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A Survey On Hough Transform-based fingerprint Alignment Approaches

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Abstract - *Fingerprint is the most common and authentic biometric for personal identification, especially for forensic security. This review paper describes minutiae extraction from fingerprint image and also classifies existing fingerprint alignment approaches based on Hough Transformation. These approaches are efficiently described and compared on the basis of computing time and memory usage with accurate alignment parameter (rotation and translation). We found that performance of DRBA approach is good with minutiae points in large amount of translation, and also its computational time is less than that of LMBA approach. However, the memory requirement in DRBA is greater than LMBA. This comparative study is helpful in selection of the method to get optimal alignment result with given constraints. The whole paper presents a good technical summary for the beginners to work in the area of fingerprint alignment*

Key Words*—Hough-Transformation; fingerprint; alignment; matching; minutiae-points*;

1.INTRODUCTION

A fingerprint is an impression left by the friction ridges of a human finger. An important method of forensic science is the recovery of fingerprints from a crime scene. Human fingerprints are detailed, nearly unique, difficult to alter, and durable over the life of an individual, making them suitable as long-term markers of human identity. They may be employed by police or other authorities to identify individuals who wish to conceal their identity, or to identify people who are incapacitated or deceased and thus unable to identify themselves, as in the aftermath of a natural disaster. Fingerprint analysis, in use since the early 20th century, has led to many crimes being solved. Fingerprint identification, is the process of comparing two instances of friction ridge skin impressions called minutiae, from human fingers to determine whether these impressions could have come from the same individual or not. Minutiae in biometrics are major features of a fingerprint, using which comparisons of one print with another can be made.

Variations of fingerprint features extracted from two fingerprint images of the same finger captured at different instances is the common challenge in fingerprint recognition systems. The number of features extracted from different fingerprint images is generally not equal because the coordinates and orientations of corresponding fingerprint features may differ. Some of the fingerprint feature would not be extracted due to poor image or mistake with the feature extractor. The most powerful variations considered in this research are caused by transformation namely; rotation and translation [1]. The process of estimating how much the finger was rotated and translated referred to as alignment.

Fingerprint alignment is a significant task in the process of fingerprint matching. The fingerprint alignment is used to improve unknown translation and rotation between two fingerprint images taken in different instances. The purpose of alignment is to simplify the process of determining corresponding features extracted from the same finger. Mostly used fingerprint matching method, called minutiae based matching; alignment is achieved by first determining rotation and translation, and then superimposing fingerprint features using determined parameters. Minutiae points are locations on the fingerprint where a ridge either ends or splits to form two ridges; these are known as a ridge ending and a ridge bifurcation respectively. Performing alignment make simpler the process of finding corresponding points, because the alignment involves modifying minutiae point data of one or both minutiae point sets to ensure that location and orientation values of corresponding minutiae point are approximately equal. Therefore, a problem of matching can be simplified into a problem of determining corresponding points from aligned fingerprint representation [2].

This paper is divided in to five sections. Section 1 provides the brief introduction on figure print, section 2 gives details of minutiae used in figure print, section III elaborates the mostly used Hough Transform and its underline approaches. Section IV gives a comparative summary of results. Finally conclusion is done in section V.

2 MINUTIAE EXTRACTION

Although there are about 20 different minutiae types, but ridge ending and ridge bifurcation are mostly used for fingerprint matching. Figure 1 shows the most frequent minutiae types.

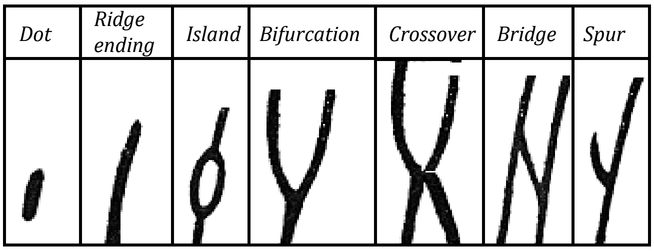


Figure-1: Commonly used minutiae types

Minutiae extraction approaches are basically divided in two groups: one performed on binary thinned images [3, 4] and other works directly on grey scaled images [5, 6]. In literature many traditional methods has been proposed for minutiae extraction. Each method consists of following steps:

2.1 Binarization

In this process the gray-scale image is converted in the binary image consisting of only two values of image intensity: black, representing the ridges, and white, representing the valleys or background. A simple method to binarize the image is to use a global threshold value; however, this is not well suited for the noisy images. A more robust method consists of using some rectangular mask, rotate according to orientation of the ridges.

