SINGULAR POINT DETECTION IN FINGERPRINT IMAGE AND CLASS MATCHING

S SARAVANA 1*, Prof. T ANURADHA 2*

Department of Computer Science Dravidian University Kuppam – 517426 A.P India
E- Mail: ssaravana_ssi@yahoo.co.in, rajamaata@yahoo.co.in

Abstract
Singular point detection is an important task in many Automatic Fingerprint Identification Systems (AFIS). There already exists many singular point detection algorithms, most of them can efficiently detect the core point when the image quality is fine, but when the image quality is poor, the efficient of the algorithm degrades rapidly. In this paper, we present a new singular point detecting algorithm based on Multi-Resolution Direction Field (DF). First we use the low resolution DF to find an area that includes singular point, then we use high resolution direction field to search the precise position of the singular point. Experiment results show that the detection precise is rather high, even with a poor quality image.

Key words: Singular Point detection: Gabor Filters: discrete Fourier Filters: Finger print recognition

1.**Introduction**

Fingerprint-based identification has been used for a very long time. Owning to their uniqueness and immutability, today, fingerprints are the most widely used biometrics features. Most AFIS are based on minutiae matching[1].According to the dependence of the core point, fingerprint matching algorithms are divided into two groups, core-based match algorithm and noncore-based match algorithm. The core-based match algorithm depends on core point to alignment the feature vector, and the noncore-based match algorithm depends on other alignment method such as local structure. Although core-based match algorithm is more efficient than the noncore-based algorithm, the main problem of the core-based algorithm is how to precisely localize the core point. There already exist lots of algorithms that deal with the singular point detection in literature. In [1], 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 [2], 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 [3], 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 Poincare index. However, because of computing high resolution direction field, the algorithm efficient is rather low. In [4], Jain presents a Poincare 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. In this paper, we present a new singular point detection algorithm which can precisely localize the singular point and does not need post processing step. It mainly involves two steps: first, using low resolution direction field to find a rough area that include core point, then using high resolution direction field of the area which found in the first step to precisely localize the singular point. The estimation of direction field is presented in section 2, and in section 3, the method of detecting singular point is presented. In section 4, the experiment results of the algorithm are shown. At last, in section 5, the results and further work are given.

2. A calculation for the particular point recognition and order was produced

Despite the fact that, in a unique finger impression, there will be at most two centers and two deltas that exists, it is expected in this postulation, and furthermore from the accumulated database, that fingerprints either have two centers or a center and a delta in them. The information picture was first flipped vertically for the reason that the calculation just applies on the flipped picture. The real strides in the solitary point discovery are as per the following:

1. Gauge introduction field of the information unique mark from the binarized picture utilizing the Rao's calculation talked about at the past area.

a. Apply a pixel-wise versatile 2-D Gaussian lowpass Wiener channel to the information binarized unique mark picture. The channel utilizes neighborhoods of
size 5 by 5 to evaluate the nearby angle mean and standard deviation. This will help in diminishing any clamor that may bring about spurious outcomes in the accompanying slope computations.
b. Isolate the information unique mark picture into non-covering squares of size 10x10.
c. Figure for the x and y sizes of the slope at every pixel in each square, Gx and Gy.
d. Apply a similar 2-D Gaussian lowpass channel on the x and y inclinations as above to smooth out the slopes.
e. With each piece, gauge the neighborhood edge introduction, 0O, utilizing the recipe in the Rao's calculation portrayed in the past area.
f. Round the nearby edge introduction to the closest component of pi/4 or 45 degrees.
g. Rehash the progression until every one of the pieces in the picture are handled.
h. Put the nearby edge introduction of each piece in a network relating to the introduction picture.
2. After the introduction field has been evaluated, the following stride is to distinguish where the solitary point is. By watching the introduction field of the database, it was seen that the particular focuses lie at the pieces were the nearby edge introduction is 135 degrees. More often than not, the pieces with 135-degree introduction are assembled together or associated with each other. So the 135-degree squares were isolated from alternate pieces by binarisation: the 135-degree pieces were characterized as the articles (white) while alternate squares were characterized as the foundation (dark).

3. <u>Label the items in the twofold picture.</u>

1. If there is just a single principle gathering present in the binarized mark picture (figure 4.4), the info unique mark will consequently be delegated a curve.
2. If there are more than two principle bunches in the picture, the information will be delegated unclassified.
3. But for the situation where there are for the most part two gatherings of 135-degree squares (figure 4.5)[binarized, label], it will further be named whorl, left or right circle or a rose curve.

