Review of Various Fingerprint Orientation and Classification Techniques

Ramanjot Kaur  
Student, Department of Computer Science and Engineering, BGIET, Sangrur

Anupam Garg  
Assistant Professor, Department of Computer Science and Engineering, BGIET, Sangrur

ABSTRACT
Fingerprint recognition is a commonly used biometric feature. This feature is used to authenticate a person’s identity. Orientation field estimation techniques are used to measure the orientation of a fingerprint. Reference point detection is used to deal with the issues of rotation and displacement. In this paper, different techniques of orientation field estimation and reference point detection are discussed.

General Terms
Method for fingerprint classification

Keywords — fingerprint, fingerprint recognition, preprocessing, orientation field estimation, classification.

1. INTRODUCTION
Now days, interest in digital image processing applications stems from two major application areas: for enhancement of pictorial information for human interpretation and image data processing for storage and transmission. In digital image processing, digital computers are used to process digital images. For accurate retrieval of visual information, digital image processing is used in different live area applications such as medical, law enforcement agencies, forensics systems.

Biometric system provides a variety of applications for authentication of people. It plays very important role in security purposes. Performance, scalability, non-invasiveness, circumvention are used for effective biometric system. Desirable properties for choosing biometric characteristic are: universality, uniqueness, permanence, collectability, acceptability. Authentication system based on biometric system is easy to deploy because fingerprint, voice, iris etc. are not forgotten or lost and transferred. These systems provide number of advantage over passwords or token based approaches. Biometric application provides efficient method for authentication and this area is still under improvement and enhancement.

Physiological features of the body are used for authentication. These features are mainly includes face, iris, signature, voice, fingerprint, hand. Fingerprint recognition is widely used technique because of its ease and reliability. A fingerprint is a unique property of a person’s body. A fingerprint is an impression of the friction ridges from the surface of a fingertip. Due to ease of its availability, reliability and low cost, fingerprint is used for personal identification.

Fingerprint recognition system involves the following steps: preprocessing, orientation estimation and matching.

The Preprocessing system is used to enhance the fingerprint image. Enhancement is done basically in terms of noise removal. Noise is removed from fingerprint and after it normalization, binarization, filtering and thinning is applied to image for enhancement. In orientation estimation process, orientation of a fingerprint is measured from input image using different orientation field estimation techniques like curvature based etc. The mostly used methods for orientation measurement are Poincare index method and gradient method. Then, the matching process takes place. It is toughest part of fingerprint recognition; in this two templates are used for matching process.

2. GENERAL CLASSIFICATION TECHNIQUES
Fingerprints are classified into different categories based on information which is extracted from global pattern ridges. Recognition process retrieves a fingerprint from large dataset correspond to a given fingerprint and, classification process assigns a fingerprint to a class which is pre-defined. Manual classification is taking long time as compared to automatic detection system. Still, this is a challenging
area to classify fingerprints correspond to its pre-defined classes. A good classification system must be very effective, reliable and it must be selective in terms of different non-overlapping classes with same properties.

Fingerprint is classified into different classes. These classes consider information from different levels to classify fingerprints. These levels are: global level, local level and fine level.

- Global level – This level of classification finds singular points for fingerprint classification. Singular points are also known as core point and delta point.
- Core and delta points are individually not sufficient for accurate matching process.
- Local level – At local level, fingerprints are basically classified into three categories: loops, arches and whoels. These three categories are further sub-divided into sub categories: left loop, right loop, upper loop, lower loop, tented arch, plain arch.

A fingerprint classification technique is an efficient and symmetric approach for developing classification models from given data set. Examples of classification systems are: rule-based, multi-classifier based, neural-network based, structural based, statistical based. Different algorithms are developed for classification system. Ridge line flow, orientation estimation, singular point detection algorithms are commonly used for classification system. Several approaches are developed for classification of fingerprints. Mostly used approaches are classified into following categories [1]:

- Rule based – Rule based approach is based upon number of singular points in an image. This approach is used for manual decisions. Basically, a plain arch has no singular points. A tented arch, left loop, right loop consist of one core and one delta. A whorl consists of two deltas and two core points.
- Structural based – This approach basically based upon orientation measurement of fingerprint. Orientation field estimation techniques are used to calculate orientation of given input image.
- Statistical based – In this approach, a general classifier is used for classification. Correspond to each feature vector, which is derived from given image is compared with general classifier.
- Neural network – Neural network based approach used multilayer perceptrons for fingerprint classification.
- Multilayer classifier – different classifiers like k-nearest neighbor classifier are used for classification.

3. RELATED WORKS

Now days, fingerprints are widely used in biometric recognition system. In general, a fingerprint is stored in a template for further verification. A fingerprint stored in a template might be gray scale image, thinned image according to requirement of matching algorithms. The general approach for fingerprint recognition is rule based, structural based and neural network based.