2.2 Thinning

The objective of thinning is to find the ridges of one pixel width. This process includes successive erosions until a set of connected lines of unit-width is reached. These lines are also called skeletons. An important property of thinning is the preservation of the connectivity and topology, which however can lead to generation of small bifurcation artefacts and consequently to detection of false minutiae. Therefore some procedures aiming the elimination of these artefacts must be performed after the thinning.

2.3 Minutiae Detection

From the binary thinned image, the minutiae are detected by using the 3×3 pattern marks. Samples of marks used for identifying the ridge ending and bifurcations point are shown in the figure 2. Although the process seems to be simple, it is necessary to consider the elimination of false detected minutiae. are shown in figure 2.

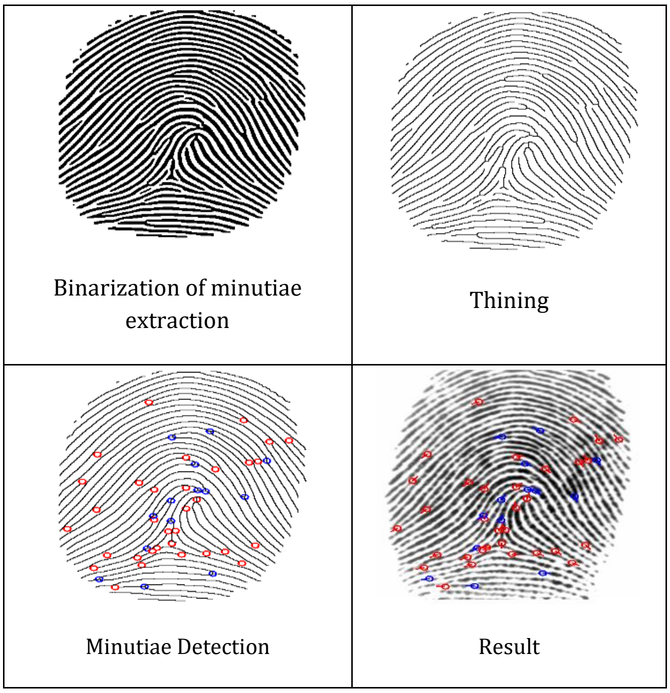


Figure-2: The results of each step for minutiae extraction

In summary, we can say that after fingerprint image acquisition, minutiae detection algorithm is performed through several steps which include pre-processing (normalization and segmentation), orientation and frequency estimation, binarize enhancement, thinning (skeletonization), minutiae detection and verification (filtering).

3.HOUGH TRANSFORM

The HT-based method is normally used to have a good alignment results. As the computing time and memory usage is an on-going challenge because of continuous improvement of the technology, e.g. the embedment of AFIIVS on Smart Cards, cell phones, tokens, and other small devices [8]. So the need of improving existing fingerprint fingerprint methods leads us to include Hough Transformation based fingerprint alignment approaches. In general, HT-based fingerprint alignment methods are classified into two main approaches. The first approach is a Discretized Rotation Based Alignment (DRBA). The second approach is a Local Match Based Alignment (LMBA). Both approaches are briefly explained with the emphasis of their difference with relative to the general Hough Transform approach. In DRBA approach, each discretized rotation angle and pairs of minutiae points are used to compute alignment parameter. In addition, each discretized rotation angle is added into each orientation of Image. Then, for every pairing minutia found to have allowed direction difference and add votes for all possible translations and rotations.

