Core Point Detection Using Orthogonal Gradient Magnitudes of Fingerprint Orientation Field

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Core point detection is very important in fingerprint classification and matching process. We have developed a fast and reliable algorithm for core point detection based on orthogonal gradient magnitudes of orientation field of fingerprint image. It is found that the technique proposed herewith can improve the identification correctness with slightly better in computation performance.

***Index Terms*—Biometric techniques, Fingerprint, Core point, Singular point, Orientation.**

I. Introduction

Fingerprints are the oldest and most widely recognized biometric trait. All human being posses fingerprint and these fingerprints are result of unique ridge and valley structure formed by skin over the fingers. Ridges and valleys are often run in parallel; these structures have bifurcation and ridge endings called as termination. The ridge structure as a whole takes different shapes, characterized by high curvature, terminations, bifurcations, crossover etc. These regions are called singular regions or singularities. These singularities may be classified into three topologies; loop, delta and whorl. What makes fingerprint unique is the distribution of such structures at local level. These are called as minutiae [1]. At a global level the fingerprint pattern exhibits the area that ridge lines assume distinctive shapes. Such an area or region with unique pattern of curvature, bifurcation, termination is known as a singular region and is classified into core point and delta point. The singular points can be viewed as the points where the orientation field is discontinuous. Core points are the points where the innermost ridge loops are at their steepest. Delta points are the points from which three patterns i.e. loop, delta and whorl deviate. Definitions may vary across papers, but this definition of singular point is the most popular one [2].

II. Existing Algorithms

There already exist lots of algorithms that deal with the singular point detection in literature. In [3], V.S.Srinivasan presents a singular point detection method based on orientation histogram, which is robust to noise, but the precision of the detection result is low. In [4], Marius Tico present a wavelet based multi resolution method, which can localize the singular point in 2*2 pixel width window. However, because of involving wavelet decomposition and dealing the direction field in pixel, it is time consuming, and not suitable for real time application. In [5], Asker M. Baze presents a singular point detect algorithm based on high resolution direction field, which first computes a high resolution direction field, then detect the singular point based on Poincaré index. However, because of computing high resolution direction field, the algorithm efficient is rather low. In [6], Jain presents a Poincaré index based method to localize the singular point, this algorithm can only detect a little window which includes the singular point. Moreover, most of above singular point detect algorithms can efficiently detect the core point when the image quality is fine, when the image quality is poor, the efficient of the algorithm degrades rapidly. Some algorithms also include post processing step in order to remove false singular points detected [7]. In this paper, we present a new singular point detection algorithm which can precisely localize the singular point.

III. Proposed Approach

For input fingerprint image the orientation field is estimated. Orientation field, $\Theta(x,y)$, represents the ridge flow of a fingerprint at each location and it is defined in the interval $[0;\pi)$. Also the Region Of Interested (ROI) is computed for fingerprint image. This segmentation creates a binary mask that can assume logical values. This task can be performed using a simple block-wise thresholding based on local variance or any other approach, since the proposed algorithm is robust to this pre-processing operation [8]. Then we compute the orthogonal matrices:

$$\begin{aligned} a &= \cos(\Theta(x,y)) \\ b &= \sin(\Theta(x,y)) \end{aligned} \quad (1)$$

in this way a and b matrices are the cosine of orientation field and of orthogonal orientation field. The we apply the gradient operator to matrices a and b:

$$\begin{aligned} [g_{xa}, g_{ya}] &= gradient(a) \\ [g_{xb}, g_{yb}] &= gradient(b) \end{aligned} \quad (2)$$

g_{xa} and g_{xb} are the x-components of gradient, while g_{ya} and g_{yb} are the y-components of gradient. Then we compute the norms of these gradients:

$$G_a = \sqrt{g_{xa}^2 + g_{ya}^2}$$
$$G_b = \sqrt{g_{xb}^2 + g_{yb}^2} \tag{3}$$

All these matrices have the same size of input fingerprint image. Then we consider a global gradient matrix G that, for each position, has the minimum value between G_a and G_b corresponding pixel:

$$G = min(G_a, G_b) \tag{4}$$

Let V_{max} be the maximum value of matrix G, we consider all points $(x_{0,} y_0)$ that are local maxima whose value is $G(x_{0,} y_0) \geq 0.3 V_{max}$. In this way we obtain a list of candidates for core point $(x_{1,} y_1)$, $(x_{2,} y_2)$,..., (x_N, y_N) . Among these possible candidates we select as core point (x_P, y_P) the closest point to the center of mass of the Region Of Interest (x_C, y_C) for which $\Theta(x_P - W, y_P - W) > \Theta(x_P - W, y_P + W)$, with $W = 10$. These two conditions (about distance from center of mass of ROI and angular condition) assure that detected point is a core point.

IV. Result

We tested the proposed algorithm on two public domain fingerprint databases [9][10]. Core points are detected in a fast and efficient way. Matlab source code can be downloaded at [11].

