Automatic fingerprint Identification Using Minutiae Matching

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***Abstract*— In recent days, as an impact of upcoming technologies, it is very important to authenticate people in a secure way. The online web applications developed for banks and shopping malls and theatres are using the techniques that depend on personal identification numbers, keys, or passwords to every specific end user. These technologies imply the risk of data being forgotten, lost, or even stolen. This could be because of missing out the confidential data unknowingly. Therefore biometric authentication methods promise a unique way to authenticate people. A most secure way of confidential biometric authentication is the utilization of fingerprints. A frequently used technique called "minutiae matching" which can handle automatic fingerprint recognition with all of the above mentioned web application systems.**

Keywords— **Fingerprint, Minutiae Matching, Feature Extraction.**

I. INTRODUCTION

A biometric fingerprint is a normal fingerprint taken by a computer, probably to access secured areas, or to enter a person into an identification database. Fingerprints are most widely used their high acceptability, immutability and individuality. Here immutability refers unchangeable. The most automatic system for fingerprint comparison are based on minutiae matching, [1]. There are six major steps included in automated fingerprint recognition. They are a) Fingerprint Acquisition, b) Fingerprint Segmentation, c) Fingerprint Image Enhancement, d)Feature Extraction e) Minutiae Matching, f) Fingerprint Classification [2].

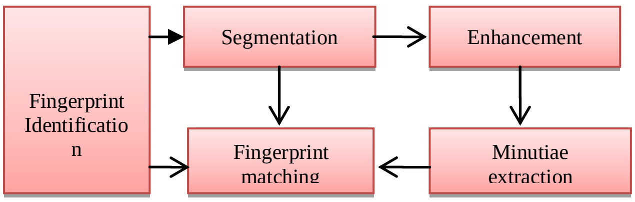


Fig (1) Architecture of fingerprint Minutia matching.

This fig shows the architecture of system for fingerprint minutiae matching. Fingerprint Identification, Matching Enhancement, Extraction, Fingerprint Identification, Segmentation are done here for Finger print process by using finger print images.

In Proposed System was evaluated at two levels: finger level and subject level. At the finger level, we evaluate the performance of distinguishing between natural and altered fingerprints. At the subject level, we evaluate the performance of distinguishing between subjects with natural fingerprints and those with altered fingerprints.

The proposed algorithm based on the features extracted from the orientation field and minutiae satisfy the three essential requirements for alteration detection algorithm:

- Fast operational time,
- High true positive rate at low false positive rate,
- Ease of integration into AFIS.

The goal of this paper is to announce the problem of fingerprint alteration and to design methods to automatically detect darkened or obscure fingerprint. In this paper is organized as follows. First, Section II discusses existing process. Then, section III presents a proposed work and design of algorithm. Section IV contains the step of algorithm pre-processing, minutiae Extraction, and post processing and also including the experimental result and advantage. Section V contains conclusion and future Scope.

II. EXISTING SYSTEM

In Existing System, since existing fingerprint quality assessment algorithms are designed to examine if an image contains sufficient information (say, minutiae) for matching, they have limited capability in determining if an image is a natural fingerprint or an altered fingerprint. Obliterated fingerprints can evade fingerprint quality control software, depending on the area of the damage. If the affected finger area is small, the existing fingerprint quality assessment software may fail to detect it as an altered fingerprint.

A. Fingerprint Acquisition

Fingerprint acquisition image is classified as offline(inked) or Online (Live scan).An inked finger is first obtained on a paper, and then scanned. An offline images produce very poor quality images because the ink spread un-uniformly and is therefore not exercised in online AFIS. In live scan sensing mechanism that can detect the ridge and valleys present in the fingertip. For online fingerprint image acquisition, capacitive or optical fingerprint scanners such as URU 4000, etc. are utilized which make use of techniques such as frustrated total internal reflection (FTIR) [10], ultrasound total internal reflection [8], sensing of differential capacitance [6] and noncontact 3D scanning [7] for image development. Live scan scanners offer much greater image quality, usually a resolution of 512 dpi, which results in superior reliability during matching in comparison to inked fingerprints.

B. Segmentation

An important step in an automatic fingerprint recognition system is the segmentation of fingerprint images**.** Segmentation refers to the separation of fingerprint area (foreground) from the image background [11]. Segmentation is useful to avoid extraction of features in the noisy areas of fingerprints or the background. A Simple thresholding technique [12] proves to be ineffective because of the streaked nature of the fingerprint area. The presence of noise in a fingerprint image requires more vigorous techniques for effective fingerprint segmentation.