In LMBA approach, a local match between all minutiae points is determined first such as minutiae with corresponding triangles. To compute the alignment parameter these corresponding minutiae points are used. Then, for each Alignment Parameter, minutiae points are aligned to determine N number of aligned points and these points are then added into accumulator array. The alignment parameter that receives the maximum number of votes is believed to be the best transformation. Figure 3, shows the summary of the general HT based fingerprint alignment algorithms and the steps involved in the implementation of DRBA and LMBA.

3.1 DRBA Approach

The DRBA approach has been implemented in different ways, as explained in [9-13]. In the DRBA approach, it is common to consider all given points from I and T as possible corresponding points [9]. In addition, by checking if the direction difference of minutiae orientation is smaller than a defined threshold [10]. In second stage, estimate Alignment Parameter (AP) from estimated corresponding pairs. The rotation angle is occupied from the discretized data and used to compute AP. Using the affine transformation with the rotation angle from discretization data, translation parameters are computed. At the third stage, the accumulator array A is required to store all possible AP.
The bin size is used to specify the step size in A and it is used when voting for the nearest bins of the current estimated AP. During the voting procedure it is general to cast the votes on the nearest bins, and the bin sizes are experimentally defined by considering different values from too small to large amounts.

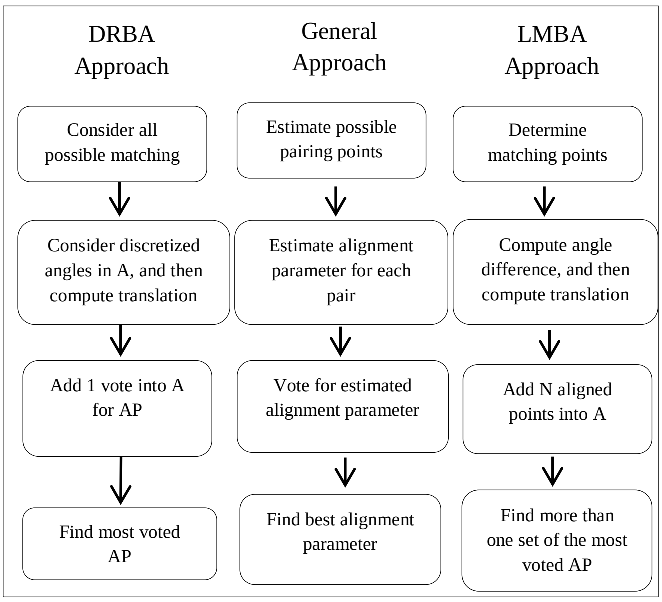


Figure 3: general HT based fingerprint alignment algorithms

The number of votes is accumulated by adding a vote for each computed parameters, shown in equation (1).

$$A[\Delta_x^+, \Delta_y^+, \theta^+] = A[\Delta_x^+, \Delta_y^+, \theta^+] + 1 \qquad (1)$$

It is common in both approaches to define the accumulator array as a 3D array for rotation angles, and translations along the x and the y axis. The last step is to find the best alignment set, which can be one set or N sets of indexes of A with the largest votes.

3.2 LMBA Approach

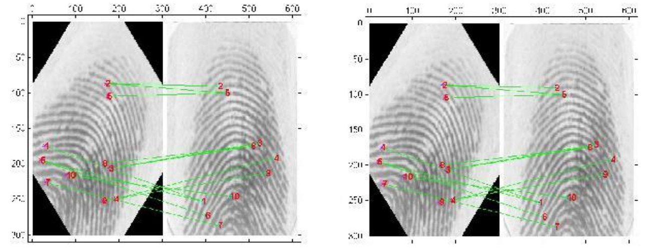
The LMBA approach also has been implemented in different ways [14-19]. In first stage determining the matching points by using some methods, for example: by finding pair of points with similar Euclidean distance from their locations; or by first determining corresponding triangles between I and T [16-18]; or by using similar triangles from Delaunay triangulation [19-20], and then, estimate matching points from corresponding triangles. In second stage, computing the alignment parameter by using the affine transformation with the computed rotation angle. In the third stage it is common to define different bins of the accumulator array, e.g. starting from a large size of bins to the small size of bins to find the finer results of AP. The number of votes is accumulated by adding a number of aligned points determined after aligning points using each set of parameters, as shown in equation (2).

