# A Hybrid Core Point Localization Algorithm

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**Summary**
The localization of core point represents an important stage of many fingerprint processing algorithms. We present a novel hybrid method based on modified angular orientation field estimation and an improved complex filtering technique.

***Key words:***
*Hybrid Core Point, Localization*

## 1. Introduction

Fingerprint based identification is one of the important biometric technology which has drawn a substantial applications now. A fingerprint is the pattern of ridges and furrows on the surface of a fingertip. Ridges and valleys usually run in parallel sometimes terminate and sometime bifurcate. At a fine level or local level, the characteristics of ridges and valley are known as minutiae. 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 and etc is classified into three main topologies: loop, delta and whorl. Such a region is also known as a singular region.

The core point has played important role in most fingerprint identification techniques. It is widely used in fingerprint classification and fingerprint matching. In many cases, fingerprint with numerous discontinuous ridges can cause errors in fingerprint identification process. In some cases the core point cannot be located at all. Apart from correlation based, a minutiae based fingerprint matching technique is also widely used. In many cases there is no need to define the core point exactly. In some cases of fingerprint processing such a point is very important; for instance when one want to count the number of ridge lines between the core point and another reference point (such as delta point). Exactly located core point is also useful in fingerprint classification.

The alignment of two fingerprints is based on certain landmark point, as well as the more recent filter bank – based fingerprint matching. The localization of core point represents the most critical step of the whole process. A good matching requires an accurate positioning, so the small errors must also be avoided. The usage of complex filtering technique can be greatly improving accuracy. On the other side, for very poor quality input images a traditional algorithm can fail even using a hierarchical approach with a multi scale filtering.

To overcome this problem, in this paper we propose a novel hybrid algorithm based on modified angular orientation field estimation and an improved version of complex filtering technique. In section 2, fingerprint pre-processing steps are elaborated. In section 3, details of core point localization techniques are given. In section 4, the combination of these known algorithms, the optimal core point detection is investigated. The results obtained when applying an algorithm to the fingerprint database is reported in section 5, before the proper conclusion.

## 2. Pre – Processing

The fingerprinted image can be electronically scanned with ranges of resolution. However, the generally accepted one is that of 500dpi. The quality of the acquired image may vary in both the printed location and the clarity of the image itself. The uncertainty of first issue can be remedied by applying the guide frame when scanning the fingers. For later case, the image quality is highly depended on the finger condition. The enhancement process, therefore, tries to level - up the image condition to the state that it can be later processed with high degree of success. In this discussion the images are pre – processed with gray level enhancement that followed by the orientation estimation.

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## 2.1 Normalization and Enhancement

Let I (i, j) denotes the gray – level value at pixel (i. j) , $M_i$ and $V_i$ denotes the estimated mean and variant of image I , respectively , and N (i, j) denotes the normalized gray – level value at the pixel (i, j) . The normalized image is then defined as follows

$$N(i,j) = \begin{cases} M_0 + \sqrt{V_0 \frac{(I(i,j) - M_i)^2}{V_i}} & if\ I(i,j) > M \\ M_0 - \sqrt{V_0 \frac{(I(i,j) - M_i)^2}{V_i}} & Otherwise \end{cases} \quad (1)$$

Here $M_0$ and $V_0$ are the desired mean and variant respectively. The recommended desired values are used, with a mean and a variance of 100. For enhancement a directional Fourier filtering using polar coordinates. In order for it to function well, the frequency origin of the frequency domain transformed image (by FFT) shall be shifted to the middle of the image. This is done, just by changing the sign of the odd pixels of the image. The result is a shifted frequency origin located at the middle of the image.

## 2.2 Orientation Field Estimation

A major common step in core point detection is the orientation or direction of the ridge estimation. Let θ be defined as the orientation field of a fingerprint image. θ(i, j) represents the local ridge at pixel (i ,j). Local ridge, however, is usually specified for a block rather than that of every pixel. Thus, an image is divided in to a set of non – overlapping blocks, size of w × w. Each block holds a single orientation. A number of methods for orientation estimation have been proposed [5 – 7]. However, in connection to the work outlined in this paper, the smoothed orientation field based on least mean square algorithm is summarized as follows [6.7].

