International Journal of Innovation and Scientific Research
ISSN 2351-8014 Vol. 10 No. 1 Oct. 2014, pp. 64-70

http://www.ijisr.issr-journals.org/

Review On Fingerprint Recognition: Minutiae Extraction and Matching Technique

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ABSTRACT: The recent advancement in fingerprint identification and authentication have encouraged many people to conduct researches in Fingerprint Identification and Authentication (AFIA) as fingerprint identification is becoming a new domain for user authentication. Fingerprint classification plays an important role in large organizations where fingerprint identification systems are deployed. Fingerprint identification is very helpful in authentication when two fingerprints do not match and also it reduces the time used for identification. This paper presents a thorough review on the existing classification approaches that have applied to fingerprint recognition problems. The explanation in this paper covers the various evaluation parameters used by AFIS classification approaches.

KEYWORDS: Fingerprint Recognition, Biometrics, Classification Approaches, Evaluation.

1 INTRODUCTION

Biometrics is method of identifying a human being based on a physiological or behavioral characteristic. Biometric system includes face, fingerprints, hand geometry, handwriting, iris, gait, palm print, vein pattern, and voice. These technologies have become the foundation of highly secure identification and verification systems. The increase in factors like vulnerability to security and transaction process, then the need for secure identification and individual verification also increases. Biometric-based systems provide secure financial transactions and data confidentiality. Biometrics can be implemented in local, governmental, military and commercial applications also. Network security, ID proof, E-banking, Money transactions, retail sales and social services are already in benefit due to biometric technology. In biometric systems, iris and fingerprint technologies are widely accepted as they have reliability and possess uniqueness. Identification of fingerprint is most popular due to its unique characteristics formed out of ridges and furrows. Fingerprint classification is categorizing fingerprint database in which the input fingerprint is first processed and then classified into set of same class. A database usually contains a number of fingerprints with different features. The identification of input fingerprint inside a database becomes a cumbersome process. Therefore classification of fingerprint helps to increase the throughput of identification and authentication process. The fingerprints are classified among the set of classes of predefined categories in database.

2 FINGERPRINT CLASSIFICATION TECHNIQUES

Fingerprint classification identifies and categorizes various fingerprints. Various unique identification points such as e.g. island, ridge end, core and delta exists in a fingerprint.

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A typical fingerprint classification is categories into the following six classes: whorl, right loop, left loop, arch, twin loop, and tented arch [3] . It also contains one or more regions where the ridge lines make different shapes (curvature, termination, etc.). These regions are called singularities or singular regions may be classified into three typologies: loop, delta, and whorl.

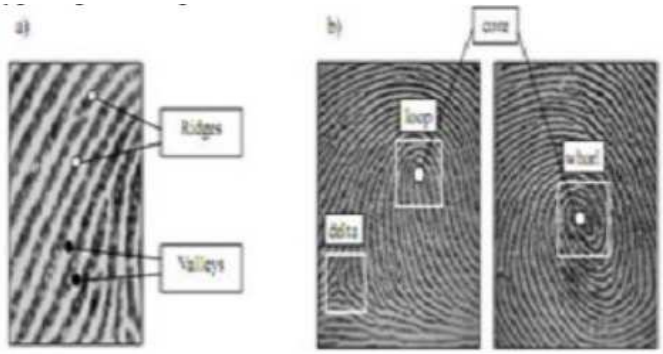

Fig. 1: Structure of fingerprint.
a) Ridges and valleys on a fingerprint image
b) Singular regions (white boxes) and core points (small circles) in fingerprint images.

3 STRUCTURE OF FINGERPRINT RECOGNITION

Fingerprint based recognition system can operate in either identification or verification mode. Fingerprint identification refers to one-to-many match, where input Fingerprint image of an individual is matched with other templates present in database. It is used to confirm the identity of a person. Fingerprint recognition system basically follows four steps that are image Acquisition/Enrollment, Image Enhancement/Preprocessing, Feature extraction and Matching/Authentication.

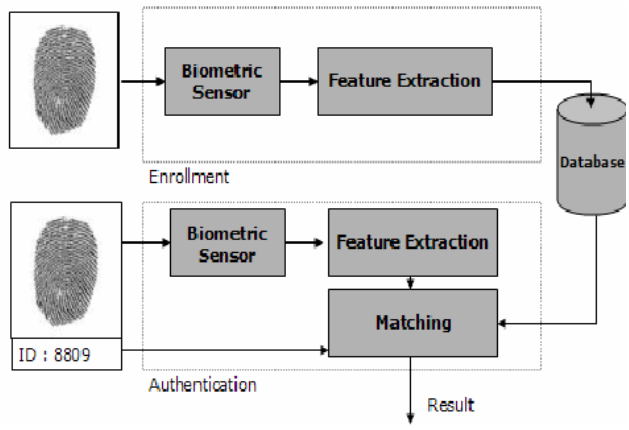

Fig. 2. Block diagram of Fingerprint recognition system

The various steps of fingerprint recognition are:
a) Fingerprint Acquisition/ Enrollment
b) Fingerprint Image Enhancement
c) Minutiae Extraction
d) Minutiae Matching
e) Fingerprint Classification/Authentication

3.1 IMAGE ACQUISITION

In this part, image of Fingerprint is first acquired with the help of sensors. Captured images may be blurred or may contain noises, which Detroit the quality of an image and affect the performance of Fingerprint recognition system. The fingerprint image acquired may vary by location of finger placed, direction and stretching degree.

