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Effect of Pressure Variation on the Fingerprint Minutiae Based Feature Vector Matching

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Abstract— Fingerprint verification of online fingerprint images has become a very actively studied field in biometric systems. This paper investigates the major challenges in fingerprint recognition if the images are captured at varying pressure. Extracting minutiae from fingerprint images is one of the most important steps in automatic fingerprint verification and classification. Minutiae are local discontinuities in the fingerprint images, mainly ridge termination and bifurcations. In this paper we proposed an algorithm m-margin to fill the broken curves on a fingerprint. Our proposed algorithm eliminates false minutiae that connect broken curves in fingerprint. The method is initialized with the captured image using local histogram equalization, FFT, image binarization, thinning, skeleton refinement, end-points, filtering and matching. The images achieved from these steps are passed through proposed m-margin algorithm. This method show some improvement in the minutiae extraction process in terms of either efficiency and/or time required. The quality of the fingerprint images greatly affects the performance of the minutiae extraction.

Keywords- biometrics; minutiae; ridge; valley; FRR; FAR; skeletonization; m-margin.

I. INTRODUCTION

Fingerprints are the most widely used biometric trait for the human identification or verification, because of its robustness and its justified implementation cost. The most obvious structural characteristic of a fingerprint is the pattern of interleaved ridges and branches that often run in parallel. Other important features called minutiae (the end point and bifurcating point) refer to ridge discontinuities [1-3]. The minutiae are characteristic features of fingerprints that conclude their uniqueness. Reliable automatic minutiae extraction is a critical step in fingerprint classification. The ridge structures in fingerprint images are not always well defined, and therefore, an enhancement algorithm, which can improve the clarity of the ridge structures, is required [4-6].
The minutiae can be used in fingerprint matching since they represent unique details of the ridge flow and are considered as a proof of identity [7]. However, intensive researches on fingerprint recognition shown that their ridges and burrows are not able to distinguish fingerprints. Therefore, In order to improve the performance of the fingerprint recognition system, many researchers have made efforts on the image enhancement algorithms [4]. D. Maio and D. Maltoni [8] and other [9-15] proposed an algorithm which is based on the local features i.e. minutiae extraction, because poor quality fingerprint images lead to missing and spurious minutiae that degrade the performance of the matching system. Therefore, minutiae extraction is one of the important steps in fingerprint verification algorithms.

Most of the minutiae detection methods which have been proposed in the literature are based on image binarization, thinning [4], skeleton refinement process before filtering process from gray scale images [8,16]. The traditional method is carried out using local histogram equalization, Wiener filtering, image binarization, thinning [4,17-18] etc. In this paper we present an algorithm to fill the broken curves on a fingerprint i.e. m-margin due to low finger pressure and uneven surface. The proposed algorithm eliminates false minutiae that connect broken curves in fingerprint. This increases the curves margin of endpoints by one pixel of the curves of the length at least three pixels in each directions of ridge endings and ridge bifurcations.
The paper is organized as follows, In section II Development of a fingerprint enhancement algorithm based on *m-margin* techniques. Section III present Experimental Setup and sample capturing methods. Section IV presents the results of our approach and the analysis of the results. Finally, in Section V some conclusions are drawn.

II. DEVELOPMENT OF PROPOSED M-MARGIN MODEL

The main stages of the proposed enhancement process (*m-margin*) conducted on a skeletonized fingerprint images are shown in Fig. 1.
We have not applied any image enhancement methods which are suggested by many researchers because we want to see the full effect of *m-margin* process. Histogram equalization and Fast Fourier Transform are used for image enhancement [10].

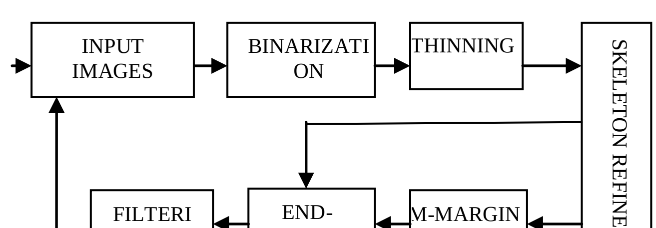

Figure 1. Proposed *m-margin* based fingerprint enhancement

Now, proposed *m-margin* image processing procedure is applied to skeleton fingerprint image. Then a filtering procedure is applied. This processing eliminates false minutiae points created due to degradation in the image that originates from multiple sources. After filtering the fingerprint image is transformed into a form, which facilitates the feature extraction process.