1) Divide the input image I into non – overlapping blocks with size w × w.
2) Compute the gradients $ð_x(i, j)$ and $ð_y(i, j)$ at each pixel (i, j) which is the center of the block.
3) Estimate the local orientation using the following Equations

$$V_x(i,j) = \sum_{u=i-\frac{w}{2}}^{i+\frac{w}{2}} \sum_{v=j-\frac{w}{2}}^{j+\frac{w}{2}} 2\, ðx(u,v)\, ðy(u,v) \quad (2)$$

$$V_y(i,j) = \sum_{u=i-\frac{w}{2}}^{i+\frac{w}{2}} \sum_{v=j-\frac{w}{2}}^{j+\frac{w}{2}} 1\ ð_x^2(i,j)\ ð_y^2(i,j) \quad (3)$$

Subsequently

$$\theta(i,j) = ½ Tan^{-1} [Vy(i,j)/Vx(i,j)] \quad (4)$$

Here, the θ(i,j) is the least square estimate of the local ridge orientation of the block centered at pixel (i,j).

4) Assumed that the local ridge orientation varies slowly in a local neighborhood where no core point appears. The discontinuity of ridge and valley due to noise could be softening by applying a low pass filter the orientation image must be converted to a continuous vector field. The continuous vector field, which its x and y components are defined as $\varphi_x$ and $\varphi_y$ respectively.

$$\varphi_y(I,j) = \sin(2\theta(i,j)) \quad (5)$$
$$\varphi_x(I,j) = \cos(2\theta(i,j)) \quad (6)$$

5) With the resulted vector field, the two dimensional low – pass filter G with unit integral is applied. The specified size of the filter is $\omega_\varphi \times \omega_\varphi$ . As a result

$$\varphi'_x(i,j) = \sum_{u=-\omega_\varphi/2}^{\omega_\varphi/2} \sum_{v=-\omega_\varphi/2}^{\omega_\varphi/2} G(u,v).\varphi_x(i - u\omega, j - v\omega)$$
$$\varphi'_y(i,j) = \sum_{u=-\omega_\varphi/2}^{\omega_\varphi/2} \sum_{v=-\omega_\varphi/2}^{\omega_\varphi/2} G(u,v).\varphi_y(i - u\omega, j - v\omega) \quad (8)$$

6) The smoothed orientation field can then be computed as follows

$$\varphi'(i,j) = \frac{1}{2}\tan^{-1}\left[\frac{\varphi_x(i,j)}{\varphi_y(i,j)}\right] \quad (9)$$

# 3. Fingerprint core point detection

The core point, no more precisely or loosely located, has shown in applications in both fingerprint classification and fingerprint matching using either spatial domain [5,10] or transformed domain [11,12]. This section details several techniques for such a reference point locating.

## 3.1 Geometry of Region Technique (GR)

The GR technique can be summarized as follows [7].

1) Compute the smoothed orientation field $\varphi'(i,j)$ by using equation (9) above.

2) Compute $\varepsilon(i, j)$, which is the sine component of $\varphi'(i, j)$

$$\varepsilon(i, j) = \sin(\varphi'(i, j)) \quad (10)$$

3) Initialize a label image *A* which is used to indicate the core point.

4) Assign the corresponding pixel in *A* the value of the difference in integrated pixel intensity of each region

$$A(i, j) = \sum_{R1} \varepsilon(i, j) - \sum_{R2} \varepsilon(i, j) \quad (11)$$

The region R1 and R2 were determined empirically and also their geometry are designed to capture the maximum curvature in concave ridges. In practice, the region is defined within the radius of 10-15 pixels (should cover at least 1 ridge). In addition R1 that is sandwiched R2 is expected to hold the maximum point.

5) Find the maximum value in $A$ and assign its coordinate as the core point.

6) If the core point still cannot be located, the steps(1-5) could be iterated for a number of times while decreasing the window size used in step 1 above. For instance; w = 15, 10 and 5 pixels respectively.

