ACEEE Int. J. on Signal & Image Processing, Vol. 4, No. 2, May 2013

A Novel Approach for Detection of Fingerprint by Constructing Relational Graph using Singular Points

Bintu Alias, Ginto Johnson and Anoop Thomas
Dept. of Electronics and Communication Engineering
Rajagiri School of Engineering and Technology

***Abstract*- Fingerprint is the dominant trait between different biometrics like iris, retina, and face. A fingerprint is the pattern of ridges and valleys on the surface on a fingertip. Now days itself this method is very powerful because of their immutability and uniqueness of patterns .immutability means the patterns by ridges and valleys are permanent and unchanged. Many techniques have been proposed for pattern recognition in fingerprint, most of them being based on minutiae and singular point. In the singular points method we are extracting the core, delta, arch and whorl points. In human fingerprint, it may contain more than one core point or delta point by . By using these points we can construct a graphical shape that is used for fingerprint identification. So the whole image storing in database is replaced by some shape or values. According to the position of each point the graphical shape for each person is different from others, so comparing with this shape can identify each person.**

***Keywords:*-Fingerprint matching; POINCARE INDEX; Singular Point; OPENCV; BEAGLE board**;

I. Introduction

Automatic fingerprint identification system is one of the oldest biometric technology and as such has become one of the most used. When the number of the registered users at the fingerprint identification system becomes larger, the number of comparisons becomes larger. To reduce the computation time at the identification phase, it is necessary to classify fingerprints at the registration stage. In order to reduce the computational complexity we can reduce the total matching points taken for fingerprint matching. But it should be significant as compare with our fingerprint. Here also we are taking some key points from fingerprints by using anyone of the feature point detection algorithm and use that points for further matching. 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 sometimes bifurcate. Fingerprint has some referential points to classify fingerprints. they are core delta whorl arch etc..Poincare method is the most popular and practical approach to detect these points from fingerprints. For the estimation of Poincare index, the given image has to be divided into several blocks of smaller images. Then obtain the gradients for each block is obtained by applying Gaussian operator or Sobel operator all over the image. Smooth the above obtained moments using suitable filter. Gaussian would produce good results .The local field orientation is computed according to some special equations using gradients. The directional image of the fingerprint estimated with the smoothing process of ridge orientation. Poincare method extracts singular points, due to the estimation of the ridge orientation difference between adjacent blocks. Since the algorithm of Poincare method is simple, the computation overhead is rather small. Thus this paper proposes an algorithm for fingerprint identification using the singular points. Here we use Orientation field, coherence and Poincare index for core and delta point detection. The core whorl arch and delta points are detected and the distances between these singular points are used as criteria for fingerprint detection and identification. Few singular points are required and thus reduce the time for detection. The algorithm is coded using OpenCV and tested for time of detection. This method thereby overcomes the timing issues of previous methods like SURE, SIFT,FLANN etc .The code was also tested in Angstrom Distribution-Linux OS for ARM based BeagleBoard.

II. Singular Point Extraction

In a fingerprint, singular points (SPs) [7] can be identified. SPs are the points in a fingerprint where the directional field is discontinuous. There are some singular points, on the basis of the ridge and valley structures. The core is the topmost point of the innermost curve ridges, and a delta is the center point of the triangular regions where three different direction flows meet. Each fingerprint contains maximal 2 cores and 2 deltas; a segment of a fingerprint image around an SP has an orientation. Arch and whorl points are also included in singular points. The core [3] of the fingerprint is defined as a center point of the semicircle pattern of the ridge shape. The delta of the fingerprint is defined as a center point of the triangle of the ridge pattern. Arch is the point where ridges are follow in one direction and follow out in opposite direction. the midpoint in that arch shape is known as arch. From the positional relation of delta and core, it is possible to judge the rotational direction of the fingerprint and to classify fingerprints. Therefore they are handled as important characteristic of the fingerprint.

A. Fingerprint Singular Points Detection

Singular points detection is a non trivial task. To determine the location of these point we first need to estimate the orientation field of the fingerprint. A number of methods for orientation estimation have been proposed. The singular

DOI: 01.IJSIP.4.2.1244

points detection algorithm is described below

Divide the Input Image : To calculate the Poincare index value, simply iterate over all the blocks in the image. The blocks are no longer pixel sizes but have been adjusted to be two times the average ridge frequency. As iterate over the blocks we calculate the Poincare index value for each block.

The Gradients Calculation: Compute the gradients $\partial x(i, j)$ and $\partial y(i, j)$ at each pixel *(i, j)* which is the center of the block. The gradient operator is choose according to the computational complexity.