3.2 PRE-PROCESSING

After acquiring the image through sensors, preprocessing or image enhancement is done on the image. Sometimes image may contain noise while enrollment process, noise can be remove with help of filters utilized in processing/enhancement part of the processing. Sometimes there is a need of images normalization.

3.3 FEATURE EXTRACTION

The third process is the pre-processing feature extraction process. In feature extraction phase, features of image are extracted such as Ridges, valleys, minutiae and singular points (loops, core, whorls and delta). These features are helpful for unique identification or verification of an individual. The features obtained from captured images are stored in database for further process of matching.

3.4 MATCHING

Next phase is matching process after feature extraction. Feature matching phase identifies similarities between current fingerprint templates and previously stored template. Input images provided to the system are matched with previously stored templates present in database. Matching is entirely dependent on whether the system Performs identification or verification. If it performs identification i.e. one-to-many matching approach is used, where fingerprint of an individual matches with all available templates in database otherwise one-to-one match is done for verification, where input image of a person is matched with only one template.

4 RELATED WORK

This section gives overview of various fingerprint classification methods. The following parameters are used for differentiating between various methods: Orientation map, singular points, Ridgeline flow and multiple parameters based methods etc. [5]

4.1 RIDGELINE FLOW

The direction of flow of the ridges is an important identification characteristic. It is not always easy to extract ridges from noisy images. It is usually represented as a set of curves parallel to the ridge lines as in figure 3; these curves do not necessarily coincide with the fingerprint ridges and valleys.

Fig. 3. Tracing of Ridges [6]

Andrew has described a classification technique based on the characteristics of the ridges. Two new classifiers have been presented by Andrew. The first classification described is by using Hidden Markov Model (HMM). In fingerprint image

the direction changes slowly hence HMM is suitable here for classification. The second classification method describes named Decision Trees.

Features are extracted from input images and then classified using a decision tree approach. Neeta and Dinesh have presented an approach for classification based on ridge flow. To reduce computation HRC is calculated based on the values of the slope within the block. After locating HRC, Ridge tracing is performed. Hye-Wuk and Lee [9] have published classification approach using HMM. Features are extracted from orientation field by locating the direction of the extracted ridge which is then taken as input for HMM for designing fingerprint models.

4.2 ORIENTATION MAP

Orientation map is also an important phase in image mapping. It describes the orientation of the ridge-valley structure in an image.

Fig. 4. Smoothed Orientation Field [6]

Jiao Jiao Hu, Mei Xie has introduced a classification technique using genetic algorithm and neural network. Orientation field is given as input to genetic programming process. Extracted features are given as input to neural network algorithm like back propagation and Support Vector Machine (SVM) for classification.

4.3 CORE AND DELTA POINTS

In fingerprint image mainly loops and whorls points are classified. These points are also called as core and delta. The delta is that point on a ridge front of and near to the center of the divergence of the type lines. The core is present when there is at least one ridge that enters from one side and then curves back, leaving the fingerprint on the same side as shown in figure 5.

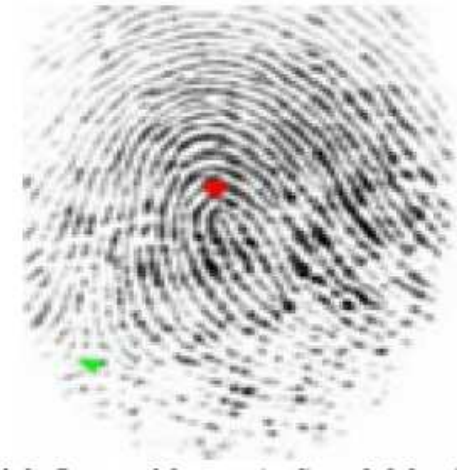

Fig. 5. Right Loop with core (red) and delta (green) [6]

M.Usman, Assia Khanam has suggested way of locating core point form the region of interest. Msizia and Ntsika have preprocessed image and a novel way of locating core and delta points.

4.4 REMOVAL OF SPURIOUS SINGULAR POINTS

Accuracy of a system increases if singular points are reduced, if the image is of poor quality as shown in figure 6.

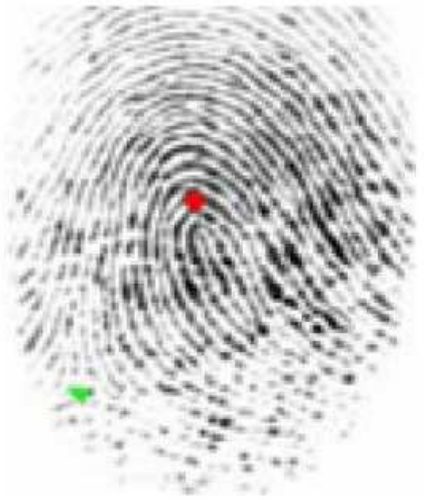

Fig. 6. Spurious Singular Points (yellow) [6]

N.Johal et al. presents an algorithm to tune orientation map by finding the direction of gravity. Blocks are found whose slope is in the range of 0 to pi/2 to obtain singular points.