### 3.2 Detection of Curvature Technique (DC)

1) Compute the local orientation $\theta(i, j)$ by using equation (6) above. The input block size could small as w = 3, i.e. k × l = 3 × 3 pixels.

2) Smooth the orientation field $\varphi'(i, j)$ by using equation (9) above.

3) In every progressive block the difference of direction components is computed.

$$Diff\ Y = \sum_{k=1}^{3} \sin 2\theta(k, 3) - \sum_{k=1}^{3} \sin 2\theta(k, 1) \quad (12)$$

$$Diff\ X = \sum_{l=1}^{3} \cos 2\theta(3, l) - \sum_{l=1}^{3} \cos 2\theta(1, l) \quad (13)$$

4) The curvature point (**x**) could be located at the corresponding (i, j) where $Diff\ X$ and $Diff\ Y$ are negative.

5) If can't find core point of interesting location. We decrease size image and core point detect again, until find core point or nearby.

### 3.3 Complex symmetrical filter based method

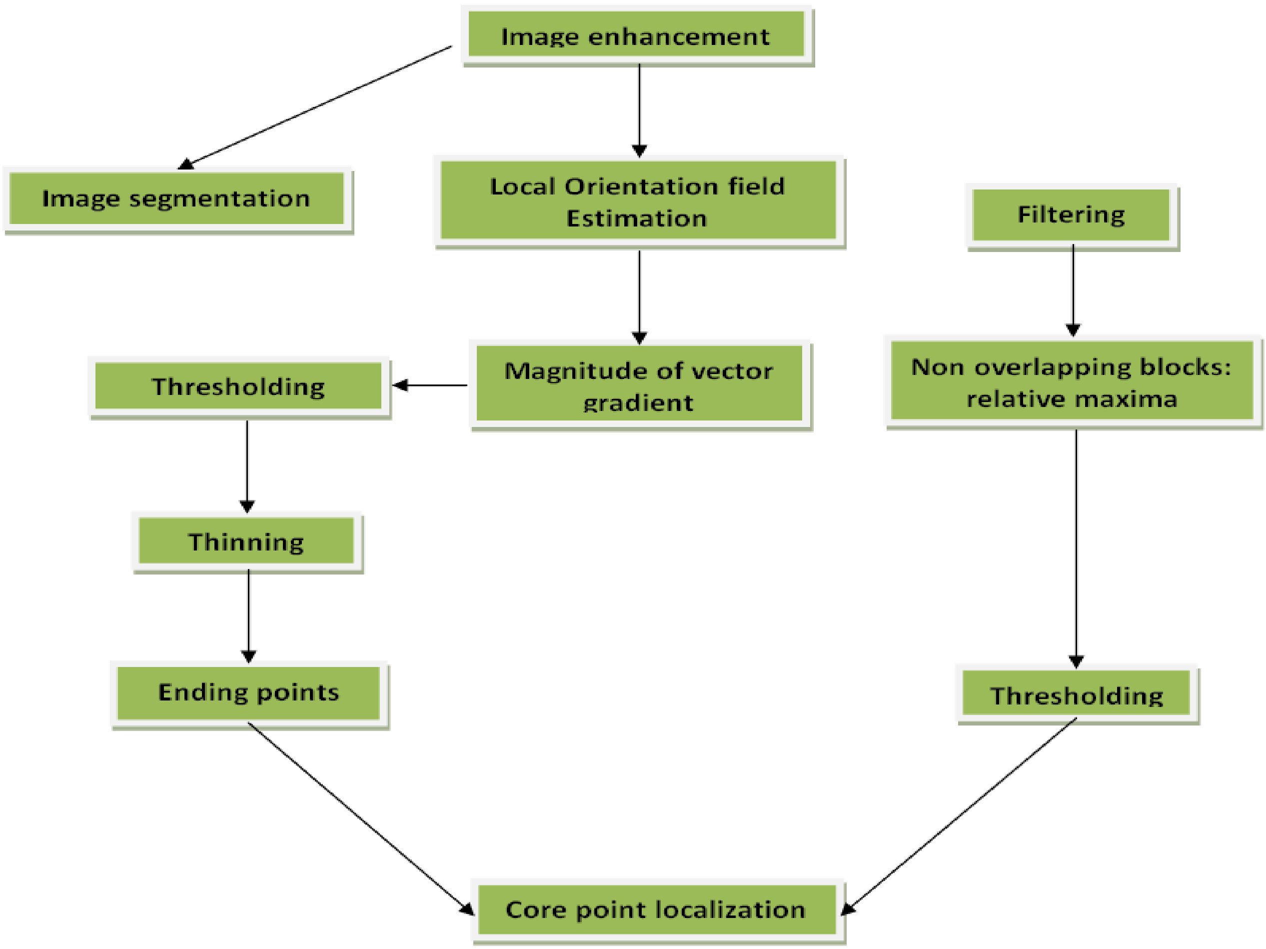
This method is used to compute both the position and orientation of the singular point, allowing for image alignment. Complex symmetrical filters – based method [3,10] is to detect the pattern with radial symmetries modeled by exp $\{im\emptyset\}$ with 'm' an integer, $\emptyset$ the orientation of the pattern and 'I' the imaginary unit. 'm' = 1 approximates the orientation pattern of a core while m = -1 approximately the orientation pattern of a delta. The candidate core point will always have strong filter response; all points with the local maximum magnitude of filter response are extracted. To keep the number of candidate singular points to a reasonable number, the local maximum magnitude of filter response should be larger than a pre – determined threshold. Otherwise the points will be removed from the candidate singular points,

