Fingerprint Recognition using Minutiae Extraction

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Abstract: Fingerprints are a great source for identification of individuals. Fingerprint recognition is one of the oldest forms of biometric identification. However recognition of fingerprint is not always easy. The objective of this paper is to provide a way for fingerprint recognition using minutiae extraction. The factors relating to obtaining high performance feature point detection algorithm, such as image quality, segmentation, image enhancement and feature detection. Commonly used features for improving fingerprint image quality are Fourier spectrum energy, Gabor filter energy and local orientation. Accurate segmentation of fingerprint ridges from noisy background is necessary. For efficient enhancement and feature extraction algorithms, the segmented features must be void of any noise.

Keywords: Image Segmentation, Minutiae, fingerprint, CN.

I. Introduction

The quality of fingerprint images and extraction of minutiae have an important role in the performance of automatic identification and verification. In general, the minutiae extraction algorithm starts with a preprocessing for improving the quality of images without changing the local and global properties of the image. The fingerprint image can be characterize by the features as core and delta or as minutiae represent the end of ridge or the bifurcation .the methods based on minutiae are sensitive to this stage .Any missing minutiae or false minutiae can degrade the performance of the matching algorithm. In literature search we found many techniques for enhancement, Hong et al proposed an effective method based on Gabor filters]. Gabor filters have both frequency ridge and orientation ridge properties; the frequency ridge depends on orientation ridges. Chikkerur et al proposed an efficient implementation of contextual filtering based on short-time Fourier transform (STFT) that requires partitioning the image into small overlapping blocks and performing Fourier analysis separately on each block. The orientation, frequency and mask region of image are all simultaneously estimated [1].The several approaches to automatic minutiae extraction are two categories techniques, there are different from one other. The most of these methods transform fingerprint images into binary images, the images obtained are submitted to a thinning process which allows for the ridge line thickness to be reduced to one pixel finally, a simple image scan allows for locating the pixels that correspond to minutiae. On the other hand, other techniques are based on ridge line, where the minutiae are extracted directly from gray images.

What is a fingerprint?

Fingerprints are the patterns formed on the epidermis of the fingertip. The fingerprints are of three types: arch, loop and whorl. The fingerprint is composed of ridges and

valleys. The interleaved pattern of ridges and valleys are the most evident structural characteristic of a fingerprint. There are three main fingerprint features
a) Global Ridge Pattern
b) Local Ridge Detail
c) Intra Ridge Detail

Global ridge detail:
There are two types of ridge flows: the pseudo-parallel ridge flows and high-curvature ridge flows which are located around the core point and/or delta point(s). This representation relies on the ridge structure, global landmarks and ridge pattern characteristics.
The commonly used global fingerprint features are:
(i) Singular points – They are discontinuities in the orientation field. There are two types of singular points- core and delta. A core is the uppermost of a curving ridge, and a delta point is the point where three ridge flows meet. They are used for fingerprint registration and classification.
(ii) Ridge orientation map – They are local direction of the ridge-valley structure. It is helpful in classification, image enhancement, and feature verification and filtering.
(iii) Ridge frequency map – They are the reciprocal of the ridge distance in the direction perpendicular to local ridge orientation. It is used for filtering of fingerprint images.

Local Ridge Detail:
This is the most widely used and studied fingerprint representation. Local ridge details are the discontinuities of local ridge structure referred to as minutiae. They are used by forensic experts to match two fingerprints. There are about 150 different types of minutiae. Among these minutiae types, ridge ending and ridge bifurcation are the most commonly used as all the other types of minutiae are combinations of ridge endings and ridge bifurcations.

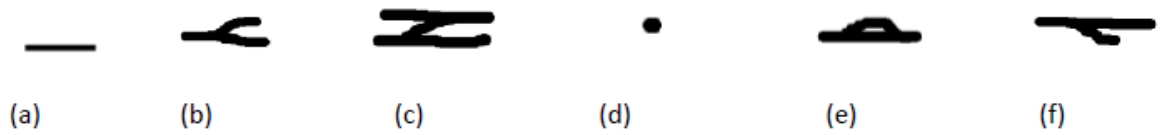

Fig. 1 Types of minutiae

The minutiae are relatively stable and robust to contrast, image resolutions, and global distortion when compared to other representations. Although most of the automatic fingerprint recognition systems are designed to use minutiae as their fingerprint representations, the location information and the direction of a minutia point alone are not sufficient for achieving high performance. Minutiae-derived secondary features are used as the relative distance and radial angle are invariant with respect to the rotation and translation of the fingerprint.