V. Conclusion

In this paper we have proposed a novel method for core point detection, this method gives perfect detection of core point if a clear loop structure is present on the fingerprint, in case of high curvature regions the accuracy is still better than existing methods. The accuracy of proposed method can be further improved by combining given method with coherence parameter of the fingerprint. This algorithm is crucial in design of a correlation based fingerprint recognition system. This method can be used in existing system for better results or can be combined with existing method to improve accuracy.

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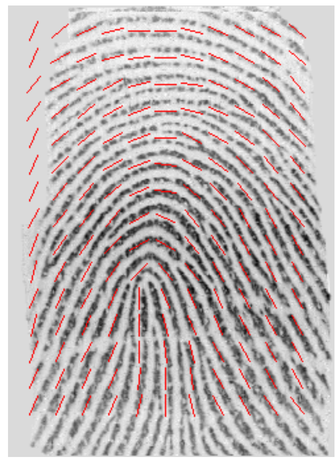

Fig. 1 Input fingerprint image and orientation field.

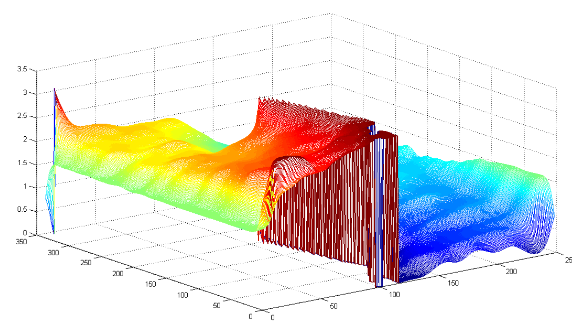

Fig. 2 Mesh plot of orientation.

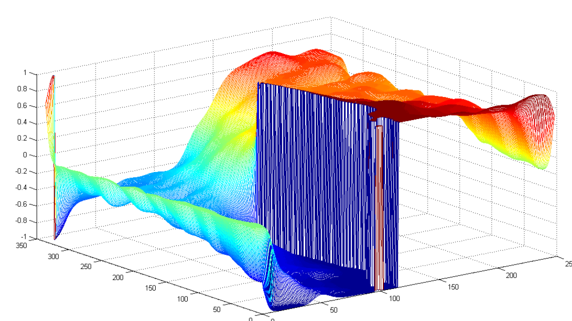

Fig. 3 Cosine of orientation field.

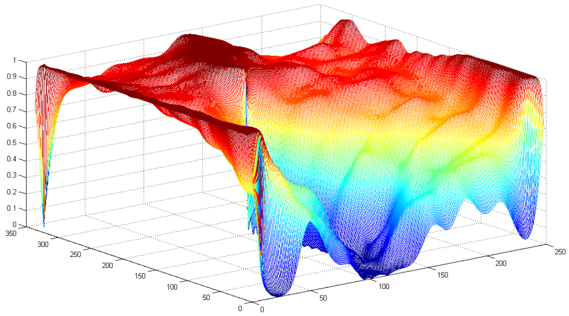

Fig. 4 Sine of orientation field.

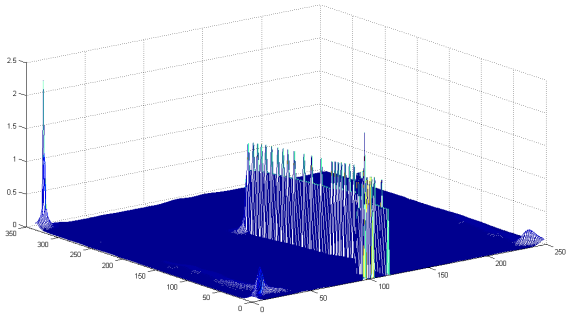

Fig. 5 Norm of gradient of cosine.

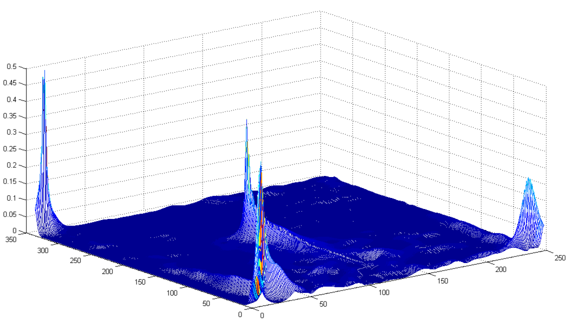

Fig. 6 Norm of gradient of sine.

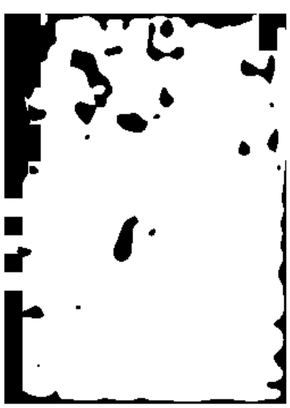

Fig. 7 Region of Interest (ROI) of fingerprint image.

Fig. 8 Fingerprint image and detected core point.