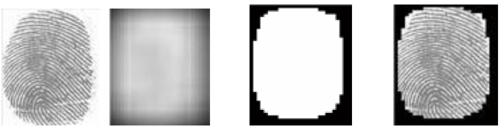


Fig 2: Different steps in segmentation

A. Original image, B. Coherence image, C. Segmentation Mask, D) Segmented.

Rent al. [13] proposed an algorithm for segmentation that employs feature dots, which are then used to obtain a close segmentation curve. The authors claim that their method surpasses directional field and orientation based methods [14, 15, and 16] for fingerprint image segmentation.

Shen et al. [1] proposed a Gabor filter based method in which eight Gabor filters are convolved with each image block and the variance of the filter response is used both for fingerprint segmentation and quality specification.Xian et al. [3] proposed a segmentation algorithm that exploits a block's cluster degree, mean and variance. An optimal linear classifier is used for classification with morphological post-processing to remove classification errors. Bazen et al. [4] proposed a pixel wise technique for segmentation involving a linear combination of three feature vectors (i.e. gradient coherence, intensity mean and variance). A final morphological post-processing step is performed to eliminate holes in both the foreground and background. In spite of its high accuracy this algorithm has a very high computational complexity, which makes it impractical for real time processing.
Klein et al. [5] proposed an algorithm that employs HMMs to remove the problem of fragmented segmentation encountered during the use of different segmentation algorithms. Furthermore, the use of a third class, representing low quality regions, is expected to improve the segmentation results.

C. Fingerprint Enhancement

Fingerprint enhancement consists of 2 major objectives i.e. i) to increase the contrast between ridges and valleys and ii) to connect broken ridges. Sherlock et al. [17] proposed an algorithm for fingerprint image enhancement that employs position-dependent Fourier-domain-filtering-based orientation smoothing and thresholding technique. O'Gorman et al. [19, 20] proposed a contextual filter based approach that utilizes four main parameters of fingerprint images at a given resolution i.e. maxima and minima of the ridge and valley widths to form a mother filter whose rotated versions are then convolved with the image to yield the enhanced output.

Fig(3) a. Orientation Field, b. Enhanced Image c. Thinned Image.

Gabor filters are used to enhance the fingerprint utilizing the ridge frequency and ridge orientation information obtained from the frequency and orientation images obtained earlier. The enhanced image IE is then binarized using adaptive thresholding to give a binarized image IEB. The binarized image is thinned to give IT. The thinned version is used for minutiae extraction. See above given fig. A common problem of image enhancement was fail when image regions are contaminated with heavy noises. In that case, the orientation field can hardly be estimated and accurate computation of ridge width and valley width is prohibitively difficult.

D. Minutiae Extraction

Feature extraction and template generation are based on series of ridges as opposed to discrete points which forms the basis of Pattern Matching Techniques. The advantage of Pattern Matching techniques over Minutiae Extraction is that minutiae points may be affected by wear and tear and the disadvantages are that these are sensitive to proper placement of finger and need large storage for templates.

Fingerprints possess two major types of features: special type of pattern formed by the ridge and furrow structures in the central region of the fingerprints and minutiae details associated with local ridges and furrows. Minutiae are minute details such as ridge endings (a point where a ridge ends abruptly) or a ridge bifurcation (where a ridge breaks up into two ridges). Minutiae are characterized by the position, direction and type (Ridge ending or bifurcation). The global features are used for fingerprint classification into six major classes whereas the minutiae details are used for fingerprint based person identification. Fingerprint analysts utilize the minutiae information for fingerprint identification and it is the most established technique in the field of AFIS.
The accuracy of the technique is dependent upon the precision in the extraction of minutiae. There are two major type of methods that are used for minutiae extraction i) binarization based methods and ii) direct gray scale methods. In binarization-based methods some information is lost during binarization that can degrade the performance of the minutiae extractor. Direct gray scale methods overcome these problems but may be difficult to implement and time consuming to

operate. The typical approach for a binarization-based method involves a priori enhancement, binarization and then thinning. Various binarization and thinning approaches are discussed in [21, 22, 23, 24, and 25].

Once a binary skeleton has been obtained, a simple image scan allows the pixels corresponding to the minutiae to be detected by finding the crossing number. The minutiae obtained as a result of minutiae extraction need to be filtered in order to remove the false minutiae introduced. Various minutiae filtering techniques are proposed in [26, 27]. The scope to improve the quality of image either by improving the hardware to capture the image or by improving the image enhancement techniques, So that the input image to the thinning stage could be made better which can improve the future stages and the final outcome.

