.2.2. Minutiae Post Processing

Minutiae post processing are categorized as false minutiae and false minutiae elimination procedure. The preprocessing stage does not totally restore the fingerprint image. The false ridge breaks caused by insufficient amount of ink and ridge cross connections caused over inking are not totally eliminated. Earlier stages introduce some artifacts which expedite spurious minutiae. These false minutiae affect significantly with the matching accuracy. Algorithmic steps to be involved for removing false minutiae for making effective fingerprint verification system [3].

Seven types of false minutia are specified in following diagrams:

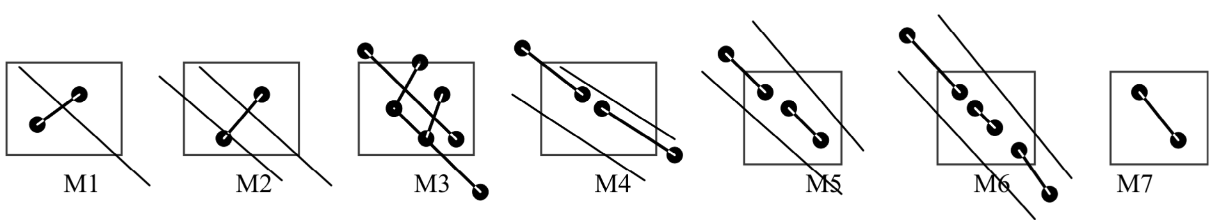

Figure 4: False minutiae structures

Spike making bore into a valley shown in M1. Spike are falsely connects two ridges shown in M2. The two near bifurcations located in the same ridge shown in M3. The two ridge broken points shown in M4. In M5 the broken ridge is short with another termination. M6 is nothing but extension of M4 with the extra property of third ridge is found in the middle of the two parts of the broken ridge. A short ridge found in the threshold window as shown in M7.

If the distance between one bifurcation and one termination is less than average inter ridge width and the two minutiae are in the same ridge then remove them. If the distance between two bifurcations is less than average inter ridge width and if they are in the same ridge then remove the two bifurcations. If two terminations are within a average inter ridge width and their directions are coincident with a small angle variation as well as they suffice the condition that no any other termination is located between the two terminations. There for the two terminations are regarded as false minutia derived from a broken ridge and are removed. If two terminations are located in a short ridge with length less than average inter ridge width then remove the two terminations [16] [17]. The design flow of for fingerprint recognition using minutiae extraction technique is describe with three main block such as fingerprint image, minutiae detection and extraction and post processing as shown in figure 5.

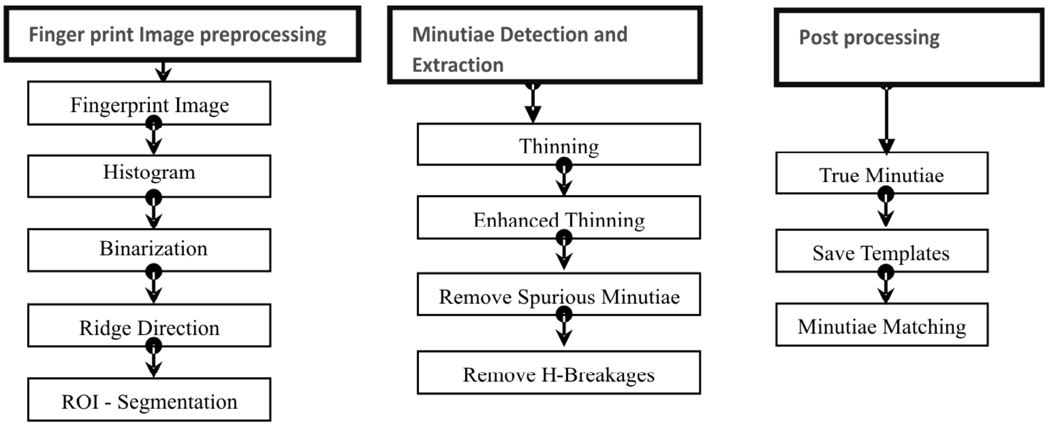

Figure 5: Design flow of for fingerprint recognition using minutiae extraction

III. MINUTIAE MATCHING

The minutia match algorithm is used to obtain the two minutiae matching of two fingerprint images. An alignment based match algorithm is used in this paper. It consist of two consecutive stages i.e. alignment stage and match stage.

a) Alignment stage: In this stage for two input fingerprint images to be matched for this purpose consider any one minutia from any one image and obtain the similarity of the two ridges which is associated with the given two referenced minutia points. The similarity value is found larger than a threshold then transform each set of minutia to a new coordination system which has origin at the referenced point and has x-axis coincident with the direction of the referenced point.

b) Match stage: The elastic match algorithm is used after alignment stage to count the matched minutia pairs by assuming two minutiae which has nearly identical position and direction.

