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Fingerprint Matching with Ridge Ends and Virtual Core Point using Enhanced Concentric Ring Algorithihm

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Abstract: ***Fingerprints are the most common and widely accepted biometric feature for person identification and verification in the field of biometric identification. Fingerprints consists of two main types of features : (i) Ridge and Furrow structure: Ridge ends and bifurcation and (ii) Core Point: the of maximum curvature in central region of the fingerprint. This paper presents the implementation of a minutiae based approach to fingerprint identification and verification and serves as a review of the different techniques used in various steps in the development of minutiae based Automatic Fingerprint Identification System (AFIS). The technique conferred in this paper is based on the extraction of ridge termination and virtual core minutiae from the thinned, binarized and segmented version of a fingerprint image.***

Keywords: Fingerprint, Core, Ridge End, Minutiae Extraction, Minutiae Matching

1. Introduction

With the recent development in information technology, the need for secure personal authentication systems has increased rapidly. Earlier, IC cards and passwords are widely used and are popular in personal authentication. However, these methods have several drawbacks. The IC cards could be stolen or duplicated, and in the case of passwords, they could become known to others, this makes it insecure.

Fingerprints have been used for biometric recognition since long because of their high accuracy, immutability and individuality[2]. Immutability is defined as the persistence of the fingerprints over time whereas individuality is the uniqueness of ridge details across individuals. Fingerprint authentication is one of the most important biometric technologies [4]. A fingerprint is the pattern of ridges and valleys (furrows) on the surface of the finger. This paper focuses on fingerprints, which can provide personal authentication at high accuracy. Firstly, Fingerprint image is obtained from sensor. And this image is enhanced because enhancement algorithm can improve the clarity of the ridge structures of input fingerprint images, then the enhancement image is binarized by fixing the threshold value. The binarization image is thinned using morphological operations.

Then the output image is segmented for minutiae extraction. After minutiae extraction, false minutiae are removed by using Euclidean distance. After pre-processing, the existing data collection and template data collection are matched by using two steps (registration and verification).

Figure. Fingerprint Pattern

For the fingerprint image pre-processing stage, Histogram Equalization and Fourier Transform is used to do image enhancement [8] [29]. And then the fingerprint image is binarized using the locally adaptive threshold method [5] [12]. The image segmentation task is fulfilled by a three-step approach: block direction estimation, segmentation by direction intensity [4] and Region of Interest extraction by

Morphological operations. Also the morphological operations for extraction ROI are used for fingerprint image segmentation.

For minutia extraction stage, three thinning algorithms [12] [2] are tested and the Morphological thinning operation is finally bid out with high efficiency and pretty good thinning quality. My technique for minutia extraction is carried out in two phases, in first phase, virtual core point is calculated which is the main and initial identification feature.

Once the virtual core in the centermost region of the fingerprint image(in case of no core point) is identified, its x-y coordinates and angle of rotation is stored in database (Table 1) as primary identifying feature and in second phase, rest of the minutia are extracted and stored as secondary identifying feature in another database (Table 2). Most methods used in the minutia extraction stage are developed by other researchers but they form a brand new combination in my paper. The minutia marking is a simple task as most literatures reported but one special case is found during my implementation and an additional check mechanism is enforced to avoid such kind of oversight.

For the post processing stage, an existing algorithm is used to remove false minutia based on [12][1]. The superficial approach of minutia matching mechanism is one of the main proposed modifications in this paper to achieve efficient results. When minutia matcher initiates, it search and identifies the Virtual Core Point / Reference Point only from the fingerprints from the fingerprint scanning device and compares them among the values stored in fingerprint database. Once the Virtual Core Point is identified, the matcher compares the inter-distance between the core and the nearest bifurcation to ensure the identified result. If the inter-distance between the core/reference minutia and nearest bifurcation minutia match well [1], two fingerprint images are aligned and matching is conducted for all remaining minutia.

Implementing the comparison of only Virtual Core Point first results in quick matching among millions of fingerprints in database. Moreover, confirmation of inter-distance between the core and the nearest bifurcation ensures avoiding any kind of oversight. Implementation of this technique uses lesser CPU time and makes system lightweight, quick and more efficient thereby reducing the total overhead..