7. The upper (first) bunch dependably contains a center and the lower (second) amass either contains a center or a delta. The calculation utilized as a part of finding the first gathering's center (first center) and the second gatherings particular point will further be clarified. In particular, the center at the first gathering is at the lower left end of the gathering. On the off chance that the second gathering contains a center, the information unique mark will be delegated a whorl and the center will be at the upper right end of the binarised name image.

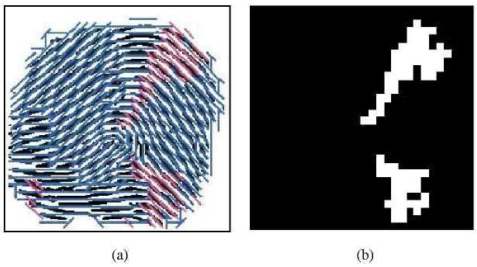


Figure 4.4 Binarized label image (a) orientation field (b) isolated 135-degree blocks

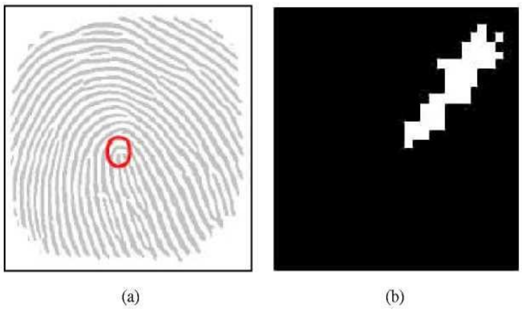


Figure 4.5 Arch (a) input fingerprint image with a mark at the core (b) binarized label image

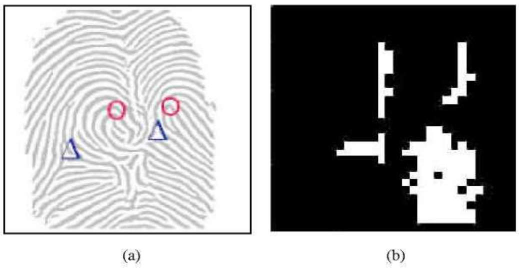


Figure 4.6 Unclassified
(a) inputfingerprint image
(b) binarized label image with marks at the singular points

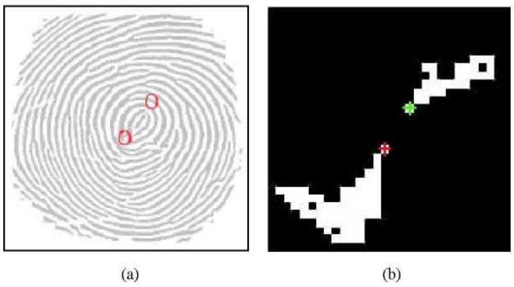


Figure 4.7 Whorl (a) input fingerprint image (b) binarized label image with marks at the two cores

8. Then again, if the gathering contains a delta, the unique mark will either be named left or right circle or a rose curve. The delta is situated at the upper left end of the second gathering.

9. To recognize a left or right circle from a rose curve get the edge, alpha, between the line fragment associating the center and the delta and the vertical hub.

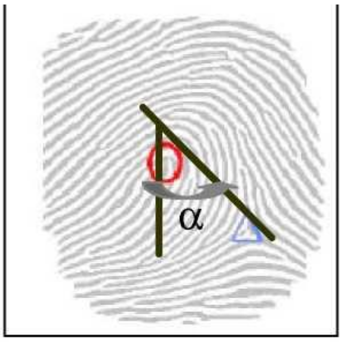


Figure 4.8 Angle alpha

10. On the off chance that the alpha is not as much as a limit esteem, 15 degrees, order the contribution as a rose curve.

11. On the other hand, if alpha is more prominent than the edge, the unique mark will either be a left or a correct circle. On the off chance that the delta is at the correct side of the center, then arrange the contribution as a left circle.

12. On the off chance that the delta is at the left half of the center, order the contribution as a correct circle.

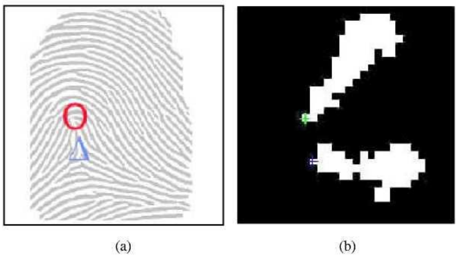


Figure 4.9 Tented arch (a) input fingerprint image (b) binarized label image with marks at the singular points