4.5 TRANSFORMS

In Fourier Transform the basis function is sine wave whereas wavelet transform is based on small waves called wavelets of different frequency. Fourier Transform gives only frequency information, where time information is lost in transformation process. M.Mokji et.al has used Haar Wavelet transform (HWT) is used for directional image. H.Neto et.al has proposed Discrete Wavelet Transform (DWT), which is used to feature extraction and neural network does the classification process. Different classification techniques have been proposed by several authors in the field of Artificial Neural Networks. ANN is used to give higher accuracy and learning rate. It is basically used for classification purpose in image processing. The fingerprints have been traditionally classified into categories based on information in the global patterns of ridges. Classifying fingerprints into groups reduces the need to matching an input fingerprint with an entire fingerprint database during identification and recognition process and thus reduce computing requirements.

Two classifiers, namely, K Means and 3-nearest neighbor, were used to classifier the extracted features into four different fingerprint types, namely, Arch, Left Loop, Right Loop, or Whorl. The method achieved high classification accuracy and was quick in producing the results. Tan, X., Bhanu, B., Lin, Y, used a feature-learning algorithm using Genetic Programming (GP) to learn and features that are evolved in image processing operations for fingerprint classification. The primitive operators used were simple and easy to compute. These operators were separated into computation operators and feature generation operators. This classification method can be found to be effective over quality fingerprint images.

Maheswari and Chandra, presents fingerprint classification system using Fuzzy Artificial Neural Network. The fingerprint features like singular points, their positions and directions of core and delta points are obtained from a binarized fingerprint image captured from sensors. The method used for producing good classification results using fuzzy neural networks. An algorithm that used two machine learning algorithms was presented by. They used Support Vector Machine (SVM) and Recursive Neural Networks (RNNs) during classification. The RNNs are trained on a structured representation of the fingerprint image and were also used to extract a set of distributed features integrated in the SVMs. SVMs are

combined with a error correcting coding scheme, which exploits information contained in ambiguous fingerprint images. Kant and Nath presented an approach that improves the speed, efficiency of fingerprint matching algorithm during the time of enrollment itself. For this reason, the hard points of fingerprints like delta and core were used and the classifiers are grouped into any of the six other classes.

According to Wei L, singularities detection can be used to increase the accuracy of classification algorithms and proposed a method for searching singularities using delta field Poincare index. Used these singularities, a rapid rule-based classification algorithm was proposed to classify the fingerprint into 5 classes, arch, tented arch, left loop, right loop, whorl and double loop. The detection algorithm searches the direction field which has the larger direction changes to get the singularities. Wei , Yong hui and Fang has proposed a structure based approach which is based on curve features of ridgelines, used to classify the fingerprints with other fingerprint images available in database. The algorithm mainly uses the direction to classify the ridgelines in fingerprint. In this method, the classifier firstly calculates the total directional change of ridgelines; here they are grouped according to their shape. The grouped ridgelines along with the extracted singular points are used to classify the fingerprints into arch, tented arch, left loop, right loop, whorl and double loop classes.

Combining singular points and orientation image information for fingerprint classification was proposed by. Algorithm says that singular points and constrained nonlinear orientation features and the final feature vector comprised of the coefficients of the orientation model and the singularity information. This resulted in compact feature vector which is used as an input to a Support Vector Machine (SVM) classifier to perform the image classification. Maheswari and Chandra has used low dimensional features obtained from feedback based line detector to classify fingerprints into five classes (arch, left loop, right loop, whorl, and tented arch). The line detector was a cooperative dynamic system that gives oriented lines and preserves multiple orientations at points where differently oriented lines meet. The feature extraction was based on characterizing the distribution of orientations around the fingerprint.

Three types of classifiers are used namely, support vector machines, nearest neighbor classifier, and neural network. An algorithm that used two machine learning algorithms was presented by. They used Support Vector Machine (SVM) and Recursive Neural Networks (RNNs) during classification. The RNNs are trained on a structured representation of the fingerprint image and were also used to extract a set of distributed features integrated in the SVMs. SVMs are combined with an error correcting coding scheme, which exploits information contained in ambiguous fingerprint images.

5 CONCLUSIONS

We can say that fingerprint recognition is very reliable recognition system. It classified the fingerprints into five classes (arch, tented arch, left loop, right loop and whorl). Fingerprint recognition has various phases as image enrollment, preprocessing or enhancement, feature extraction and matching. The singular points are quite frequently features for classification. In a similar fashion, the rule based and neural network classifiers have been frequently used. Recently the use of SVM and machine learning classifiers has been proposed. Based on the overall survey we can say that Classification is normally based on the ridges, local feature (i.e. Minutiae) and global features (i.e. Singular points). The various methods and issues in fingerprint recognition are discussed in this paper. There is need of efficient method for fingerprint recognition system which will reduce computational time and increase efficiency.

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