## 4. Implementation of the proposed method

Reviewed in the last section, we can see that each core point finding works well but with some restrictions are may note that the GR method can gives the good result provided that the working window in small enough. However to obtain the result quicker, window size must be larger. In some case the core point cannot be allocated at all. The advantage of the DC technique is that it can estimate the core point in a quick manner with a degree of location error and also with low computational cost. In complex filter method, a high threshold could result is the misdetection of singular points in noisy regions or due to the suppression done at the boundary of the orientation image. To overcome the above problem we propose a novel hybrid

algorithm based on modified angular orientation field estimation and an improved version of complex filtering techniques.

The core point is defined as the point where convex ridges have the maximum curvature. According to this straight forward definition we can think to apply in parallel two algorithms and to merge their mutual information. The steps employed in proposed method core point detection are summarized as follows:




Fig(1). Hybrid algorithm scheme

1.Input image is enhanced by FFT.

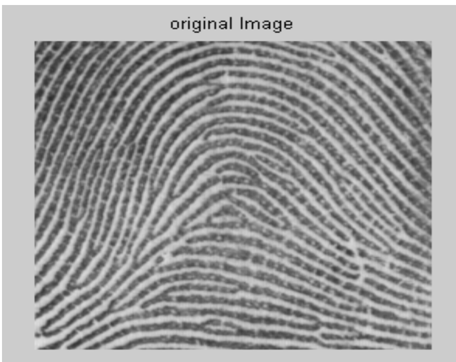



Fig .2(a). Original Image

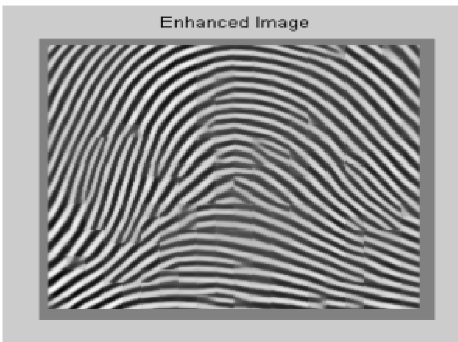



Fig .2(b). Enhanced Image

2. Then image is segmented, in order to distinguish image from background. This operation performed by block – wise variance estimation. Back ground is usually characterized by small variance. The threshold level should be chosen empirically, as well as block size.

3. Starting from the enhanced fingerprint we have to estimate the orientation field. This operation is calculated locally for each pixel of image with a moving 2 – dimensional square frame of given size.