E. Existing Algorithm

The fingerprint image quality is a key factor on the match result since it will cause spurious and missed minutiae when matching with the low quality image. It is important to estimate the image quality to guide the feature extraction and matching. In this paper we investigate the specifications that can reflect the image quality such orientation coherence, core position and so on.

F. Disadvantage

- The poor quality image results in spurious and missed minutiae, thus the degrading performance of overall system.
- To reject very low quality sample during the enrollment or/and to select the best samples.
- Vulnerable to noise and distortion brought on by dirt and twists.
- Some people may feel offended about placing their fingers on the same place where many other people have continuously touched.
- Some people have damaged or eliminated fingerprints.

III. PROPOSED SYSTEM

In existing system the fingerprint quality assessment software can't detect damage area or altered fingerprint. Minutiae matching method overcome these problems.

A. Proposed Algorithm

AIFS is a computerized system capable of reading, Classifying, matching, and storing fingerprints for criminal justice agencies. Quality latent fingerprints are entered into the AFIS for a search for possible matches against the state maintained databases for fingerprint records to help establish the identity of unknown deceased persons or suspects in a criminal case.

The algorithm runs in two main steps.

- Local matching
- Global matching

1) Local Matching

- In local matching stepwise calculations are there:

- Calculate "k" nearest neighbours for each and every point in both patterns.
- Calculate histogram of pair wise distances in the neighbourhood of every point.
- Find out the average histogram difference between all the possible cases.
- Set the threshold level of average histogram difference
- Compare the average histogram differences with the threshold level.

2) Global Matching

- Iteration method is used to converge the result towards dense part of the graph.
- For applying this method we need to calculate mean and standard deviation of the distribution.
- In the graph all transformation parameters are present, calculated after local matching step.
- The mean for this distribution is shown by the "triangle" in centre.

The basic goal of this module is to extract minutiae from a fingerprint that has been scanned. Fingerprints reveal flow-like ridges present on human fingers. The uniqueness of a fingerprint can be determined by the overall pattern of ridges and valleys as well as the local ridge anomalies. Minutiae Extraction refers to the extraction of features in the fingerprint image.

The two most prominent local ridge characteristics, called minutiae, are Ridge Ending and Ridge Bifurcation. A ridge ending is defined as the point where a ridge ends abruptly. A ridge bifurcation is defined as the point where a ridge forks or diverges into branch ridges.

Minutiae extraction algorithm constitutes three stages:

- Pre-processing
- Minutiae Extraction
- Post-processing

B. Design of Algorithm

Pre-processing

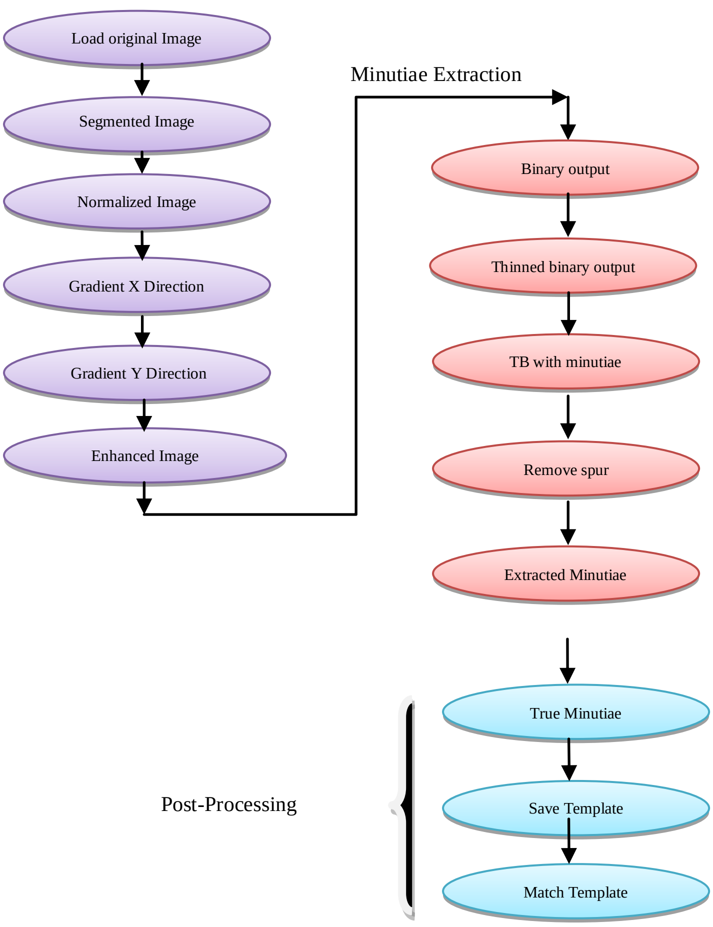


Fig (4) Design of Algorithm

The above figure shown the first step called pre-processing and gives an insight into the process that has been followed for the enhancement of the input fingerprint image. The second step deals with the extraction of minutiae. The final step is post processing, false minutiae are deleted from the set of obtained minutiae and hence the actual minutiae are obtained.

