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Minutiae Based Fingerprint Recognition System

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ABSTRACT

Biometrics refers to the use of an individual's unique physiological or behavioral characteristics to identify an individual. Fingerprint recognition is the most useful, common and economically affordable physiological biometric authentication technique. Fingerprint is the collection of ridges and valleys. The discontinuity of ridges is known as minutiae points. In this paper minutiae points based verification system has been proposed which can store intermediate file of binary image, thinned image and list minutiae points which can be used by the researchers. Before verification of the claimed image core point detection, enhancement, binarization, thinning and removal of false minutiae points are performed. Proposed system is compared with existing system to prove the robustness of it.

Keywords : Fingerprint, ridges, valley, core point, enhancement, binarization, thinning

Introduction

Bioinformatics is regarded as a significant component of the identification technology. Everywhere in the world security is given the top priority to counter the possible treats from terrorists and hence biometrics and security are receiving increased attention in search of effective solutions. Uses of biometric systems are spreading in all areas such as airports, banks, offices apart from important documentation like passports, identity cards, driving licenses, voting cards, etc. Among all the biometric techniques, fingerprint-based identification is the oldest method which has been successfully used in numerous applications. Everyone is known to have unique, immutable fingerprints. Fingerprints are one of the most mature biometric technologies and are considered legitimate proofs of evidence in courts of law all over the world [2].

Basically two types of methods are used to make sure about the person's identity. They are identification and verification.

Identification (One-to-many matching) is determining who a person is. It involves taking the measured characteristic and trying to find a match in a database containing records of people and that characteristic. This method may require a large amount of processing power and time if the database is very large.

Verification (One-to-One matching) is determining if a person is who they say they are.

It involves taking the measured characteristic and comparing it to the previously recorded data for that person. This method requires less processing power and time, and is often used for accessing places or information.[9]

Fingerprint as a Biometric

A fingerprint is made of a series of ridges and furrows on the surface of the finger. The uniqueness of a fingerprint can be determined by the pattern of ridges and furrows as well as the minutiae points. Minutiae points are local ridge characteristics that occur at either a ridge bifurcation or a ridge ending. An ending is a feature where a ridge terminates. A bifurcation is a feature where a ridge splits from a single path to two paths at a Y-junction[5]. Other than these bifurcation and ridge ending minutiae points crossover, island, double bifurcation, trifurcation minutiae points can also be available on a fingerprint.

Two other features are sometimes used for matching: core and delta. (Figure 1) The core can be thought of as the center of the fingerprint pattern. The delta is a singular point from which three patterns deviate [5].

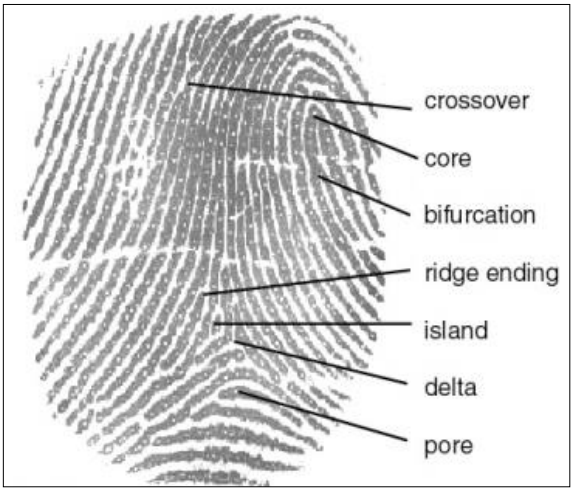


Figure 1 : Example of Fingerprint with its characterstics
[Source : Fingerprint Recognition –Andrew Ackerman, Professor Rafail Ostrovsky]

1. Fingerprint Classification

Fingerprints are classified in a three-way process:

- By shapes and contours of individual patterns
- By noting the finger positions of the pattern types and
- By relative size

Depending on the above criteria fingerprints are classified in arch, tented arch, loop, twinned loop, whorl, central pocket loop, lateral pocket loop, composite and accidental type of fingerprint.