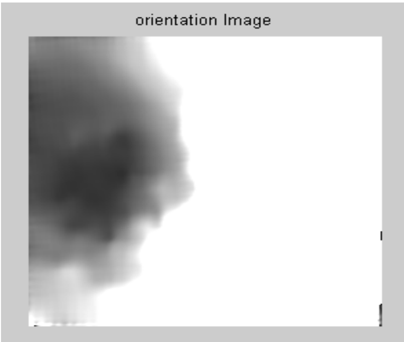



Fig .2(c). Orientation field

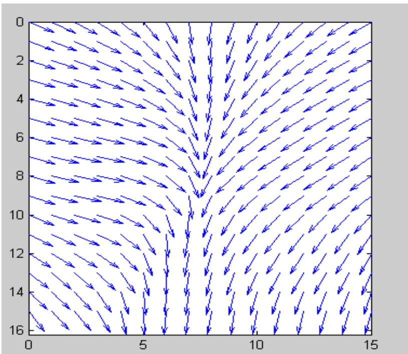



Fig .2(d). Orientation map

4. Compute the vector gradient $[G_x, G_y]$ of the orientation field and its magnitude M

$$M = G_x^2 + G_y^2$$

5. Fixed a threshold value for M we can associate a logical matrix L, where L(i,j) = 1 if M(i,,j) > Mt and 0 in all the other cases, with the threshold value Mt = 0.2 $\times$ $M_{max}$ ($M_{max}$ is the absolute maximum value of the magnitude M).

6.The logical matrix L is first thinned (binary thinning) and then ending ridges are found.

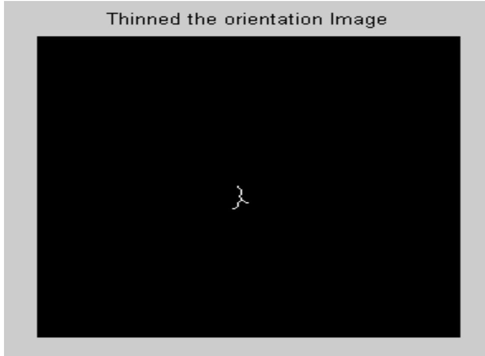



Fig .2(e). Thinned Image

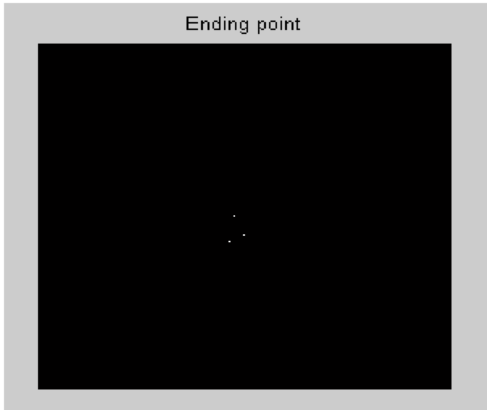



Fig .2(f). ending points

7. The result is a logical matrix T whose element T(i,j) is set to 1 if the thinned binary image has an ending point in the current pixel. The elements of matrix T set to 1 are all candidates to final core point.

8. The enhanced image is divided into non – overlapping blocks of given size (32$\times$ 32) and then filtered with a complex filter.

9. Cf _max be the maximum value of the filtered image. For each non – overlapping block we calculate the relative maximum Cf_rel.

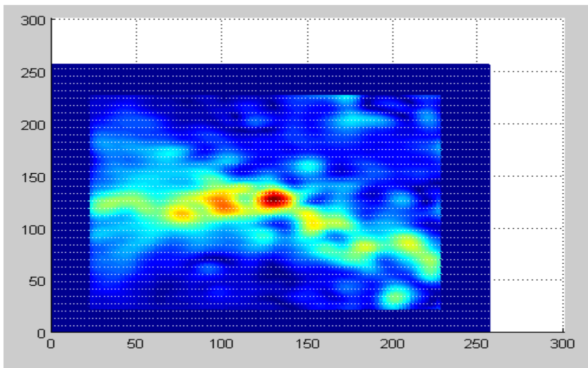



Fig .2(g). Complex filter output

10. A logical matrix F whose element (i,j) is equal to 1 if (i,j) is a block relative maximum and this value is equal or greater than a threshold value ( usually 0.65×Cf_max); F(I,j) is equal to 0 in all the other cases (i.e. if F(i.j) is not a block relative maximum or a block relative maximum smaller than the threshold value).

