Proceeding of International Conference on Electrical Engineering, Computer Science and Informatics (EECSI 2015), Palembang, Indonesia, 19 -20 August 2015

Enhanced Ridge Direction for the Estimation of Fingerprint Orientation Fields

Saparudin
Faculty of Computer Science, Universitas Sriwijaya, South Sumatera, Indonesia,
saparudin1204@yahoo.com

Abstract* - An accurate estimation of fingerprint orientation fields is an important step in the fingerprint classification process. Gradient-based approaches are often used for estimating orientation fields of ridge structures but this method is susceptible to noise. Enhancement of ridge direction improves the structure of orientation fields and increases the number of correct features thereby conducing the overall performance of the classification process. In this paper, we propose an algorithm to improve orientation field structures using variance of gradient. That algorithm have two steps; firstly, estimation of fingerprint orientation fields using gradient-based method, and finally, enhancement of ridge direction using minimum variance of the cross center block direction. We have used standard fingerprint database NIST-DB14 for testing of proposed algorithm to verify the degree of efficiency of algorithm. The experiment results suggest that our enhanced algorithm achieves visibly better noise resistance with other methods.

Keywords: Orientation fields; Gradient; Ridge direction.

I. Introduction

Topologically, fingerprints images are often viewed as oriented textures by assuming local ridge flow. There are two types of ridge flows: the pseudo-parallel ridge flows and high-curvature ridge flows. The pseudo-parallel ridge structures are coarsely determined by estimating of orientation fields and high-curvature ridge flows which are located around the singular points. The orientation fields belong to the set of features that can be detected at the global feature which describes one of the basic structures of a fingerprint image. The accuracy of orientation field estimation is crucial to fingerprint classification, which is an essential step toward large scale fingerprint related system [1]. However, fake orientation fields are inevitable due to skin or impression conditions etc. Low-quality regions pose a great threat to both feature extraction and fingerprint classification as their positions and size are unpredictable.
Orientation field can be used for a variety of purposes, such as singular points detection and others feature extraction. Varieties of the methods for orientation field estimation are known from literatures, which include gradient-based approach and model-based approach i.e., polynomial model, constrained nonlinear phase portrait, multi-scale directional operator and line sensor. The simplest and most frequently adopted method is the gradient-based approach in [2][3][4][5][6][7][8][9][10].

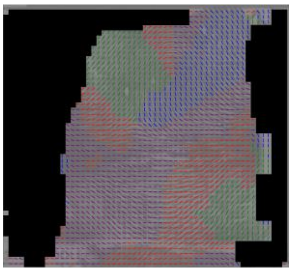
II. Methods

The purpose of the orientation field estimation is to determine the global structure and direction of the ridges in the fingerprint image. Instead of computing local ridge orientation at each pixel, most of the fingerprint processes estimate the local ridge orientation at discrete positions based on block of pixels. This obviously reduces computational efforts and complexity. The simplest and efficient way to extract the ridge orientation is by computing the gradient of each block of pixels of the fingerprint image. The accuracy of the orientation field is greatly relied on image quality and size of the block. The method used for orientation field estimation is derived from Hong in [11] and is as follows.

1. Partition the foreground image.
2. Calculate gradient angle for each block.
3. Convert orientation field into a continuous vector field.
4. Calculate smoothed orientation field using Gaussian filtering operator mask.
5. The final smoothed orientation field in each block of fingerprint image.
6. Separate the orientation field into four regions.

Normally, after the orientation field estimation, there are still remaining orientation fields do not perfectly align with true ridges direction. This is due to the persistence of the noises. Therefore, an improved method is proposed. This method only focuses on the noise regions without encroaching rest of clean area of the fingerprint. Detailed process is as follows:

1. Calculate mean and variance of gradient each 3 x 3 block of orientation field.
2. Replace orientation field at the centre block with gradient value for which attains its minimum value.
3. Calculate smoothed orientation image using Gaussian filtering operator mask.


(a)

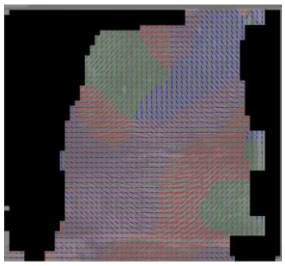

(b)

Figure (a) : Result of orientation field estimations in the fingerprint image.
Figure (b) : Orientation fields of fingerprint after enhancement using minimum variance of orientation fields.

III. Results

We have used standard fingerprint database NIST-DB14 for testing of proposed algorithm to verify the degree of efficiency of algorithm. Experiment using visual inspection of cores and deltas. As for the quantitative performance evaluation, the same assessment criteria that have been used in the above segmentation are also applied here [12]. In addition, for the sake of benchmarking, the proposed method is compared with the lone Poincarè index approach that has been employed by the majority in this field.

Table 1. Comparison results of singular points detection.

Methods	MC	MD	FC	FD
Poincaré index	4.96	9.47	27.37	20.90
Proposed Method	4.81	16.39	5.86	2.11

In order to accomplish the task, an experiment was conducted using 500 fingerprints viz. f0000001 to f0000500 and the results are compiled in Table 1. The results have shown that the proposed method has outperformed the Poincarè index in term of False alarm rate on both core and delta.

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