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論 文
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A New Fingerprint Reference-Point Detection Method Using Cosine Component

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Abstract - A new reference point location method using the cosine component is proposed, where an edge map is defined and used to find the reference point. Because all processes used in the proposed method are performed at the block level, less processing time is required. Experimental results show that the proposed method can effectively detect the reference point with higher speed and accuracy for all types of fingerprints.

Key Words : Cosine Component, Reference Point Location Method, Edge Map

1. Introduction

The detection of the reference points is an important and difficult task in automatic fingerprint classification and identification. Reference position can he used for direction registration and image adjustment. These adjustments reduce the influence of displacement of the fingerprint on the image and increase the accuracy of the recognition system. The number of cores and deltas, and the relative position between these points can be used for fingerprint classification and recognition. There are many approaches proposed for core point detection in the literatures [1-5]. The *Poincar index* (PI) method is one of the most commonly used techniques to detect the reference point [1]. In this method, PI of each block is computed by summation up the direction changes around a closed digital curve of the block. This method is efficient, but it is sensitive to noise as the orientation deviation caused by noise affects the computation of PI, especially when the direction change is near $-\pi/2$ or $\pi/2$. In addition, this method cannot locate the corresponding reference point in plain arch fingerprint. While the sine-map based method proposed by Jain et al. detects the reference point based on multi-resolution analysis of the differences of sine component integration between two defined regions of the orientation field. In addition this method is not effective for reference-point localization in plain arch type fingerprint. This method is robust to noise, it requires a lot of processing time to reduce the possible error due to scar or noise in the fingerprints. Accordingly, this paper proposes a new reference point location method that is robust to noise and can rapidly detect a reference point in all types of fingerprint images. The proposed method employs the cosine component instead of the sine component [2], and uses it to make an edge map which is used to detect the reference point. Thus, the aim of this paper is to show the usefulness of the cosine component for detecting the reference point.

2. Reference point detection

The algorithm details are described as follows.

1) Divide the input image I into nonoverlapping block of size w×w (8×8) and apply the least square orientation estimation algorithm to obtain a smoothed orientation field O' [2]. The smoothing process is performed at the block level using Gaussian smoothing operator with a window size of 5×5.

2) Compute the cosine component $\epsilon(i,j)$ of the smoothed orientation field

$$\epsilon(i,j) = cos(O'(i,j)) \quad (1)$$

Figure 1(b) shows the obtained cosine component $\epsilon(i,j)$ as the intensity distribution, which ranges from -1 to 1.

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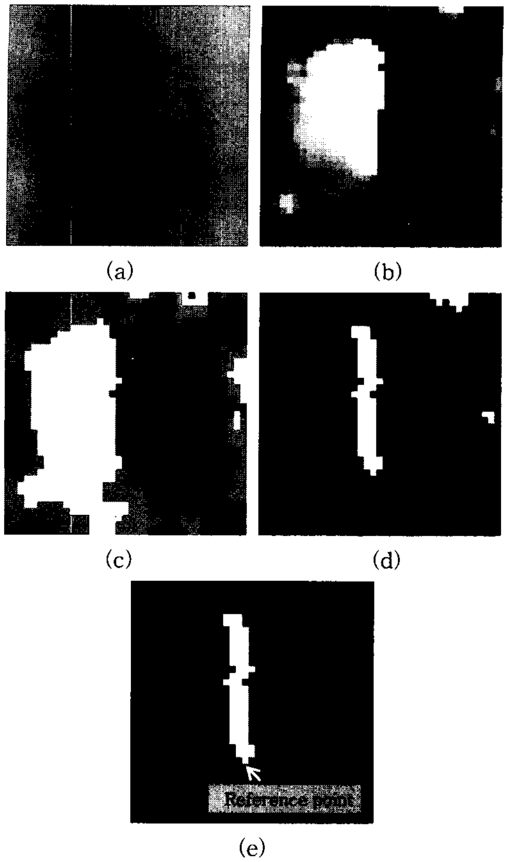

Fig. 1. Procedure for reference point detection (c=0.3, iteration=1). (a) input image and detected reference point (300×300), (b) cosine component (37×37), (c) reformed cosine component (37×37), (d) edge map (37×37), (e) labeled edge map and detected reference point (37×37)

Note that all processes started from Step 3 are performed at the block level instead of the pixel level. Thus, less processing time is required to detect the reference point compared to the sine map-based method. For example, while the image size of Fig. 1(a) is 300×300 pixels, the image sizes of Fig. 1(b)~1(e) are all 37×37 pixels.

3) To find the edge map, the cosine component $\epsilon(i,j)$ is reformed to four color regions using the defined color look-up table. First, we set the cosine components ranging from -1~0 as the black region. Then we set the cosine components ranging from 0~c and c~0.99 as the grey and white regions, respectively, where the range of each region can be increased or decreased according to the c. The variable c is initially set as 0.3, which can be replaced with a value less or grater than 0.3. In this paper, the initial c was randomly selected. Finally, the cosine components greater than 0.99 are set as the black region, which eliminates the strong edges caused by the noise and the vertical stripe in the background region. As a result, the proposed algorithm shows a consistent

