Accurate Localizations of Reference Points in a Fingerprint Image

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Abstract. Reference points play important role in the field of fingerprint recognition. It is mainly used for fingerprint classification and fingerprint matching. There are many methods proposed for fingerprint reference point detection like Poincare Index technique, Direction curvature technique etc. The purpose of this paper is to detect the reference points considering the uncertainty for imperfection of fingerprint reference point position.

1 Introduction

Biometric Application,Fingerprint, has taken part a major role to identify a particular person uniquely. We can analyze the fingerprint from global and local perspective.From local perspective we concentrate on minutiae like bifurcation point,trifurcation,ridge ending etc. At global level ,there are some unique landmarks of fingerprint,where the ridge curvature is higher than other areas and the orientation changes rapidly. They are commonly known as core and delta[4] which are shown in Fig1(a) and they are used as a reference point. Each fingerprint should have the local features and may or may not have the global feature. The number of core and delta point differs in different type of fingerprint. There are several techniques available for singular point detection. Most of the techniques developed on the basis of orientation field of the image. The poincare index method(PI) one of the commonly used method for reference point detection[1][7]. This method is efficient but very much sensitive to noise as the orientation deviation caused by image imperfection that effects the computation of PI. Another method is to detect the reference point by searching the curvature point from the orientation image[6][8][3].

The main problem of all such approaches is the uncertainty presents in the process of detection of the exact location of reference points. Though it is easy to detect the approximate region where reference point exists but it is difficult to get a unique point as a reference one. In this paper we have proposed a method where some template is to be used to detect the reference points using strength of similarity from which the exact (single) point may be detected from the approximate core and delta region using fuzzy reasoning.

Organization of the paper is as follows. The estimation of direction field and reference points are presented in section 2.1 and 2.2 The false reference Point

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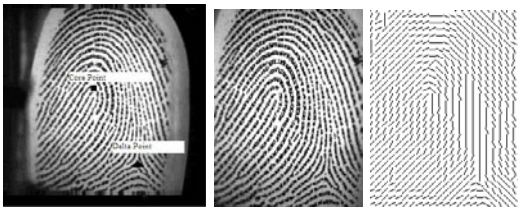


(a) Fingerprint Reference Point (b) Original image (c) Orientation image

Fig. 1. (a)Fingerprint Reference point (b)Original finger print image (c) field of Fingerprint image

removal technique is described in section 3. In section 4,A technique for identification of finer core point from core region is described. The experimental results and future works are given in section 5 and 6.

2 Proposed Method to Identify Reference Points

2.1 Formation of Orientation Image

Before going to minutiae extraction,an orientation field flow map is computed. The input image is subdivided into number of blocks of equal size and dominant ridge gradient direction is computed for each block. The average direction of all ridges represents the dominant direction of each block. Same algorithm is repeated for each block. So the image is scaled down by the size of factor w if We assume that the size of each block is $w \times w$. All possible directions should get converted only into eight discrete directions in the range of 90 degree to -67.5 degree[9][2]. The Direction angle θ(i,j) is representing the dominant direction of the block (i,j). Now the reduced image is represented as $D(i,j)$ and its position is represented by D_{ij} . The main steps to calculate the orientation of each block is as follows.

1)Divide the fingerprint image into non overlapping blocks of size $w \times w$.

2)Compute the gradient $\delta_x(i,j)$ and $\delta_y(i,j)$ of each pixel (i,j) corresponding to the Horizontal and vertical direction.The gradient operator used here is Sobel operator for simplicity.

3)Estimate the orientation of each block (i,j) by averaging the square gradients as follows.

$$V_y(i,j) = \sum_{u=i-w/2}^{i+w/2} \sum_{v=j-w/2}^{j+w/2} 2\delta_x(u,v)\delta_y(u,v) \tag{1}$$

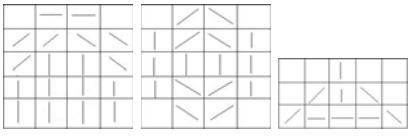
$$V_x(i,j) = \sum_{u=i-w/2}^{i+w/2} \sum_{v=j-w/2}^{j+w/2} (\delta_x^2(u,v) - \delta_y^2(u,v)) \tag{2}$$

$$\theta(i,j) = (1/2)tan^{-1}(V_y(i,j)/V_x(i,j)) \tag{3}$$

The original Fingerprint image and its direction image is shown in Fig 1(a),(b).

2.2 Reference Point Detection

The Poincare index method and the modified Poincare Index Method are the most popular method to detect the singular points in the fingerprints. By using this method the core point,delta points and virtual core point for whorl type are extracted on the basis of gradient differences among the adjacent blocks[1][7]. But it has been shown that reference point detection is considerably difficult for low quality image and the image containing noise. This may cause the faulty detection of reference point.



(a) Core mask (b) whorl mask (c) Delta mask

Fig. 2. Different mask figure a)Core b)Whorl)delta

To overcome this problem,besides the gradient difference method proposed in PI method additionaly We have used block based matching technique where number of blocks are used which depicts the different kind of reference point pattern. This hugely improved the performance of fingerprint reference point detection methodology. The template masks, $CoreM(i,j)$,$WhorlM(i,j)$ and $DeltaM(i,j)$ in fig2 are defined as a convolution mask for calculating similarity measurement strength of each pattern in the Direction image. Initially We consider three empty sets for the core,whorl and delta point ,let it say S_C,S_W,S_D.

