Reliable Core Point Detection in Fingerprint

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Abstract - Fingerprint recognition is a widely used biometric identification mechanism. In case of correlation based fingerprint recognition detection of a consistent registration point is a crucial issue; this point can be a core point of a fingerprint. Many techniques have been proposed but success rate is highly dependent on input used and accurate core point detection is still an open issue. Proposed paper discusses an algorithm which is based on multiple features derived from the fingerprints which are collectively used for consistent core point detection. Though all fingerprints don't possess core point still this algorithm is useful to detect high curvature regions and gives high accuracy as it combines advantages form individual features. Proposed paper demonstrates the use of second derivative of Gaussian filters (SDG) together with pyramid technique for fingerprint image enhancement. For preprocessing of core point it uses segmentation (mean and variance) method to extract best region of interest (ROI) from image and Core Point is detected using least mean square algorithm. To detect core point Direction of curvature technique (DC) has been used in coarse core point detection whilst geometry of region (GR) technique is used in the fine finding of the core point. The proposed technique is believed to improve the identification correctness with slightly better in computation performance. This technique detects core point for low quality images also with 90% accuracy.

Index Terms— Biometric, Core Point, Fingerprints, Reliable core point detection,

I. INTRODUCTION

Fingerprints are the oldest and most widely recognized biometric trait. All human being possess fingerprint and these fingerprints are result of unique ridge and valley structure formed by skin over the fingers [1]. Fingerprints have been used as a method of identifying individuals due to the favorable characteristics such as “unchange ability” and “uniqueness” in an individual’s lifetime. In recent years, as the importance of information security is highly demanded, fingerprints are utilized for the applications related to user identification and authentication. The quality of fingerprint images depends on acquisition environments, skin conditions and user interactions. Dirt, moist, creases and cuts on the surface of fingertips produce noise in fingerprint images. The noise effects can cause uncertainties in feature extraction of fingerprints, thus increase the error rate of the identification system. 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, cross-over 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 [3]. Minutiae mean small details and this refers to the various ways that the ridges can be discontinuous. A sudden ridge end is called termination or it can divide into two ridges which is called bifurcations.

Mainly two types are systems are there (a) Minutiae based matching (b) Correlation based matching. Minutiae based systems identify the location and type of minutia and match it with database template. The accuracy is totally dependent on the identification of minutia point [4][5][6]. In case of correlation based techniques, rather than detecting minutiae, we go for global matching of ridge valley structure, here the system matches the texture of fingerprint. Such techniques are robust but less accurate.

The core point based techniques are robust, but for matching the global ridge structure, we need a consistent point for aligning the fingerprints. Core points and delta points are critical points in finger Core points and delta points are critical points in fingerprint. A core is defined as a point in the orientation filed where the orientation in a small local neighborhood around the point presents semi-circular
tendency. Core points are the points where the innermost ridge loops are at their steepest and delta points are points from which three patterns deviate [9,10]. We are interested in core point which is shown on figure 1.

Fig. 1. Ridges and automatically detected minutiae points in a fingerprint image. The core is marked with a x

**II. LITERATURE SURVEY**

A number of algorithms have been proposed for optimal core point detection and most of them are based on ridge orientation estimation techniques. A common method used for core point detection is Poincare index in which point in the ridge orientation field is classified as singular point if orientation along a small closed curve around that point changes 0, ±180 or ±360 degrees [11]. Poincare index had used geometry of region technique for reference point detection. Poincaré index method uses only the local features of the fingerprint. Although some improved versions of the Poincaré index method have already been proposed to improve the success rate of singularity detection [6,13,14,15], the tolerance to local image noise is not sufficiently high [12] had proposed a method for reference point detection especially for arch-type fingerprint.

The estimation of orientation fields is an essential module in a fingerprint recognition system. The orientation fields represent the ridge flow directions on regularly spaced grids. They help to reveal intrinsic features of ridge topologies, and thus have great impact on almost all subsequent processes. To estimate fingerprint orientation fields reliably, the most popular approach is to use gradient based methods [16, 17, 18, 19]. Many methods are proposed but they do not provide accurate results, some of the methods are also known to be computationally expensive as they involve exhaustive comparing processes [2]. Hence, a more accurate estimation of coarse orientation fields can increase the accuracy and reduce the computation burden of the post processing stage.

This paper details the more accurate core point detection. In section II, fingerprint pre-processing steps are elaborated which proposes use of second derivative of Gaussian filter and orientation field estimation. In section III, details of core point location techniques are given. Those are geometry of region and direction of curvature techniques. Poin’care technique left out since its performance is low for bad quality or low quality images.

**III. PREPROCESSING FOR CORE POINT DETECTION**

Generally scanned fingerprint image includes noisy background, distortion and includes even scanner boundary reflection, which may cause problem in detecting the reference point. So, some preprocessing is required to locate core point correctly.