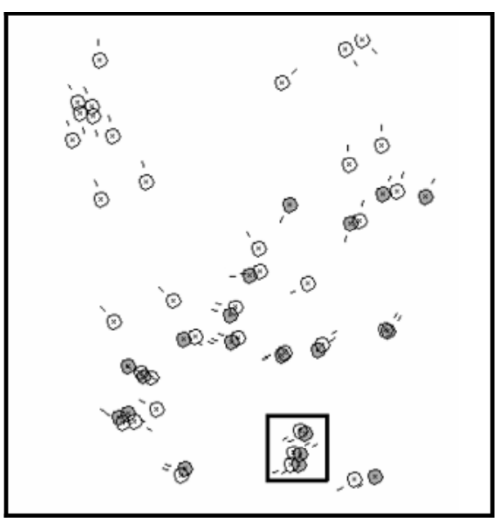

Figure 6a: Allignment Stage

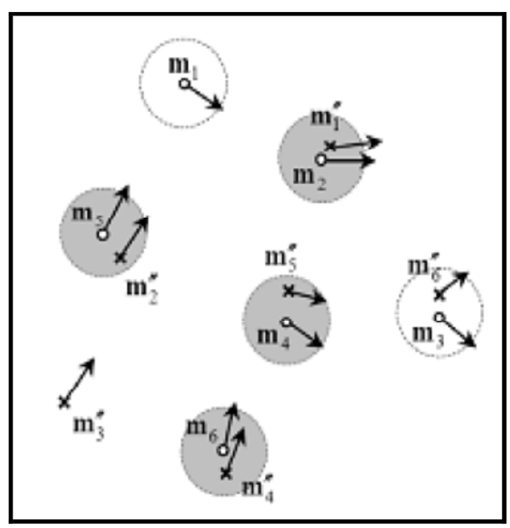

Figure 6b: Match Stage

Figure 6: Minutiae Matching

Matching algorithm is used to obtain characteristic formations of minutiae which are present in both datasets to match the desired output. See whether there are sufficient accordance's visible between the datasets. Figure 6a represents the actual minutiae matching of the features which were extracted from the stored template and the other from current input image. Figure 6b shows the actual comparison between two minute points i.e. one from the stored template and the other from current input image. In figure 6b, the points m_1, m_2 … m_6, which are represented by a 'small white circle (o)' indicates the extracted minute point from the pre-stored database, whereas the points m_1', m_2' … m_6' are represented by a 'cross sign (x)' indicates the extracted point from current input image. The 'dotted circle of are of radius 'r_0' and the small white circles acts as the origin of the respective dotted circles. Now, two extracted minutiae points are matched if and only if the following conditions are satisfied [11].

Euclidean distance<ro

Difference between angles < θ_0

where; r_0 = radius of dotted circle ('s)

θ_0 = angle tangential to ridge line

IV. RESULTS

There are 1000 images stored in database for accuracy purpose. This paper produces better accuracy for matching. The procedure to follow the finger print recognition is explained earlier. Initially input image is to be processed to obtain enhanced image as shown in figure 7. Enhanced image is further processed to obtain the binary image whose results are shown in figure 8. Thinned image is obtained after the binary process whose results are shown in figure 9. To proceed for matching algorithm binary thin image of single pixel is obtain whose results are shown in figure 10. This paper produces results for fingerprint image matching with 99 percent accuracy.

V. CONCLUSION

A technique of fingerprint image enhancement and minutiae extraction is performed in this paper. These methods give accuracy of 99 percent with huge database. This will be helpful for identification of matched finger. This is useful for identification of the person. These techniques can then be used to facilitate the further study of the statistics of fingerprints. The future scope of the work is to improve the quality of image either by improving the hardware to capture the image or by improving the image enhancement techniques for getting thinned image. Minutiae based fingerprint matching algorithms have some drawbacks which limit their application. Minutiae sets are unordered and individual minutia in two

Figure 7a): Original Image (Left) b) Enhanced Image (Right)