$$A[\Delta_x^+, \Delta_y^+, \theta^+] = A[\Delta_x^+, \Delta_y^+, \theta^+] + N \qquad (2)$$

At the end of this approach, a set of AP with the highest number of votes is deemed as the one that represent the best transformation of tested sets of minutiae points.
Cynthia S. Mlambo and Fulufhelo V. Nelwamondo were performed experiments using a public FVC2000 database to investigate the accuracy of alignment parameters as computed using the LMBA and DRBA. The LMBA and DRBA algorithms were implemented in Matlab and compared in terms of accuracy of alignment results, computing time and memory usage. In addition, the performance for code implementation were evaluated by considering different impressions of fingerprint images that represent common challenges in alignment, such as unequal number of minutiae points with translation and rotation of minutiae points.

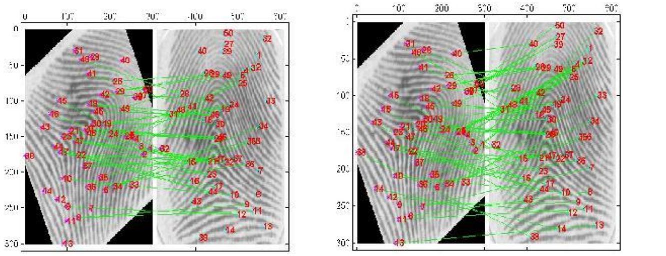
4. COMPARISON OF RESULTS

The performance of the DRBA and the LMBA on the amount of rotation is illustrated in Figure4 and Figure5. In Figure4 images have about 10 minutiae points and were rotated by 45 degrees, with number of minutiae unchanged. The alignment parameters computed using DRBA and LMBA are, (-61, 129, -40) and (-60, 150, -40), respectively. In Figure5 images have about 50 minutiae points and were rotated by 60 degrees. The alignment parameters computed using DRBA and LMBA are, (-51, 109,-50) and (-30, 150,-60), respectively. The experimental results indicate that the correctness of alignment for both approaches decreases as the rotation amount decrease, with the LMBA performs better than the DRBA. This is because both approaches involve certain limitations on the rotation.



(a) Results from the DRBA (b) Results from the LMBA

Figure-4: 10 minutiae points rotated by 45 degrees.



(a) Results from the DRBA (b) Results from the LMBA

Figure-5: 50 minutiae points rotated by 60 degrees

Table-1: Summary of Results

Minutiae Conditions and Methods		Average performance		
		Accuracy	**Time**	**Memory**
Number of Points	DRBA	93%	0.31s	1.06KB
	LMBA	98%	0.93s	0.13KB
Amount of translation	DRBA	90%	0.33s	1.06KB
	LMBA	85%	0.95s	0.13KB
Amount of rotation	DRBA	80%	0.92s	1.06KB
	LBMA	85%	0.86s	0.13KB

5. CONCLUSIONS AND FUTURE WORK

The comparison between two main HT based fingerprint alignment approaches is presented, which are Discretized Orientation Based Approach and Local Match Based Approach. The AP is computed from a FVC2000 database which contains different rotated and translated fingerprints impressions of the same finger. The experimental results show that LMBA approach performs better than the DRBA approach on minutiae point sets with larger rotation and small number of points. While the DRBA approach performs better with minutiae points with larger amount of translation. The required time in LMBA approach is greater than the time required in DRBA, while the memory usage required in DRBA is greater than required in LMBA. This study is useful for understanding the quality and relationships between the wide variety of existing HT-based fingerprint alignment methods and for assisting in the selection of the most suitable method for translation and rotation of fingerprint minutiae points.

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