2. Proposed Technique

Matching is accomplished in two phases: Initial Matching and Final Matching

2.1 Initial Matching

1. Coordinates of Virtual core point (VCP) i.e. (x, y) are identified and values are stored in Primary Table 1.
2. The coordinates of nearest ridge end to the VCP are found using Enhanced Concentric Ring algorithm are found and stored in Primary Table 1.
3. Coordinate values of VCP and Ridge End along with Inter-distance(r) is used as the Primary matching feature at identification level in Primary Table 1.

2.2 Enhanced Concentric Ring Algorithm

1. Identify the coordinates of all the minutiae present in fingerprint and store in Secondary Table 2.
2. Find types of all the minutiae in Secondary Table 2.
3. If MINUTIA TYPE = Ridge End, then transfer x and y coordinate values to Secondary Table 1 else skip the values.
4. Identify the coordinate values of VCP (x, y) using [28].
5. Use VCP(x, y) as the center and radius(r) = 1 (in pixels)
6. Draw imaginary circle and compare each pixel on circumference of circle with values in Secondary table 1, starting from direction of VCP in clockwise manner.
7. If minutia matches then inter-distance radius = r and exit, else search for next minutia with same radius.
8. If no minutia match using same radius, then radius = radius+1 and go to step 6.Set your page as A4, width 210, height 297 and margins as follows:

Table 1: Primary Table 1

Virtual Core Point coordinates			Nearest Ridge End coordinates		Inter-Distance r (in pixel)
X Axis	Y Axis	Angle	X Axis	Y Axis	
62	104	0.64	51	105	9

2.3 Final Matching

When initial matching is done, rest of the minutiae in fingerprint which are stored in Secondary Table 2 are matched to confirm the result.

Table 1: Secondary Table 2

X Axis	Y Axis	Angle 1	Angle 2	Angle 3
52	26	0.00	0	0
58	29	3.14	0	0
42	43	-2.62	0	0
154	58	2.36	0	0
52	59	0.52	0	0
180	79	-1.05	0	0
61	92	-2.09	0	0
93	98	-1.57	0	0
137	116	-1.57	0	0
151	116	-1.05	0	0
108	117	-2.09	0	0
70	124	-0.79	0	0
162	126	-1.57	0	0
79	133	2.36	0	0

146	13	2.36	NaN	-0.52
52	105	-2.36	1.57	-0.79
126	115	-2.36	1.57	-1.05
169	136	-2.36	2.09	-0.79
NaN	NaN	0.00	0.00	0.00
79	145	-1.05	-1.05	0.52
178	149	1.57	1.57	-0.79
77	153	2.09	2.09	0.00
Nan	NaN	0.00	0.00	0.00
90	167	2.36	-2.36	0.52
119	174	2.36	-2.09	0.00

The matching algorithm for the aligned minutia patterns needs to be elastic since the strict match requiring that all parameters (x, y, θ) are the same for two identical core/reference minutia is impossible due to the slight deformations and inexact quantization of minutia.

The approach to match rest of minutia in secondary phase is achieved by placing a close circuit box around each template minutia. If the minutia to be matched is within the rectangle box and the direction discrepancy between them is very small, then the two minutiae are regarded as a matched minutia pair. Each minutia in the template image either has no matched minutia or has only one corresponding minutia.

The final match ratio for two fingerprints is the number of total matched pair over the number of minutia of the template fingerprint. The score is 100*ratio and ranges from 0 to 100. If the score is larger than a pre-specified threshold, the two fingerprints are from the same finger. However, the elastic match algorithm has large computation complexity and is vulnerable to spurious minutia.

3. Conclusions

At present the methods that are in use are the ones involving the use of Gabor filtering and Fourier filtering. The first technique consists of implementation of 2D Fourier Transform for the enhancement stage. This is the computationally fastest method since it classifies the orientations to 16 directions. But this results in lesser accuracy since it assumes the frequency to be constant throughout which is not the case.

In the second method the improvement is done by introduction of Gabor filters which takes into account both the frequency and orientation of the image and the filtering is done with a greater accuracy.

The Wavelet Transform has been found to be a very effective tool in denoising and compression techniques. But the accuracy of these techniques is far from satisfactory. A new mechanism is proposed that incorporates Gabor filtering & Wavelet transformation.

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