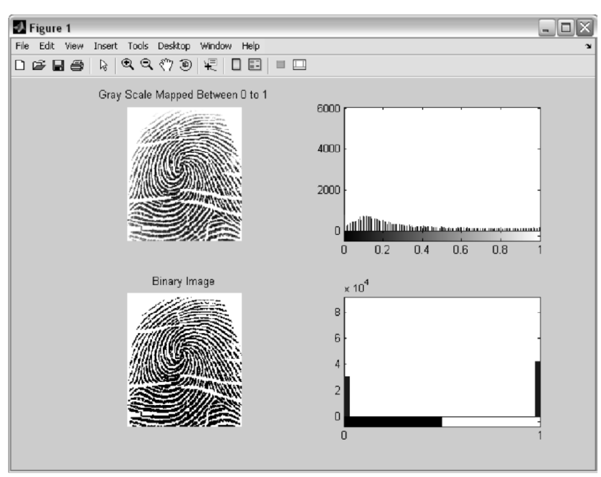

Figure 8 a): Gray Scale Image Mapped Between 0 to 1 (Top) b) Binary Image (Bottom

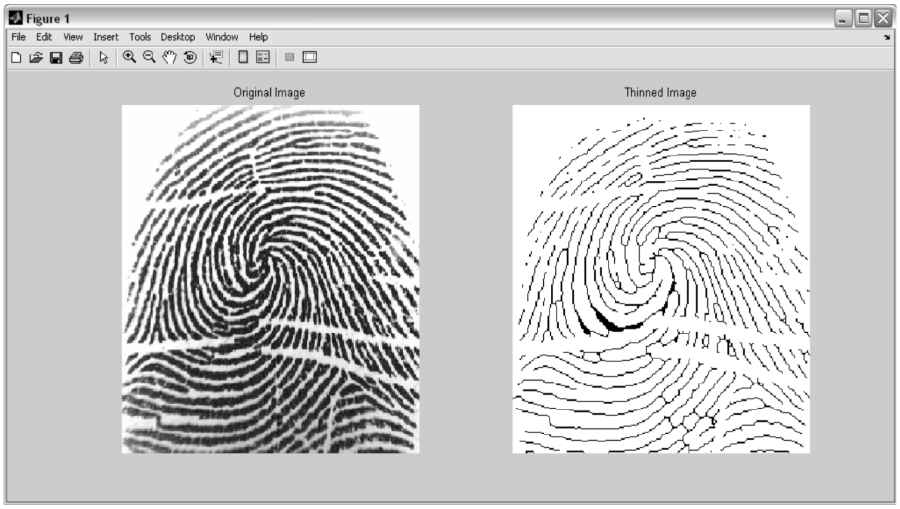

Figure 9 a): Original Image (Left) b) Thinned Image (Right)

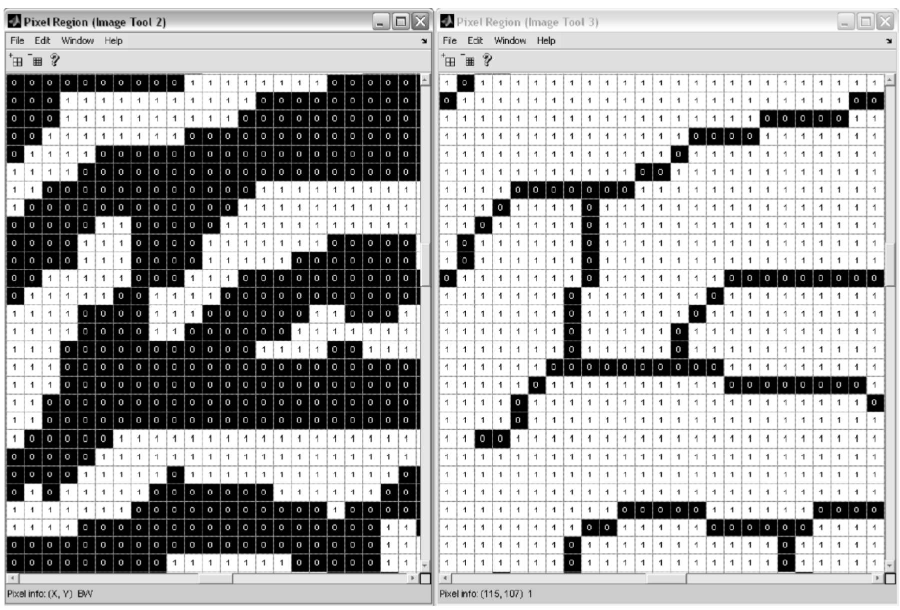

Figure 10 7.4: a) Binary Image Before Thinning (Left) b) Binary Image After Thinning – Single Pixel Wide (Right)

minutiae sets is unknown before matching which makes it difficult for getting geometric transformation and identification with a very large database. Minutiae based matching algorithms are needed high performance speed requirements.

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