2. Matching approaches for Fingerprint Recognition

The first approach, which uses image-based methods, tries to do matching based on the global features of a whole fingerprint image. It is an advanced and newly emerging method for fingerprint recognition.

The second approach, which is minutia-based, represents the fingerprint by its local features, like terminations and bifurcations.

3. Stages performed in a Fingerprint Recognition System
The following stages are performed during fingerprint recognition process:

- **Image Acquisition**
- **Core Point Detection**
- **Image Enhancement**
- **Binarizarion**
- **Thinning**
- **Feature Extraction**
- **Matching**

3.1 Image Acquisition
A number of methods are used to acquire fingerprints. Among them, the inked impression method remains the most popular one. Scanners are also used to capture the image.

3.2 Core point Detection
Fingerprint's core point can be defined as the point of maximum curvature in the fingerprint image [8]. After image acquisition, the core point of the fingerprint is detected.

3.3 Image Enhancement
A fingerprint image is one of the noisiest of image types because of dirt on a tip, cut, scarred, creased, dry, wet, worn, etc. The image enhancement step is designed to reduce this noise and to enhance the definition of ridges against valleys.

Fingerprint Enhancement consists of five main stages:

- Segmentation
- Normalization
- Orientation estimation,
- Ridge frequency estimation, and
- Gabor filtering.

3.4 Binarization
Binarization is the process that converts a gray level image into a binary image. The black pixels represent ridges, and the white pixels represent valleys.

3.5 Thinning
The final image processing operation usually performed prior to minutia detection is thinning. Thick ridges are converted to one pixel

3.6 Feature Extraction
The fingerprint minutiae are found at the feature extraction stage. Operating upon the thinned image, the minutiae are straightforward to detect. Endings are found at termination points of thin lines. Bifurcations are found at the junctions of three lines.

3.7 Matching
A fingerprint matching means comparison of two given fingerprints and returns the decision whether they are from same finger or not. Matching fingerprint images is an extremely difficult problem, mainly due to the large variability in different impressions of the same finger. The main factors are displacement, Rotation, Partial overlap, Non linear distortion, Pressure and skin condition, Noise, Feature extraction errors etc.

In this paper, main work focuses on minutiae extraction and matching stages. The work describes a simple fingerprint recognition system that constitutes core detection, fingerprint preprocessing, feature extraction and matching. The proposed system uses a minutia based method which is based on core points of the fingerprint. The structure of proposed system is given in figure 2.

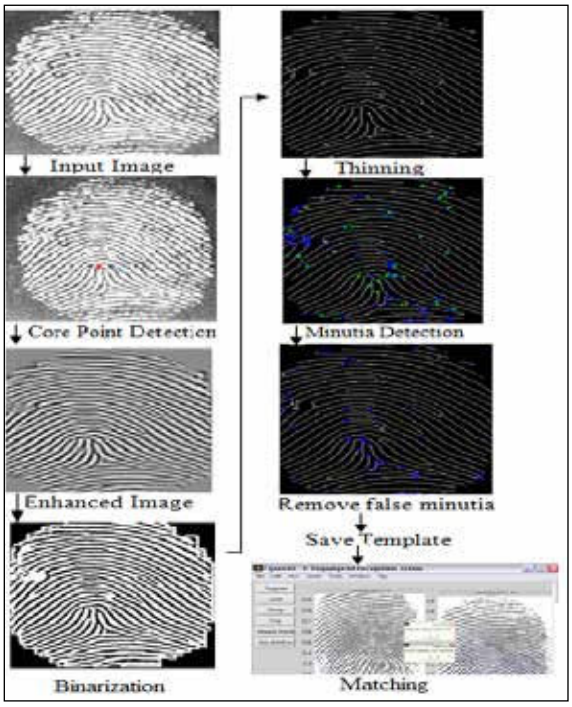


Figure 2: Components of Matching Stage

4. Functions of Proposed System
Proposed system has following functions:

- Register
- Verify
- Binary
- Thin
- Minutia points
- Clear Database

Register function performs image acquisitions, core point detection, enhancement, binarization, thinning, minutiae extraction, true minutiae detections and saving process of templates.