This process increases length of curves by adding white pixel at each end. The pixel is added at the adjacent position of the end pixel of the curve. Although the minutiae marking positions are diverted one pixel far away from the actual position, but as a final result FRR is improved due to elimination of some false (invalid) minutiae. Figure 2 (a) represent false minutiae because extra end points created due to low finger pressure or due to presence of dust particle on finger.

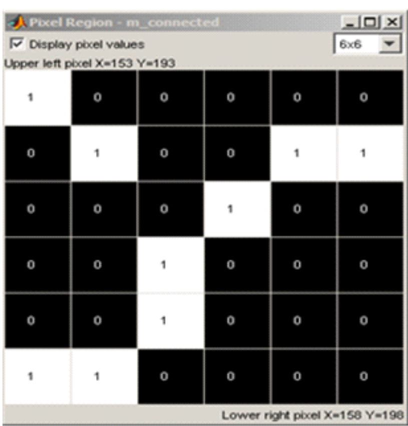

Figure 2. (a)

It filters out all the valid end points. The filtering operation eliminates false point as discussed above and shown in Figure 2(b) contains only one valid minutia (yellow) after elimination of false end-points.

We have taken 10 images of a finger at varying pressures/weight from 0.3 to 3.2 kg. We have taken 100 peoples samples i.e. 10x100=1000 fingerprint for the analysis

Figure 2. (b)

A. *Proposed Algorithm m_margin*

- Use a (3x3) matrix and check whether the central pixel is white or black.
- If center pixel is black move ahead without any change.
- If center pixel is white, then check the pixels surrounding to the center pixel in a 3x3 matrix.
- If there is more than one white pixel in matrix, leave the pixel and move ahead as it means that center pixel is not the end pixel.
- If the number of white pixel is only one that implies that the center pixel is end pixel.
- Now we extend the pixel value, by taking the advantage of local feature of the image, we extend the pixel that is diagonally opposite to the surrounded white pixel.

The preprocessing stage does not totally heal the fingerprint image. For example, false ridge breaks due to insufficient amount of ink and ridge cross-connections due to over inking are not totally eliminated. Actually all the earlier stages themselves occasionally introduce some artifacts which later lead to spurious minutia. This false minutia will significantly affect the accuracy of matching if they are simply regarded as genuine minutia. So some mechanisms of removing false minutia are essential to keep the fingerprint verification system effective.

B. *Experimental setup*

The performance of fingerprint identification system relies critically on the image quality. Hence, good quality images make the system performance more robust. However, it is very difficult to obtain good quality images practically. To overcome this problem, image enhancement/manipulation steps are applied. But, most of the enhancement algorithms are applied equally to images without considering the image characteristics. In this paper, we have considered image characteristics to improve the verification performance of proposed algorithm.

of results. The images are captured by fingerprint scanner with 500dpi. The size of images 320 x 260 pixels are used for proposed work.

III. RESULT ANALYSIS

In each experiment say sample image p000_0.3.jpg is matched with itself and it also matched with 9 other images of a same fingerprint. Second column of the experimental table I, show the results without *m-margin* approach. Third column of the table shows the matching score after applying the proposed algorithm one time. Fourth column represent matching score applying the proposed algorithm two times. Similarly, fifth column of the table is associated with the score of matching when proposed algorithm is applied up to maximum possible extent. First row of the table shows matching score 100% always and there is no change in matching scores even after applying the proposed algorithm because matching a finger with its same instance should be 100%. Therefore, proposed algorithm do not change the matching scores in any cases but in other cases, when matching score is less than 100%, proposed algorithm has either changed the matching score or unaltered. In this table I, we can see that 6 images out of 10 images scores are improved or unaltered. As we see that matching scores with the same finger are 100% then corresponding cells in the table are marked as white cells. The cells which show improvement in matching are marked as black and those showing decrement in matching scores are marked by gray color. The whole table I of the 10 fingerprints matching is a collection of 40 sub-experiments. 10 experiments are done without applying our proposed *m-margin* approach and 30 experiments are divided into three parts of 10 sub-experiments. Next table will consider p004_0.4.jpg as sample image and repeat the above steps. In this way all other images are also taken as samples and tested for their matching. Final analysis with all 10 images is shown in table II. In this paper, we have shown only one sample's 10 images to show experimental setup for proposed work.