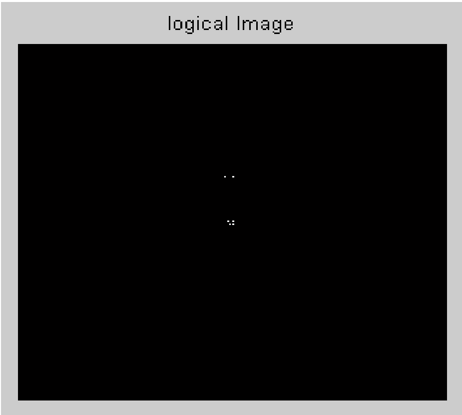



Fig .2(h). Logical Image

11. We have two logical matrices T and F. For each non zero pixel of matrix T (by using the Euclidean distance transform).

12. Core point is the nearest nonzero pixel of matrix T to a nonzero pixel of matrix F.

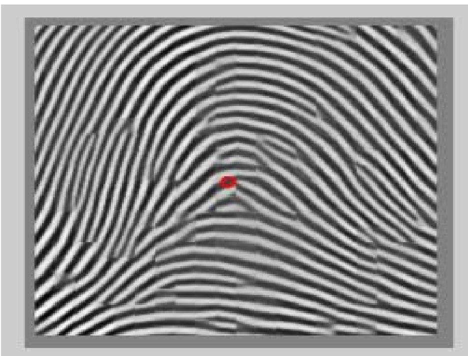
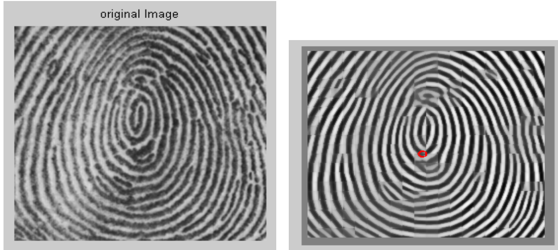
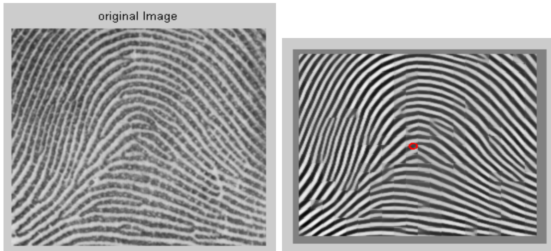


Fig .2(i). Plot the core point

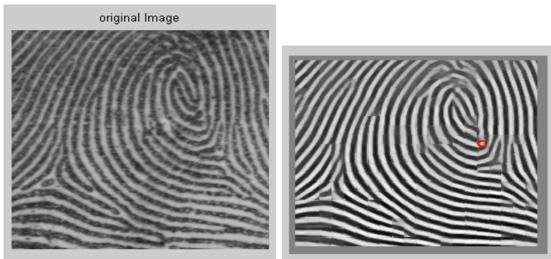
In core point extraction, the orientation image is considered trustworthy. Error in the information causes error in the results. Filtering operation can reduce the noise. Fig(2) shows the results of our core point location algorithm. Fig(3) shows plot the core point for different fingerprints. The core point location algorithm performs extremely well for fingerprint images of whorl, left loop, right loop and arch types. This algorithm has lower error in consistently locating the core point in the arch type fingerprints due to the absence of singular points in arch type fingerprint images.