Different approaches are used for orientation field estimation: gradient based, poin-care index method, wavelet transformations, isosceles triangles. Orientation measurement based upon isosceles triangle method is main focus of this research.

<table>
<thead>
<tr>
<th>Name of Author</th>
<th>Preprocessing</th>
<th>Proposed Method</th>
<th>Experimental Results</th>
<th>Gaps</th>
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<tbody>
<tr>
<td>Liu et. al.[2]</td>
<td>Proposed Gaussian smoothing for noise removal. Gaussian smoothing removes noise from input image which provides better results as compared to original image.</td>
<td>Proposed an algorithm based on LAS feature which is used to estimate reference point of given fingerprint image. The author starts with localization of reference points. After the detection of reference point, direction is</td>
<td>This approach provides better results as Gaussian smoothing is used for noise removal. This approach used 800 images and only 9 images are refused from 80 images. Refusal rate is very low in this approach which shows its accuracy.</td>
<td>This paper calculate the detected reference points’ coordinates in ideal coordinate systems and register their estimated direction by the Manually marked directions.</td>
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<table>
<thead>
<tr>
<th>Authors</th>
<th>Method Description</th>
<th>Result</th>
<th>Remarks</th>
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<tbody>
<tr>
<td>Jiang, Xudong et.al.[3]</td>
<td>Proposed orientation smoothing which is used to improve fingerprint images. It shows better performance in filtering noise while maintaining the orientation localization than the conventional averaging method.</td>
<td>This paper proposed an effective algorithm to locate reference point and calculate orientation consistency for all types of images. Segmentation is also performed on input image to improve results. After it, reference point localization technique is used to compute reference points. Orientation is computed at the end of proposed method.</td>
<td>Number of radial directions used in paper can be increased and it can be further used for matching process also.</td>
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<td>Thien Hoang van and Hoang Thai Le [4]</td>
<td>For noise removal, two solutions are used: smoothed orientation consistency and averaging smoothed orientation consistency.</td>
<td>Convex Orientation Consistency-based Technique is used to calculate the convex orientation in both directions of curvature.</td>
<td>Results can be improved by using different preprocessing approaches.</td>
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<td>Shaharam Mohammadi and Ali Farajzaesh[5]</td>
<td>Proposed an improved approach which is implemented using combination of two approaches: orientation field estimation and edge detection technique. A secondary filter is used for accurate detection of reference points.</td>
<td>The proposed method can be applied to any class of fingerprints. This method is also consistent to rotation issues. It shows 88.43% of accuracy for distance error&lt;=10.</td>
<td>Filtering can be used for image enhancement which can make results more effective.</td>
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<tr>
<td>Author(s)</td>
<td>Method/Approach</td>
<td>Datasets Used</td>
<td>Results</td>
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<td>Li Wang et. Al.[6]</td>
<td>Presented a method of reference point detection based on local ridge orientation patterns. To detect reference points an improved approach is proposed based on reference point maps</td>
<td>FVC 2002 database 1 and 2 is used to evaluate results[7]. For alignment and matching process false acceptance rate (FAR) and false rejection rate (FRR) is computed. Experiment results show 94.5% accuracy for correct rate of singular points.</td>
<td>This approach can be applied to arch fingerprints. It is possible to find a reference point for an arch fingerprint which can be used for next stage's coarse alignment.</td>
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<td>Byoung et. Al.[8]</td>
<td>In pre-processing steps false core points are deleted. These points are affected by noise. Enhancement is done to remove noise from fingerprint image.</td>
<td>Core points are detected using poincare index method. After the localization of core points, segmentation is used to remove bad points</td>
<td>The algorithm provides 91.6% accuracy and tested 70 images.</td>
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<td>Yang et.al [9]</td>
<td>Normalization, filtering and thinning is used to enhance input fingerprint image.</td>
<td>The proposed work detects a set of isosceles triangles using an input point as starting point. After the detection of isosceles triangles, orientation value for arch fingerprint is calculated. The fingerprint orientation calculation is done by using average orientation value. Orientation values which are not near to average value are eliminated.</td>
<td>Evaluation of results describes the accuracy of proposed approach. Results show that the proposed approach is capable of measuring the fingerprint orientation for arch fingerprint and in future can be used for alignment and matching process.</td>
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<td>Bae et.al. [10]</td>
<td>In the preprocessing step fingerprint image is enhanced to remove noise and directional image is Calculated average filter is used to enhance image.</td>
<td>Information related to core points is used for classification. Poincare index and k-mean grouping algorithm is used to evaluate results.</td>
<td>The presented algorithm was tested on 6283 images. Provides accuracy of 92.3% for the four classes (arch, left-loop, right-loop, whorl).</td>
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4. SUMMARY
This paper surveyed different fingerprint orientation field estimation techniques. Field estimation techniques consist of reference point detection, orientation smoothing and filtering for enhancement. Isosceles triangles are used to compute fingerprint orientation for arch fingerprint which can be used in alignment and matching process for future work.

5. REFERENCES