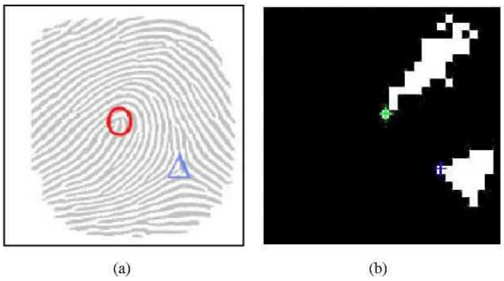


Figure 4.10 Left loop (a) input fingerprint image (b) binarized label image with marks at the singular points

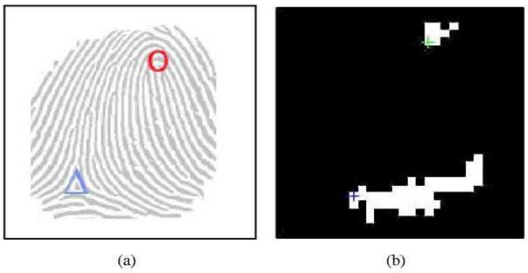


Figure 4.11 Right loop (a) input fingerprint image (b) binarized label

image with marks at the singular points

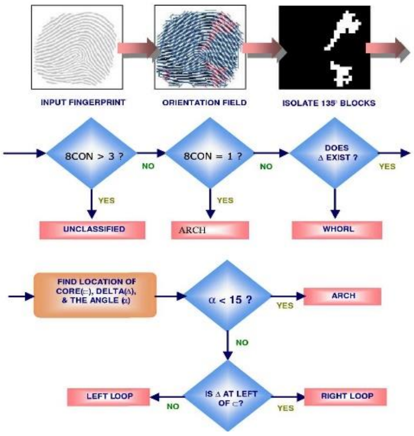


Figure 4.12 Fingerprint Classification Flowchart

4. LABELING ALGORITHM

In spite of the fact that the Image Processing Toolbox of MATLAB has the capacity "bwlabel" for the marking of pictures, a calculation for naming was additionally coded in MATLAB. This is for the reason that the compiler from MATLAB to C utilized does not bolster the capacity 'bwlabel'. It is a left-to-right, start to finish look for eight-association. Expecting the information is a paired picture (white as question, dark as foundation), the calculation is as per the following:

1. Check a line until a white pixel is experienced - filtering is from left-to-right, through and through then mark the pixel.

2. For the main line, if a white pixel is experienced, check if the pixel at the left of it is a protest and its name.

3. For the second line onwards, if a protest is experienced:

a. In the first place section, check if the pixel instantly above and additionally at the upper right of it is likewise a question and the name of it.

b. Last section, check the pixels quickly above, at the left, as well as at the upper left is a protest together with the marks.

c. Their sections, check the left, beat, upper left and the upper right pixels.

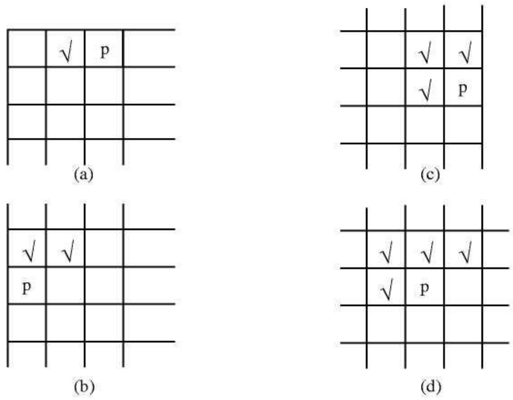


Figure4.13 Labeling algorithm p is the pixel of interest while V is the neighbor to check for (a) the first row (b) first column(c) last column (d) the other columns of the second row onwards

4. On the off chance that the pixel of intrigue has more than one neighbor, and the neighbors don't have similar marks, a nx2 equality framework will be utilized.
   The equality grid comprises of the name of the neighboring pixels. (for instance figure 4.13(a)), the pixel p1 has three neighbors with two pixels having a similar mark, 1. Also, the other, not quite the same as the two, 2. Accordingly, the marks 1 and 2 will be set at the identicalness framework since they ought to be equivalent. Likewise, the pixel p2 associates two pixels with various marks so the names of these pixels will be put in the equality lattice. The name of the pixel of intrigue will be the mark of the neighbor with the most reduced esteem.