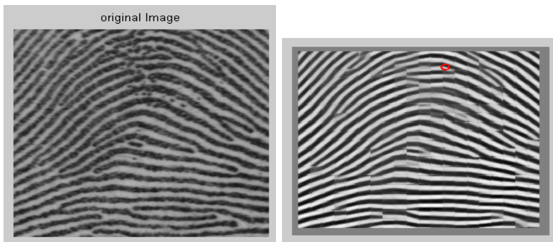

Whorl



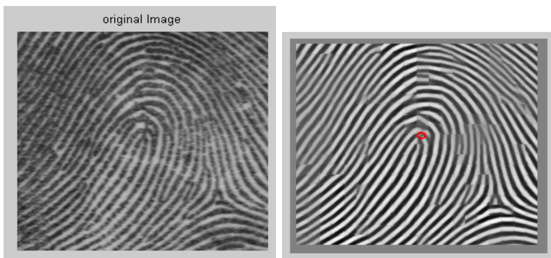

Tented Arch



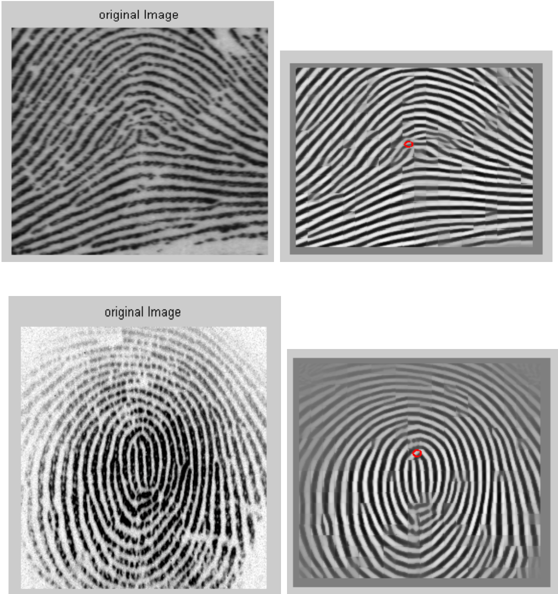

Loop




Arch




Left Loop




Poor quality fingerprint

Fig.3 Plot the core point for different fingerprints

## Conclusions

The core point detecting technique outlined in this paper does require the fairly simple field orientation estimation in its first step. This attempt requires less computational load and increase the chance in locating the core point. In second step complex filter technique reduces the noise and extracts the core point. Our proposed method can offer better accuracy in location detection by apply in parallel two algorithms and to merge their mutual information.

## References

[1] D.Maio, D. Mattoni, "Direct Gray – Scale Minutiae Detection in Fingerprints," IEEE Trans. Pattern Anal. Machine Intel. , vol.19, No.1, pp.27-40, 1997.
[2] A. Jain, L. Hong, and R.Balle, " On – line fingerprint verification,' IEEE Trans. Pattern Anal. Machine Intel. , vol.19, No.1, pp.302-314, Apr. 1997.
[3] K. Nilsson, J.Bigun, Localization of corresponding points in fingerprints by complex filtering, Pattern Recognition Lett. 24 (2003) 2135 – 2144.
[4] J. Li, W. Yau, H. Wang, constrained non linear models of fingerprint orientations with prediction, Pattern Recognition 39 (1) (2006) 102 – 114.
[5] A.K. Jain, S. Prabhakar and L. Hong, " A Multichannel Approach to Fingerprint classification," IEEE Transactions on PAMI, Vol.21, No. 4, pp.348 – 359, April 1999.
[6] Sen Wang, Wei Wei Zhang, Yang Sheng Wang, "Fingerprint classification by Directional Fields," proceedings of the Fourth IEEE international Conference on Multimodal interfaces (ICMI' 02), 2002.
[7] D. Maltoni, D. Maio, A.K. Jain, and S. Prabhakar, Handbook of Fingerprint Recognition, Springer – Verlag, June 2003.
[8] A. Moenssens, Fingerprint Techniques, Chilton, London, 1971.
[9] F. Galton, Fingerprints, Mac Millan, New York, 1892.
[10] Anil K. Jain, Salil Prabhakar, Lin Hong and Sharath Pankanti, "Filter bank – Based Fingerprint Matching", IEEE Transactions on Image processing, Vol.9, No.5, May 2000, pp. 846 – 859.
[11] S.Chikkerur, C. Wu and Govindaraju, " A Systematic approach for feature extraction in fingerprint images", ICBA 2004.
[12] A. Ravishankar Rao, " A taxonomy of texture description", Springer Verlag.
[13] F.B of Investigation, The Science of Fingerprints: classification and uses, U.S. Department of Justice, 1984.
[14] B. Moayer, K. Fu, A Syntactic approach to fingerprint pattern recognition, Patter Recognition 7 (1-2) (1975) 1-23.

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