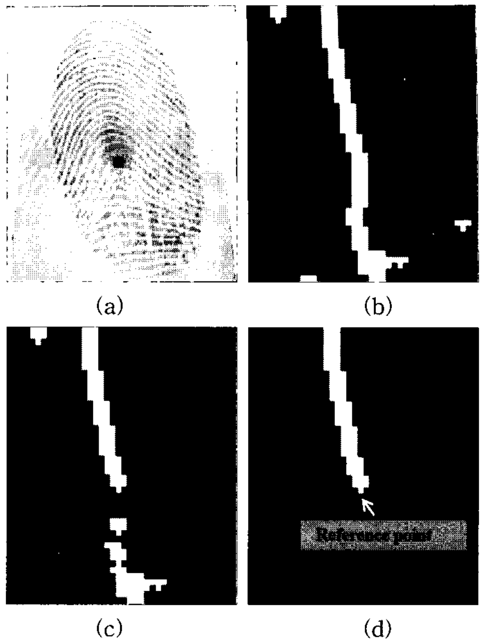

Fig. 2. Reference point detection in edge map with continuous edge. (a) input image and detected reference point (328×364), (b) edge map with continuous edge (40×45), (c) separated continuous edge with c=0.90 (iteration=2, 40×45), (d) labeled edge map and detected reference point (40×45)

capability of detecting the reference point regardless of the different background regions. Figure 1(c) shows the better result image of Fig. 1(b).

4) In the Fig. 1(c), the boundaries changing white region to black region are regarded as the edges. To eliminate the discontinuities of the found edges, we search for the edges on $(i-1,j)$, $(i,j-1)$, and $(i,j+1)$ centered at each pixel (i,j). If the edge exist one or more in mentioned coordinates, they are also regarded as edges. Figure 1(d) shows the obtained edge map. After labeling the edge map, we extract the region with the maximum area which starts from the upper parts (vertical image size/2) of the labeled image. The reference point can be determined simply by finding a point located in the lowest part of that region. As shown in Fig. 1(a) and 1(e), the proposed algorithm has an excellent reference point detecting capability with much higher accuracy.

5) The proposed method provides an iteration mode to detect the reference point in this special case. If the grey region is not found one or more on $(i,j-1)$, $(i,j+1)$, $(i+1,j-1)$, $(i+1,j)$, and $(i+1,j+1)$ centered at the obtained reference point (i,j), go back to Step 3. In the iteration mode, c is changed to 0.9, 0.91, 0.92, 0.93, 0.94, 0.95, and 0.96, sequentially. In most cases, the proposed method can detect the reference point with c=0.3 (iteration=1). However, in case of arch or a few tended arch types, some fingerprints have continuous edges as shown in

Fig. 2(b). In this case, no grey region exists around the obtained reference point, so, the iteration is needed. As shown in Fig. 2(c), we can separate the continuous edge into two parts using c=0.9 (iteration=2). Finally, after labeling the edge map, we can detect the reference point easily as shown in Fig. 2(d). Note that the iteration processes are still performed with the reduced image.

3. Experimental results

The proposed method was tested on the FVC2002 DB1, DB2, DB3, and DB4 (set Bs), which contain 80 fingerprint images collected from 10 fingers (with 8 images from each finger), respectively. The proposed method was also tested on the FVC2004 DB2 (set A), which contains 800 fingerprint images collected from 100 fingers (with 8 images from each finger). Note that they have the different background regions. Table I shows the detection rates for the proposed method. As shown in Table I, the proposed method produced the reasonable detection rates for all databases which have different noise levels and background regions. As mentioned above, the proposed method could also detect the reference point in the case of the arch-type or low quality fingerprint images. In addition, it required much less processing time because all processes are performed at the block level. As mentioned in introduction, even if the sine map-based method has a superior capability of detecting the core point, it has some problems to solve in terms of the processing time and detection rate in plain arch type fingerprint. The proposed cosine component-based method could solve these problems by employing two methods. First, to reduce the processing time, this paper used a block-based processing method instead of a pixel-based processing method. Second, this paper suggested an iteration mode to detect the reference point even in plain arch type. Therefore, the proposed method could overcome drawbacks of a sine map-based method.

Table 1. Detection rates for test databases

	FVC2002 DB1, DB2, DB3, and DB4 (set Bs)	FVC2004 DB2 (set A)
Number of fingerprints	320	800
Detection rates (%)	95.0	94.9

4. Conclusion

A new and effective reference point detection method was proposed based on the edge map. We showed the usefulness of the cosine component for detecting the reference point. Experimental results showed that the proposed method could effectively detect the reference point in poor quality and arch-type fingerprint images, producing better results in terms of the processing time and accuracy.

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참 고 문 헌

[1] K. Karu and A. K. Jain, "Fingerprint Classification," Pattern Recognition, vol. 29, No. 3, pp. 389-404, 1996.

[2] A. K. Jain, S. Parbhakak, L. Hong, and S. Pankanti, "Filterbank Based Fingerprint Matching," IEEE Trans. Image Processing, vol. 9, No. 5, pp. 846-859, 2000.

[3] Q. Zhang, K. Huang, and H. Yan, "Fingerprint Classification Based on Extraction and Analysis of Singularities and Pseudoridges," in Proc. Pan-Sydney Area Workshop on Visual Information Processing (VIP '01), vol. 11, pp. 83-87, 2001.

[4] N. Kitiyanan and J. P. Havlicek, "Modulation Domain Reference Point Detection for Fingerprint Recognition", 6th IEEE Southwest Symposium on Image Analysis and Interpretation, 28-30 March 2004, pp. 147-151.

[5] K. C. Chen, Y. S. Moon, and P. S. Cheng, "Fast Fingerprint Verification Using Subregions of Fingerprint Images", IEEE Trans. Circuits and Systems for Video Technology, vol. 14, No. 1, pp. 95-101, 2004.