1. **Segmentation**

Fingerprint image segmentation requires extracting fingerprint image from background. Cutting or cropping out the region that contains the finger- print feature (ROI) minimizes the number of operations on the fingerprint image. Mean and variance based method [4] is commonly used for fingerprint image segmentation

$$M(i,j) = \frac{1}{w^2} \sum_{i=-\frac{w}{2}}^{\frac{w}{2}} \sum_{j=-\frac{w}{2}}^{\frac{w}{2}} I(i,j)$$

and

$$\text{Std} (I) = \sqrt{\left(\frac{1}{w^2}\right) - \sum_{i=-\frac{w}{2}}^{\frac{w}{2}} \sum_{j=-\frac{w}{2}}^{\frac{w}{2}} (I(i,j) - M(i,j))^2}$$

2. **Normalization**

Normalization is performed to remove the effect of sensor noise and grayscale level background which are the consequence of difference in finger pressure [20]

3. **Orientation and field Estimation**

Orientation or direction field estimation is not only used in core point detection but also in fingerprint matching. The orientation field is calculated block wise for a fingerprint. In a WXW block of a fingerprint the direction of ridge is given by the orientation field, the orientation field estimation is calculated using Second derivative of Gaussian filter. The smoothed orientation field based on least mean square algorithm.

**IV. COREPOINTDETECTIONTECHNIQUES**

The core point is used in both fingerprint classification and fingerprint matching using either spatial domain [21] or transformed domain [6]. This section details different
techniques used for core point detection due its performance factor.

1. Geometry of Region Technique (GR)

It is very important to find the geometry of region to detect core point as the ridge line curvature varies sharply near core point region [4]. 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.

2. Detection of Curvature Technique (DC)

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. Orientation field estimation and followed by field tuning. The core point is firstly identified by using the DC technique. Then the region of interest that includes the core point (ROPC) is cropped.

IV. PROPOSED CORE POINT DETECTION TECHNIQUE:

1. Divide the input image I(i,j) into non-overlapping blocks with size w x w. In our case w = 16.

2. Use second order derivative of Gaussian filter to find the gradients \( \partial_x (i,j) \) and \( \partial_y (i,j) \) at each pixel(i,j) respectively which is the center of the block.

3. Compute the local orientation \( \theta (i,j) \) by using equation below

\[
\theta (i,j) = \frac{\pi}{2} + \frac{1}{2} \tan^{-1} \left( \frac{\partial_y (i,j)}{\partial_x (i,j)} \right)
\]

The input block size is \( k x k = 3x3 \).

4. Locate the region of interest (ROI) based on background certainty.

5. Initialize a label image A which is used to indicate the core point.

6. For each pixel, compute Poincare index, \( P C (i,j) \). The core point should yield the Poincare index between “0.45 - 0.51”.

7. Find each connected component in A with pixel values “1”. There is normally more than one object. Core Point the object will always have largest area. So we first figure out the object having the largest area.

8. Then we calculate the centroid of the selected object. This centroid gives us the location of core point.

V. EXPERIMENTATION

We used the downloaded “DB1_A” of “FVC-2004” as database in our study. There are “800” fingerprint images captured with optical sensor, “V300” by CrossMatch. An image size is of “640x480” pixels with “500 dpi” resolutions. With eyes observation, we found that “746 images” hold core point. The rest do not. We fed these few images into the Poincare procedure for core point detection. Images with wrong core point detection are selected and fed them to the enhancement process where second derivative of Gaussian filter are imposed before core point detection. The second derivative of Gaussian filter enhancement is applied. With such an attempt, alias point detection could be dramatically reduced. The filter has removed noise, the ridge and valley patterns are enhanced greatly.

The block size was changed for the same image to check for differences observed.

i. Block size of 3x3

Good quality images showed core point while very low quality or dark images showed false core point. Out of “200 good quality images” “190 images” showed correct core point while the low quality or bad quality images of 400 showed false core point.

ii. Block size 5x5

Images with bad quality but not very low quality showed the correct core point while others showed false detection. The “200 images with bad quality” “170 images” showed correct core point while low quality images showed wrong core point.

iii. Block size of 8x8

The correct core points detected were very gray or not clear quality images. All the “600 images” were considered in which “560 images” showed correct core point. Separate observation of “200 low quality images” showed that “140 images” showed correct core point inspite of its degraded quality of image.

Total images which were passed were taken from the “FVC2004 database DB1_A”. The database consisted of “800 images” of which “600” were categorized as good, bad and low quality image.

Images captured from the sensor which were passed to the algorithm of which were good quality n hence detected correct core point with “3x3” block size. Total there were “100 images” captured. Of which “98 images” showed
correct core point as the quality of the images were good. The block size was observed to play a role for the quality of image that was selected, which then fine tuned the process of detection.

The Fig. 2 shows the core point detected correctly with a block size of “3x3”.

![Image showing core point marked after being processed with the proposed algorithm](image_url)

**VI. CONCLUSION**

The proposed algorithm extracts the high ridge curvature area efficiently and enhances a variety of fingerprints even with poor quality. The image noise is removed to larger extent. The probabilities of false detections are considerably reduced. The region of Interest is reduced to avoid unnecessary processing. Extracting best region of interest (ROI) and using fine orientation filed estimation, core point s are detected with great accuracy. The proposed core point detection technique is useful as it detects the optimal core point with low computation. This method of enhancing fingerprints could be incorporated further efficiently in the fingerprint verification, identification and classification to ensure robust performance.

**REFERENCES**