Verify function performs matching operation between claimed image with each template stored in the database.

Binary function stores binary image which can be used by researchers directly any time. Same way Thinning functions stores thinned imaged and Minutia points stores minutia points in the .XLS sheet which can be used manually also.

Algorithm used to detect minutiae points.
Step 1: Start

Step 2: Input thinned Image.

Step 4: Repeat Step: 5 to Step: 6 for all points.

Step 5: If Image (i,j) = 1 then
Calculate total number of active points around Image(i,j) i.e CN
End of step: 5

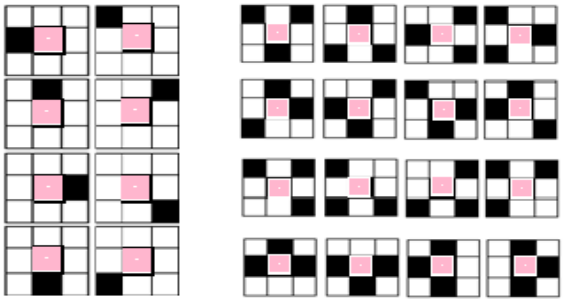
Step 6: If CN=1 then
Store Image (i,j) as ending point
Else
If CN=3 then
Check Image (i,j) for bifurcation point
End of Step: 6

Step 7: End

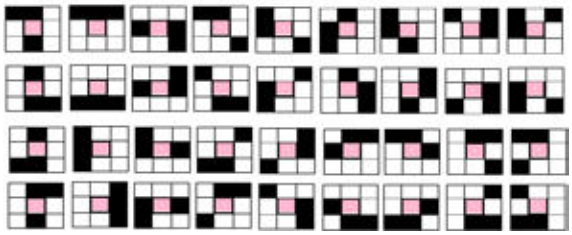
The minutiae location is derived after minutiae extraction. Crossing Number (CN) is used to locate the minutiae points in fingerprint image. If CN is 1, 2 and 3 or greater than 3 then

minutiae points are classified as Termination, Normal ridge and Bifurcation respectively.

Only the above information is not sufficient to determine the bifurcation point, because in some case if CN is 3 then only we can not consider it as bifurcation point. Possible ending points and bifurcation points can be determined in following circumstances.



(a) (b)



(c)

Figure 3: (a) Possible Ending points (b) Possible Bifurcation points (c) list of points which are not bifurcation points

Figure 3(c) lists the situation of active points which are not bifurcation points even though CN (P) = = 3.

Depending on the above conditions minutiae points are detected. False minutiae may be introduced into the image due to factors such as noisy images. False minutiae always come from structures like space, bridges and holes created during the thinning process Hence, after the minutiae are extracted, it is necessary to remove the false minutia before template saving. If the distances between a minutia and its neighbors are very small, those minutiae may be a false one. Furthermore, the minutiae below a certain distance from the boundary of the foreground region are deleted [3].

Distance between minutiae is calculated and remove the minutiae which are closed to each other. Distance between two points a(x1,y1) and b(x2,y2) is calculated using following formula:

$Dist=((x1-x2)^2 +(y1-y2)2)^{1/2}$

4.1 Format to store the true minutiae points
This is the stage where system stores the features extracted after processing of the input fingerprint for verification. Here the template is stored in .XLS format. The advantage of this format is that one can easily process the data manually also. It requires less memory space than .bmp file.

In cell (1,3) , path of the input image will be stored so one can display the (.bmp,. jpg, .tif)file at matching stage.

In cell (2,1) , The X coordinate of the core point of input image is stored.