Orientation Field Estimation: A major common step in both core point detection and finger print matching is the orientation or direction of the ridge estimation. Let θ is defined as the orientation field of a finger print image.θ(i, j) is represented as the local ridge at pixel (i, j) . Local ridge, however, is usually specified for a block rather than that of every pixel. The image is divided in to a set of non-overlapping blocks, size of w×w. Each bock holds a single orientation. A number of new methods for the orientation estimation have been proposed.

Poincare index: This approach is based on calculation of Poincare index of all the points in orientation map, we actually determine the Poincare index[7]. The Poincare Index obtained and is then threshold and the point with highest value is taken as core point. For compute the Poincare index first we estimate the local orientation or direction field of input fingerprint image.

If the angle changes equals 180 º, Poincare index is 1/ 2;
If the angle changes equals -180 º, Poincare index is -1/ 2 ;
If the angle changes equals 0 º, Poincare index is 0; 2.1.5. Core-Delta Detection
So the points and their Poincare index is concluded as followed.
Core: the Poincare index is 1/ 2;
Delta: the Poincare index is -1/ 2;
Arch: the Poincare index is 0.
Whorl :the Poincare index is -1.

III. Estimating Singular Points

1. The given image has to be divided into several blocks

Fig.1. The image contains sub blocks

2. The gradients for each block is obtained by applying Gaussian operator all over the image. The result we obtain is Gx and Gy. From this Gxx, Gyy and Gxy is obtained using the following:
Gxx = Gx.^2 Gxy = Gx.*Gy Gyy = Gy.^2

3. Smooth the above obtained moments using a suitable filter. Gaussian would produce good results.
4. Apply the following operations on the above obtained moments:
Sine component = Gxy./sqrt(Gxy.^2 + (Gxx – Gyy).^2)
Cosine component= (Gxx-Gyy)./sqrt(Gxy.^2 + (Gxx – Gyy).^2)
5. Smoothen the above components as discussed above using suitable window size.
6. Compute the orientation field using the following formula:
orientation = pi/2 + atan2(sine component ,cosine component)/2;
pi/2 -> appears because the flow direction is perpendicular to the directional dependence. Thus is obtained orientation field.

Fig.2. Orientation fields of input image

7. Now comes the computation of the Poincare index at pixel (x,y)

Poincare(x,y)=1/2π[ΣΔ(k)] Where K=0 to N-1

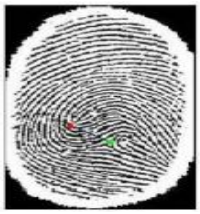
And

$$\Delta(k) = \begin{cases} \delta(k) & |\delta(k)|<\pi/2 \\ \delta(k)+\pi & \delta(k) \leq -\pi/2 \\ \pi-\delta(k) & \delta(k) \geq \pi/2 \end{cases}$$

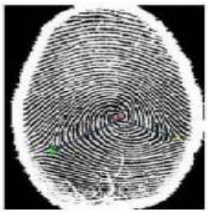
Δ(k) = θ(x(k+1) mod N , y(k+1) mod N) – θ(xk , yk) Where θ, gives the direction of any pixel in the
image.

8.Singular pointdetection:

If Poincare(i,j)=0.5, then core point is represented at the location (i,j). If Poincare(i,j)=-0.5, then delta point is represent at the location (i,j). If Poincare (i,j)=1, then a double core point and is called whorl point .And Poincare (i,j)=o is the arch point. Using these above equations we can estimate the position of singular points. After detecting these key points we just drawing the lines that join these points first core then delta, if arch and whorl is present then they are next points. So that we get a particular shape. For further identification process of fingerprint we use these points and the length between point and store in our data based and it used for further identification process. So we can reduce the amount of work for fingerprint identification.



Type1-1core 1 delta



Type2-1core 2 delta

DOI: 01.IJSIP.4.2.1244

Type3-1core, 1delta, 1whod

Type4-1core, 2delta, 1whod

Type5-1core, 1delta, 1whod, 1arch

Type6-1core, 2delta, 1whod, 1arch

Fig 3 .relational graph using singular points

By using Poincare index method, can calculate the position of core and delta points some cases whorl and arch also. And get a particular shape by joining these points as in the case of above figure. In first figure the shape is single line that has particular value and in case of second the shape is a inverted 'v'so on each one has different shape and distance between each points is different because they have different positions . In the case of this matching algorithm these shapes are analyzed and these shapes have different orientation and variation in length of their each edge. Also they are different from each person. So this can be used for fingerprint identification. Also we can use fingertip as other key point so that we will get a new shape with fingertip, delta and core. So it becomes more accurate. By using this algorithm we can reduces the number of key points as compared with other matching algorithms, because here we are using only two key point's core and delta.

IV. Timing Analysis

FLANN (Fast Library for Approximate Nearest Neighbors) is a library that contains a collection of algorithms optimized for fast nearest neighbor search in large datasets and for high dimensional features. It has high performance and less timing. So the comparison between Flann and the new matching algorithm is shown in figure both in Beagle board and in OpenCV software.