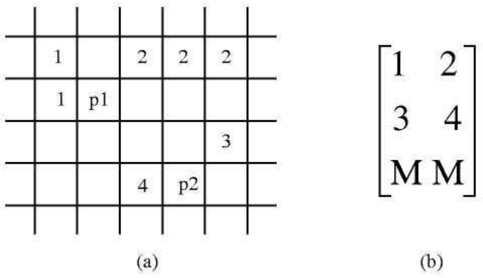


Figure 4.14 Labelling illustration (a) possible first scan label matrix (b) its equivalence matrix

1. In the second and last sweep, the equivalences are settled. In the identicalness network, each line will be examined. For each line, the two components will be thought about, the lower esteem will be held and the higher esteem will be supplanted by the lower esteem. Before continuing to the following column, locate alternate components in the equality grid that has a similar estimation of the higher component in that line and once more, supplant it with the lower esteem component in a similar line. In the primary output name framework, discover the pixels with a similar estimation of the higher component and supplant it with the lower component. At that point continue to the following line of the identicalness framework.

5 LOCATION OF THE FIRST CORE

The main gathering of the binarized mark picture dependably contains the principal center as specified before. The center is situated at the lower left end of the gathering. To find the center, the calculation is a privilege to-left, start to finish seek and is done as takes after:

1. Locate the upper right most pixel of the gathering.
2. Check if the pixel at the lower left is a protest. If not a protest, check the pixel at the base and afterward the pixel at the left and afterward the lower right pixel.

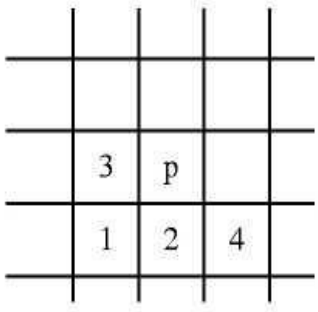


Figure 4.15 Sequence in determining the succeeding pixel

3. In the event that the primary experienced pixel is a protest, as indicated by the grouping above, continue to that pixel and rehash number two until there are no different pixels recognized by the succession.
4. The last pixel can't avoid being pixel comparing to the area of the main center.

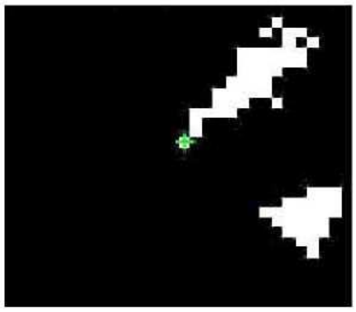
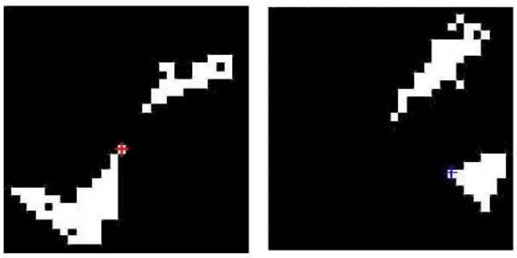


Figure 4.16 Location of the first core

5.1 LOCATION OF THE OTHER SINGULAR POINT

The second or the lower gathering of the binarized name picture either contains the second center or a delta. To decide if the gathering has both of them, thresholding is connected. In the event that the centralization of the gathering is at the left of a specific edge esteem, the gathering contains the second center. While if the focus is at the privilege of the limit, the gathering contains a delta. The edge esteem utilized as a part of this proposal is the fourteenth section from the left.



(a) (b)

Figure 4.17 Location of the (a) second core (b) delta

That the convergence of the gathering in Figure 4.17 (an) is at the left half of the edge while the centralization of the gathering in (b) is at the privilege. In the event that the gathering is found to have the second center, its particular area won't be sited since the information will naturally be delegated a whorl. In any case, if the gathering has the delta, find the highest point of the left most sections of the gathering and that will be the area of the delta.

5.2 FEATURE EXTRACTION

The contribution of the unique mark characterization program will be a 300x300 pixels binarized picture. The example of the unique finger impression will be separated from the binarized imaged. These examples are coordinated with the predefined classes as per its attributes. The particular point recognition and the class coordinating will have the unique finger impression characterization program. The solitary focuses will be removed from the introduction picture. The yield of the program will be the class of the info unique finger impression.

5.3 INTRINSIC FINGERPRINTS FOR IMAGE AUTHENTICATION AND STEGANALYSIS

With developing notoriety of minimal effort picture altering programming and advanced imaging gadgets, the respectability of picture substance can never again be underestimated. This segment presents a procedure for scientific investigation of advanced camera pictures, in view of the perception that various in-camera and post-camera handling undertakings leave particular follows on computerized pictures. A few strategies are utilized to distinguish these inborn unique mark hints of the different preparing operations and utilize them to confirm the validness of computerized information. To build up an express imaging model to describe the properties that ought to be satisfied by an immediate camera yield and model some extra handling used to the camera caught picture by a control channel. Utilizing the control channel coefficients and reference designs evaluated from direct camera yields utilizing blind deconvolution methods are fit for identifying controls made by already inconspicuous operations and steganographic inserting.