Intra Ridge Detail
On every ridge of the finger epidermis, there are many tiny sweat pores and other permanent details. Pores are distinctive in terms of their number, position, and shape. However, extracting pores is feasible only in high-resolution fingerprint images and with very high image quality. Thus the cost is very high. Therefore, this

kind of representation is not adopted by current automatic fingerprint identification systems (AFIS).

Fingerprint recognition

Fingerprint recognition is one of the popular biometric techniques. It refers to the automated method of verifying a match between two fingerprint images. It is mainly used in the identification of a person and in criminal investigations. It is formed by the ridge pattern of the finger. Discontinuities in the ridge pattern are used for identification. These discontinuities are known as minutiae. For minutiae extraction type, orientation and location of minutiae are extracted.

Two features of minutiae are used for identification: termination and bifurcation.

(a) Ridge ending (b) Bifurcation

Fig .2 Types of local ridge features

The advantages of fingerprint recognition system are

(a) They are highly universal as majority of the population have legible fingerprints.
(b) They are very reliable as no two people (even twins) have same fingerprint.
(c) Fingerprints are formed in the fetal stage and remain structurally unchanged throughout life.
(d) It is one of the most accurate forms of biometrics available.
(e) Fingerprint acquisition is non intrusive and hence is a good option.

Approach

There are two approaches for fingerprint recognition. They are image based approach, texture based approach and minutiae based approach.

In image based matching, the image itself is used as the template. It requires only low resolution images. Matching is done by optical correlation and is extremely fast. It is based on the global features of a whole fingerprint image. However it requires accurate alignment of the fingerprint samples and is not favorable for changes in scale, orientation and position.

The second is the texture based approach. It uses texture information for matching and performs well with poor quality prints. However like image based matching it requires accurate alignment of the two prints and not invariant to translation, orientation and non-linear distortion.

Minutiae-based approach is the last approach. Here the ridge features called minutiae are extracted and stored in a template for matching. It is invariant to translation, rotation and scale changes. It is however error prone in low quality images.

The minutiae based approach is applied. Usually before minutiae extraction, image preprocessing is performed. In our paper we have focused mainly on the preprocessing and extraction stage. Fingerprint enhancements techniques are used to reduce the noise and improve the clarity of ridges against valleys.

The image preprocessing consists of the following stages. They are field orientation, ridge frequency estimation, image segmentation and image enhancement thinning. It is followed by a minutiae extraction algorithm which extracts the main minutiae features required for matching of two samples.

II. Minutiae Extraction

This method extracts the ridge endings and bifurcations from the skeleton image by examining the local neighborhood of each ridge pixel using a 3×3 window. The method used for minutiae extraction is the crossing number (CN) method. This method involves the use of the skeleton image where the ridge flow pattern is eight-connected. The minutiae are extracted by scanning the local neighborhood of each ridge pixel in the image using a 3×3 window. CN is defined as half the sum of the differences between the pairs of adjacent pixel. The ridge pixel can be divided into bifurcation, ridge ending and non-minutiae point based on it. A ridge ending point has only one neighbor, a bifurcation point possesses more than two neighbors, and a normal ridge pixel has two neighbors. A CN value of zero refers to an isolated point, value of one to a ridge ending, two to a continuing ridge point, three to a bifurcation point and a CN of four means a crossing point. Minutiae detection in a fingerprint skeleton is implemented by scanning thinned fingerprint and counting the crossing number. Thus the minutiae points can be extracted. A 3×3 window is used. The CN is given by

$$CN = 0.5 \sum_{i=1}^{8} (P_i - P_{i+1})$$

For a pixel i, the eight pixels are scanned in an anti-clockwise direction. The pixel can be classified after obtaining its pixel value. The coordinates, orientation of the ridge segment and type of minutiae of each minutiae point is recorded for each minutiae.
After a successful extraction of minutiae, they are stored in a template, which may contain the minutia position (x,y), minutia direction (angle), minutia type (bifurcation or termination), and in some case the minutia quality may be considered. During the enrollment the extracted template are stored in the database and will be used in the matching process as reference template or database template. During the verification or identification, the extracted minutiae are also stored in a template and are used as query template during the matching.

Fig. 3 Original Image

Fig. 4 Image after thinning

Fig.5 Minutiae Extraction

Fig.6 Minutiae Extraction and Zooming

III. Conclusion

Our proposed method provides best way for fingerprint recognition by minutiae extraction and zooming. It also provides excellent accuracy.

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