IV. THE STEP OF ALGORITHM WITH EXPERIMENTAL RESULT

A. Pre-Processing

Segmentation is mainly used to evade noisy area of fingerprint or background. In Pre-Processing the first step is given below.

Step 1

The input image is segmented from the background that ensures the removal of noise. For that reason, the whole image is divided into blocks of size 16×16 and the variance of each block is computed. The variance is then compared with the beginning value. If the variance of a block is less than the beginning value, then it is deleted from the original image. This process is carried out for the whole image. The image obtained from the above step is then normalized to get the desired variance of the given image. The normalized image is given by

$$\mathcal{G}(i,j) = \begin{cases} M_0 + \sqrt{\frac{VAR_0(\mathcal{I}(i,j)-M)^2}{VAR}} & \text{if } \mathcal{I}(i,j) > M \\ M_0 - \sqrt{\frac{VAR_0(\mathcal{I}(i,j)-M)^2}{VAR}} & \text{otherwise} \end{cases}$$

Where M indicate the calculation of mean and VAR indicate the calculation of variance of **I** In order and $\mathcal{I}(i,j)$ indicate the gray-level value at pixel (*i*, *j*), and $\mathcal{G}(i,j)$ denotes the normalized gray-level value at pixel (*i*, *j*). and VAR_0 are the desired mean and variance values respectively.

Step 2

The valuation of the orientation of the image is then carried out as the next step. The whole image is divided into blocks of size 16×16 and the local orientation in the figure is computed by

$$\begin{aligned} \mathcal{V}_x(i,j) &= \sum_{u=i-\frac{w}{2}}^{i+\frac{w}{2}} \sum_{v=j-\frac{w}{2}}^{j+\frac{w}{2}} 2\partial_x(u,v)\partial_y(u,v), \\ \mathcal{V}_y(i,j) &= \sum_{u=i-\frac{w}{2}}^{i+\frac{w}{2}} \sum_{v=j-\frac{w}{2}}^{j+\frac{w}{2}} (\partial_x^2(u,v) - \partial_y^2(u,v)), \\ \theta(i,j) &= \frac{1}{2}tan^{-1}\left(\frac{\mathcal{V}_y(i,j)}{\mathcal{V}_x(i,j)}\right), \end{aligned}$$

Where θ (*i*, *j*) is the least square estimate of the local ridge orientation at the block centred at pixel (*i*, *j*).

Step3

The angles between the blocks are then smoothened by passing the image through a low pass filter as follows.

$$\begin{aligned} X[k] &= \frac{1}{w}\sum_{d=0}^{w-1} \mathcal{G}(u,v), \quad k = 0,1,...,l-1, \\ u &= i + (d - \frac{w}{2})\cos\mathcal{O}(i,j) + (k - \frac{l}{2})\sin\mathcal{O}(i,j), \\ v &= j + (d - \frac{w}{2})\sin\mathcal{O}(i,j) + (\frac{l}{2} - k)\cos\mathcal{O}(i,j). \end{aligned}$$

Step 4

The following method is adopted for the calculation of the frequency of the local blocks. X-signatures of each block are computed along the direction perpendicular to the orientation angle in each block. The window used for this purpose is of size 16×32. The frequency is then computed by the distance between the peaks obtained in the X-signatures. The window for this is given by the formula.

$$X[k] = \frac{1}{w}\sum_{d=0}^{w-1} \mathcal{G}(u,v), \quad k = 0,1,...,l-1,$$
$$u = i + (d - \frac{w}{2})\cos\mathcal{O}(i,j) + (k - \frac{l}{2})\sin\mathcal{O}(i,j),$$
$$v = j + (d - \frac{w}{2})\sin\mathcal{O}(i,j) + (\frac{l}{2} - k)\cos\mathcal{O}(i,j).$$

In general, the frequency of image constitutes has a certain frequency for the hole image and hence the above step can be omitted if the global frequency of the given figure is known.

Step 5

As the next step, each block is filtered along the direction of the orientation angle using the value of the frequency obtained for each block. A Gabor filter is used for this process and a suitable value of local variances is taken for carrying out the process of filtering.

A Gabor filter takes care of both the frequency components as well as the spatial coordinates. The inputs required to create a Gabor mask are frequency, orientation angle and variances along x and y directions. Filtering is done for each block using the local orientation angle and frequency.