Each point of direction image $D(i,j)$ is checked with all the template mask and correlation membership value or similarity measurement strength is calculated using the equation (4). As the convolution template are asymmetric the exact mid point or near mid point is chosen for calculating the correlation membership value,let say the point index as mid_i and mid_j.

$$\mu_C(D_{ij}) = \sum_{u=-1}^{M_H} \sum_{v=-1}^{M_W} 1 - \frac{|(D(i+u)(j+v) - CoreM(mid_i+u)(mid_j+v))|}{\delta_k} \tag{4}$$

$$\mu_C(D_{ij}) = \mu_C(D_{ij})/N_C \tag{5}$$

where M_H is the height of the Mask,M_W is Width of the Mask,δ_k is maximum possible phase angle difference,here 157.5(90 to -67.5) and N_C is No of considerable points in the Mask.

Using the above mentioned equation,correlation membership value is calculated using all the mask and say it $\mu_C(D_{ij})$,$\mu_W(D_{ij})$ and $\mu_D(D_{ij})$ for core,whorl type and delta. Now a cutoff value is decided to get the correct point into the set S_C,S_W, S_D using the equation (6).

$$S_C = \{D_{i,j} : \mu_C(D_{i,j}) > \mu_{CT}\} \quad S_W = \{D_{i,j} : \mu_W(D_{i,j}) > \mu_{WT}\}$$
$$S_D = \{D_{i,j} : \mu_D(D_{i,j}) > \mu_{DT}\} \tag{6}$$

where μ_{CT},μ_{WT} and μ_{DT} are the membership cut off value for core point,whorl type and Delta Point. The above mentioned approach is continued in reverse image to check any other reference point from the opposite direction using the same algorithm.

3 False Reference Point Detection and Removal

All the candidate points which has been detected in the set S_C,S_W and S_D are not the correct reference point. In this scenario it has been shown that if We take the help of poincare indexing method, it will remove the unnecessary core point and delta point from the set S_C and S_D.

From the experiment It has been shown that there may be some points in the set which are neighbor of each other. Multiple reference points can not be present within the neighborhood position so the points are to be removed from the set. In this scenario,Lower most Horizontal line of the Image has been taken as a base line and the candidate point having smallest distance from the base line considered as reference point.

The virtual core point(Whorl type) is a special type of point where two extreme curvature point exist above and below of the whorl pattern. As whorl point is being detected separately so at that particular case,these two extreme curvature points marked as a core point are removing from the set S_C using equation (7) and the new set is formed S_C^{New}. Finally We can draw a hypothetical line joining these two points and center of this line can be assumed as a virtual core point for whorl type which is shown in Fig 3(a).

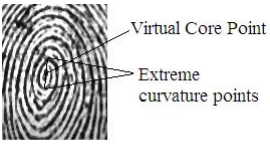
$$S_C^{New} = S_C - \{x\} \tag{7}$$
$$If(x \in S_C \quad and \quad y \in x_8^n \quad and \quad y \in S_W \quad), \quad Check \quad \forall x \in S_C$$

where x_8^n is the set of 8 neighbor points of x.

4 Identification of Finer Point from Core Region

Its a challenge to identify the exact core point position from the identified core region. It is found that the exact core point is the sharpest corner situated in the innermost ridge.To identify a corner point We have estimated some local shape parameters gradient,symmetry and straightness for this purpose. An ideal

corner point should have high gradient value,high reflective symmetry and low level straightness in a local neighborhood of pixels[5].Cornerness is checked using the table in Fig3(b)for decision making. Each parameter value of the core region points are calculated and the range between the extreme low and extreme high value is equally subdivided into three range low,medium and high. An Example of finer core points (single pixel or cluster of very few pixels) detection using proposed method and core region detection using poincare method is shown in Fig4(e) and (d).



(a) Virtual core point

Gradient	Symmetry	Straightness	Cornerness
low	low	low	low
low	low	high	low
low	high	low	low
low	high	high	low
high	low	low	low
high	low	high	low
high	high	low	high
high	high	high	low

(b) Cornerness Decision making

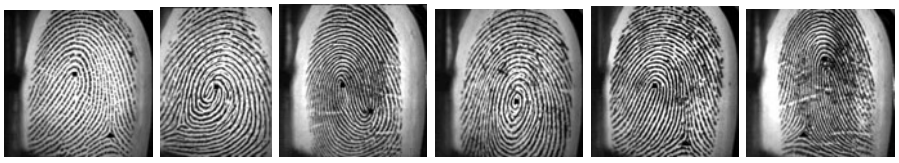
Fig. 3.

(a) Original image (b) zooming core region (c) Orientation image (d) Poincare method (e) Finer core Point

Fig. 4. Finer core point Identification

5 Experimental Results

To evaluate the performance of this algorithm, We have used the testing database FVC 2000 (http://bias.csr.unibo.it/fvc2000/databases.asp) for all type of fingerprint Image.The orientation image is formed using 8×8 block. The Similarity measurement strength cut off values are decided .8,.85 and .85 for μ_{CT},μ_{WT} and μ_{DT} respectively considering the effect for large number of images.Some Fingerprint Image and its reference points are shown in Fig 5.



(a) (b) (c) (d) (e) (f)

Fig. 5. Result Image with Core,Whorl and Delta Point

6 Conclusion

In this paper we have tried to overcome the uncertainty during the identification of exact reference point location using decision making rules. But We expect that any soft computing tool like fuzzy set theory can play important role for modeling such type of uncertainty and that is being persuaded currently.

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