V. Accuracy Analysis

This algorithm is checked their accuracy in Opencv software for around thousands of different fingerprint images. Here we analyzed 6 types from that type 6 has more accuracy than any other types. From this we can concluded that if we

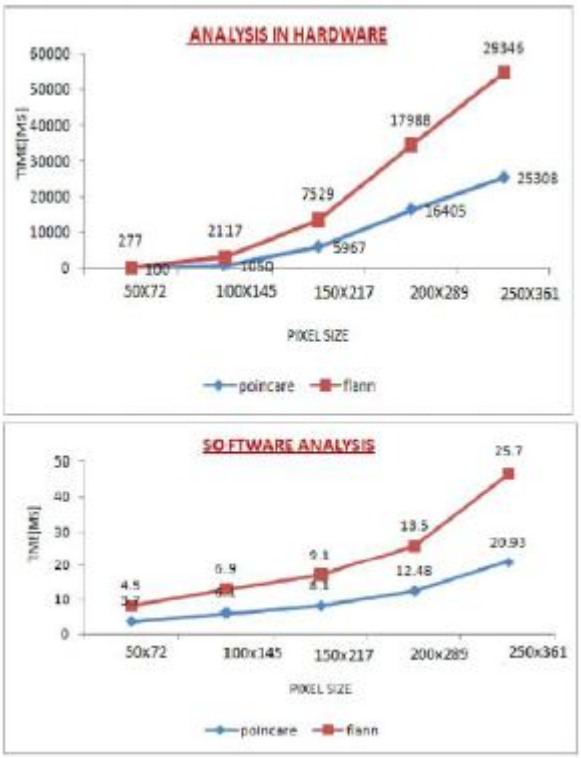


Fig 4.timing analysis in both hardware and software

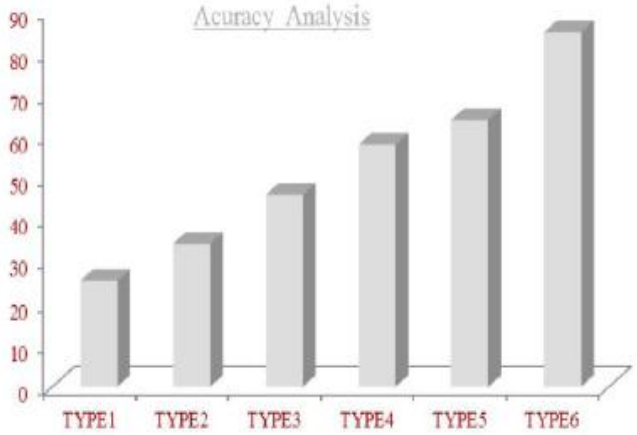


Fig5 .accuracy analysis

are increasing the number of feature points, then we can increases the accuracy. Besides that we can see the number of points is less as compared with the normal matching algorithms.

VI. Summary and Future Work

In this paper introduced a new fingerprint matching scheme that utilizes the core, whorl arch and delta points available in a fingerprint. So many algorithms are available to extract these points from our fingerprint. Here we are using Poincare Index method for extracting the feature points from the fingerprint. The main advantage of this approach is less execution time due to the reduction in key points. The timing analysis of Flann and Poincare both in hardware and software is evident for that .And also it can be used for online authentication like Gmail.

DOI: 01.IJSIP.4.2.1244

Reference

[1] D. Maltoni, D. Maio and A. K. Jain, and S. Prabhakar, Handbook of Fingerprint Recognition,published in Springer-Verlag, June 2003

[2] Sen Wang and Yangsheng Wang,"Fingerprint Enhancement in the Singular Point Area," IEEE signal processing letters,January 2004

[3] T. Ohtsuka and T. Takahashi, "A new approach for the fingerprint core detection using the modified relational graph," .2004 International Symposium on Nonlinear Theory and its Applications, vol.2, pp.565–569, Fukuoka, Dec. 2004.

[4] A.M. Bazen and S.H. Gerez. "Systematic methods for the computation of the directional field and singular points of fingerprints". IEEE Trans. PAMI, July 2002.

[5] K. Balck and C. V. Kameswara Rao " Finding The Core Point In A Fingerprint", IEEE Transactions on Computers, Vol. C-27, No. 1, January 1978

[6] Kekre H. B., Bharadi V.A. (2009), Fingerprint Orientation Field Estimation Algorithm Based on Optimized Neighborhood Averaging,International Conference on Emerging Trends in Engineering & Technology (Accepted) , Nagpur ,India.

[7] Jinwei Gu and Jie Zhou "Analysis of Singular Points in Fingerprints based on Topological Structure and Orientation Field" Technical Report

DOI: 01.IJSIP.4.2.1244