TABLE I. SAMPLE IMAGE P000_0.3.JPG

Matching with Image	Ex. No % Matching N=0	Ex. No % Matching N=1	Ex. No % Matching N=2	Ex. No % Matching N=max
p000_0.3.jpg	1 100.0000	2 100.0000	3 100.0000	4 100.0000
p004_0.4.jpg	5 11.7647	6 30.7692	7 33.3333	8 30.7692
p005_0.5.jpg	9 27.2727	10 15.3846	11 8.3333	12 30.7692
p012_0.6.jpg	13 9.0909	14 7.6923	15 8.3333	16 15.3846
p016_0.7.jpg	17 45.4545	18 38.4615	19 41.6667	20 38.4615
p018_0.8.jpg	21 9.0909	22 8.3333	23 15.3846	24 7.6923
p020_0.9.jpg	25 9.0909	26 8.3333	27 7.6923	28 7.6923
p028_1.0.jpg	29 9.0909	30 8.3333	31 7.6923	32 7.6923
p030_1.1.jpg	33 9.0909	34 7.6923	35 8.3333	36 7.6923
p036_1.2.jpg	37 15.3846	38 17.5367	39 18.4747	40 11.7647

Increment in % matching (black background) = 08
Decrement in % matching (gray Background) = 19
No changes in result (white background) = 03
Results decreasing within 10 % = 06
Favorable Results = Increment + No change + Decrement within 10%
= 08 + 03 + 06 = 17 (56.67 %)

TABLE II. COMPARATIVE ANALYSIS OF EXPERIMENTS

Exp. No.	Sample image	Increment in matching A	Decrement in matching B	No change in matching C	Result decreasing within 10%, D	Favorable Results (A+C+D)	Unfavorable Results=B
01	p000_0.3.jpg	08	19	03	06	17(56.67 %)	63.33%
02	p004_0.4.jpg	09	18	03	01	13(43.33 %)	60%
03	p008_0.5.jpg	14	12	03	03	20(66.66%)	40%
04	p012_0.6.jpg	11	16	03	03	17(56.67%)	53.33%
05	p016_0.7,jpg	08	19	03	00	11(36.67%)	63.33%
06	p018_0.8.jpg	08	17	05	03	16(53.33 %)	56.67%
07	p020_0.9.jpg	19	07	04	00	23(76.67 %)	23.33%
08	p028_1.0.jpg	09	11	10	00	19(63.33 %)	36.67%
09	p030_1.1.jpg	10	13	07	00	17(56.67 %)	43.33%
10	p036_1.2.jpg	09	13	08	00	17(56.67 %)	43.33%
						Avg=566.7/10 =56.67	Avg=483.3/10 =48.33%

In 300 out of 400 sub experiments, favorable results are 170, which is 56.67 %. In total we have conducted 400 sub-experiments, 10 without *m-margin* and 30 applying *m-margin*. This way in 56.67 % experiments, matching was improved or not altered. Average decrement in matching is 48.33. Therefore, comparative analysis shows aggregate 8.34% increase in matching. Finally, due to this encouraging improvement in matching, more than 99% samples out of 100 are successfully shown improvement in matching score.

IV. CONCLUSION

The primary characteristic of the proposed algorithm is that it uses relatively stable global characteristics to combine the broken curves in fingerprints, which may look like the human behavior when comparing two fingerprints. As a result, the errors of misalignment, which often occur in a minutiae-based registration algorithm, are dramatically decreased, resulting in better verification performance. We may thus conclude:

- Fingerprint recognition accuracy depends on the number of imprints stored in the database for each person. By implementing proposed algorithm the matching results refined by 8.33%.
- The main advantage of proposed algorithm is that the some invalid curve structures creating invalid minutiae are eliminated by considering conditions of false minutiae.

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