In cell (2,2) , The Y coordinate of the core point of input image is stored.

In cell (3……..n,1) ,The X coordinate of the minutia point of input image is stored.

In cell (3,1……..n,2) ,The Y coordinate of the minutia point of input image is stored.

4.2 Matching Process
In this stage the system verify all images against the input image one by one. If best match is found then both images are reported as same otherwise the input image is not a registered image and that is why it is not in the given database. In this stage the difference between the core points is calculated and added to the second image to transform the second image according to first image. In image there is a possibility that the thickness of ridges may vary in different images of same finger because of the pressure of the finger, noise occurs due to scanner etc. So the minutia located at the same location may be vary .To come out from this problem 5 had been taken as a threshold value to match the points. So if in template1, one minutia point location is (50,50), then any point between (55,55)-(45,45) in template2 can be considered as a match point. If the matching score is greater than 6 then both fingerprint will be matched otherwise does not matched.

Control flow in Fingerprint Recognition
- The steps given below summaries the control flow in the core based matching algorithm.
- Differences in coordinates of the core points of two images are found.
- Minutiae of second image are transformed in the view of the core point of first image.
- Matching score is calculated by considering the location of minutia within the range of - 5 to +5 pixels.
- If the number of minutiae matched crosses the threshold value, then access is granted else denied.

This process is repeated against every registered image and best match is reported.

Algorithm to count the matching minutiae points:
Step 1 : Start

Step 2 : Input two template f1, f2

Step 3 : calculate the distance between core points of f1 and f2

Step 4 : Add difference to all minutiae points of f2 to translate it.

Step 5 : Repeat step 5 to step 10 till the end of f1 , set . k=3,match=0.

Step 6 : Repeat step 6 to step 9 till the end of f2, set . n=3.

Step 7 : if (f1(k,1) == f2(n,1) || f1(k,1) == (f2(n,1)+1) || f1p(k,1) == (f2(n,1)+2) || f1(k,1) == (f2(n,1)+3) || f1(k,1) == (f2(n,1)+4) || f1(k,1) == (f2(n,1)+5) || f1k,1) == (f2(n,1)-1) || f1(k,1) == (f2(n,1)-2) || f1(k,1) == (f2(n,1)-3) || f1(k,1) == (f2(n,1)-4) || f1(k,1) == (f2(n,1)-5)) then step 8

Step 8 : if f1(k,2) == f2(n,2) || f1(k,2) == (f2(n,2)+1) || f1(k,2) == (f2(n,2)+2) || f1(k,2)== (f2(n,2)+3) || f1(k,2) == (f2(n,2)+4) || f1(k,2) == (f2(n,2)+5) || f1(k,2) == (f2(n,2)-1) || f1(k,2) == (f2(n,2)-2) || f1(k,2) == (f2(n,2)-3) || f1(k,2) == (f2(n,2)-4) || f1(k,2) == (f2(n,2)-5) then

match=match+1;

End of step 8

End of step 7

Step 9 : End of step 6

Step 10 : End of step 5

Step 11 :End

Results are tested with verifinger and FRS 5.1 which produced very good results comparative to both of these systems.

5. Conclusion

In this paper, the proposed system is a fingerprint recognition which is based on minutiae points. The algorithm also makes the use of core points and minutia points of images like endpoints and bifurcation points. In this system templates of input images and intermediate file of binary and thinned images are stored. When two templates are given for matching then second images will be transformed as the first image using core points of both images. After alignment both images are verified for matching using given algorithm. Also the achieved results are compared with some available system downloaded from the internet, which shows the robustness of the proposed algorithm. But there are still some problems which are remaining to be solved listed below:

- The proposed system is core based fingerprint verification system. This system is not suitable for the images which do not have a core point.
- Proposed system does not support rotation. It is accurate with the images with the same alignment. It means it can be work very well with images which are captured with sweeping techniques and with same alignment.

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