In the course of the most recent decade, advanced pictures have turned out to be progressively well known and have been utilized as a part of a developing number of uses, from military and examination to medicinal finding and purchaser photography. The picture content honesty can never again be underestimated and various criminological related inquiries occur in the midst of such far reaching use with such boundless notoriety and the appearance of ease and complex picture altering programming. For example, given the last advanced picture after a handling chain, to choose how the picture was produces? What technique(s) were used? What preparing/alterations were done to the substance of picture after catch? Is the picture altered or controlled in a few ways? Does it have some shrouded data?

Some of these legal inquiries are related to finding the computerized picture source, and deciding likely altering. Prove acquired from such examination of legal

would give supportive legal data to law implementation and knowledge offices as to if the given picture was basically caught with a camera (or produced by different means) and to establish the computerized picture realness. Strategies, for example, semi-delicate picture watermarking and hearty picture hashing [70] have been set out to build up the information realness. On the other hand, these methods require that an outer watermark or mark, likewise alluded to as an outward unique mark, be embedded at the season of development of mixed media information. This forces various confinements on its tradition as various computerized cameras and video recorders in the market still don't contain the abilities to include a watermark or disarray at the season of picture making. In this way, there is a solid inspiration as a developing field of picture legal sciences part to devise non-nosy methods to separate bona fide pictures from controlled ones.

Building up a novel technique for measurable examination is vital. The procedures depend on the perception that each in-camera and post-camera handling undertaking leaves a couple of intrinsic follows on the last yield picture that are normal for the preparing piece. The follows as the inherent fingerprints as they straightforwardly catch the adjustments created to the picture by the few handling operations amid obtaining and after it has been shot by a camera. By describing the properties of an immediate camera yield are utilizing a picture securing model, to utilize a few strategies to infer in-camera and post-camera preparing undertakings the inborn fingerprints. The nearness or nonappearance of conceivable post-camera controls is in this way found by looking at the likenesses between the inborn fingerprints assessed from the test picture and the ones gotten from direct camera yields. The utilized calculation does not require any earlier learning of the handling operation nature. In this way, it can perceive beforehand inconspicuous controls and will go about as a front-end for recognizing computerized falsifications.

Related earlier works fall into two noteworthy classifications. In the altering discovery writing, there have been works that attempt to perceive inauthentic controls by portraying the properties of an altered picture regarding the bends it experiences. In

doing as such, different works expect that producing an altered picture includes a progression of preparing operations, which may contain re-testing, JPEG pressure, focal point bends, gamma adjustment [70], conflicting clamor examples and changes in connections presented by shading insertion [70]. In light of this perception, they utilize methods to recognize such controls by extricating clear most essential elements that would help separate such altering from bona fide information [70]. Despite the fact that these strategies can be utilized to distinguish the sort, and the parameters of the post-handling operation, it would require a comprehensive inquiry over each various sorts of post-preparing operations to identify altering. Differentiating the current work that plans to determine natural fingerprints of each preparing module independently, the measurable investigation approach does not separate between different sorts of handling, and in this manner gives a widespread structure to perceive a few conceivable altering operations.

Picture controls, for example, watermarking and steganography will likewise be considered as post-handling errands utilized to camera yields. A steganographic strategy implants shrouded messages into the host picture by executing appropriate adjustments on the information. Over the previous decade, with the development of web and across the board fame of sight and sound information, advanced pictures have been used as a general medium for passing on mystery data. Countless implanting strategies [70] have been to permit secretive correspondence. At the comparative time, various steganalysis strategies [70] to perceive concealed messages have additionally been enhanced to counter steganography. as inserting particular steganalysis calculations target correct steganography procedures, general steganalysis techniques [70] intend to recognize clandestine communication free of the installing calculation. With an upgrading number of new advancing steganographic implanting calculations, there is a solid require for vigorous systems for visually impaired steganalysis. Investigation of denoising channels strategies using natural fingerprints help perceive the follows abandoned by such post-camera controls, and give an all inclusive technique for visually impaired steganalysis.

6. Conclusion

In this paper, we present a new singular point detection method, which is efficient and has higher precision. This method first uses low resolution to detect a small area that includes the singular point, then uses the high resolution direction field to localize the singular point precisely. Experiment results show that present method has higher precision and is fairly robust to noise. More over the present algorithm is very efficient and suitable for an online system.

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