Pre-processing of the image is completed by the steps as mentioned and the enhanced image is obtained.

B. *Minutiae Extraction*

The next step after enhancement of the image is the extraction of minutiae. The enhanced image is binarised first in this step. The skeleton of the image is then formed. The minutiae points are then extracted by the following method. The binary image is thinned as a result of which a ridge is only one pixel wide. The minutiae points are thus those which have a pixel value of one (ridge ending) as their neighbour or more than two ones (ridge bifurcations) in their neighbourhood. This ends the process of extraction of minutiae points.

1) *Fingerprint Thinning:* Thinning is the process of reducing the thickness of each line of patterns to just a single pixel width [18]. The requirements of a good thinning algorithm with respect to a fingerprint are

- The thinned fingerprint image obtained should be of single pixel width with no discontinuities. b) Each ridge should be thinned to its centre pixel.
- Noise and singular pixels should be eliminated.
- No further removal of pixels should be possible after completion of thinning process. [8] Uses an iterative, parallel thinning algorithm. In each scan of the full fingerprint image, the algorithm marks down redundant pixels in each small image window (3x3). And finally removes all those marked pixels after several scans. Enhanced thinning algorithm is applied to obtain an accurately thinned image.

2) *Enhanced thinning algorithm*

- Step 1: Scanning the skeleton of fingerprint image row by row from top-left to bottom-right. Check if the pixel is 1.
- Step 2: Count its four connected neighbour.
- Step 3: If the sum is greater that two, mark it as an erroneous pixel.
- Step 4: Remove the erroneous pixel.
- Step 5: Repeat steps 1 – 4 until whole of the image is scanned and the erroneous pixels are removed.

C. *Post-Processing*

The minutiae points obtained in the above step may contain many spurious minutiae. This may occur due to the presence of ridge breaks in the given figure itself which could not be improved even after enhancement. This results in false minutiae points which need to be removed. These unwanted minutiae points are removed in the post-processing stage.

False minutiae points will be obtained at the borders as the image ends abruptly.

These are deleted using the segmented mask. As a first step, a segmented mask is created. This is created during segmentation carried out in the stage of pre-processing and contains ones in the blocks which have higher variance than the threshold and zeros for the blocks having lower variance. This segmented mask contains all ones in the regions where the image is located and all zeros at the other places.To know if a minutiae point is valid or not, a local window of size 11×11 is taken in the segmented mask at the location of the minutiae point and the total sum of the window is computed. If the sum is lesser than 121, then the point is invalid as it would be on the borders. If the sum is 121, it means that the point is not on the border and hence it has to be preserved. Thus, minutiae at the borders are removed preserving only those inside the figure. For the deletion of minutiae inside the figure which would occur due to ridge breaks, a window of size 11×11 is taken around each minutiae point keeping it at the centre of the window and then is checked for any other minutiae that lie in the block. If other minutiae exist in that block, all the minutiae in the block are deleted. Thus, the minutiae points resulting from ridge breaks are eliminated. Though this process helps in removing false minutiae, it also poses a risk of eliminating closely placed minutiae points even though they are real.

D. *Experimental Result*

A.Original Fingerprint Image

B. Segmented Image along with the orientation field

C .Normalized Image

D .Gradient along X- Direction

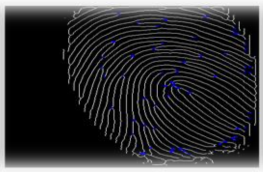
E .Gradient along Y – Direction

F. Enhanced Image after Gabor Filtering

G. Binary Output

H. Thinned Binary Output

I. Thinned Binary along with all the minutiae



J. Minutiae obtained after deleting spurious minutiae at the borders

K. Final extracted Minutiae after applying the windowing technique

E. Advantage

- This algorithm undergoes two steps, so accuracy is good and false acceptance rate is low.
- Can enroll multiple fingerprints.
- Calculation is less complex with comparison to other methods proposed yet. Here, histogram is a basis to select the local matching pairs, while in other

randomize algorithms are lacking in any basic attribute to compare.
- Performance is better in case with missing points from a specific region.

V. CONCLUSION AND FUTURE SCOPE

Improved Identifying the alternated fingerprint in the present work contributed to. The main advantage of this algorithm is system accuracy and fast running speed. It improves the verification performance too. The algorithm identifies the unrecoverable corrupted areas in the fingerprint and different false minutiae are detected and are removed properly. This is an important aspect of the algorithm as the presence of these areas would prove to be extremely harmful for the extraction of minutiae points. It helps in removing the spurious minutiae too which may also prove to be harmful in matching fingerprints correctly. 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.

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