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Finger Print Image Recognition-A Review

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Abstract

Fingerprint recognition is one of the most well-known and publicized biometrics. Because of finger print uniqueness and consistency over time, fingerprints have been used for identification for more than a century. Though Many systems with minutiae extractor and minutiae matcher are available for minutiae extraction and matching ,it is very difficult to mark all the minutiae accurately as well as rejecting false minutiae because of the presence of noise in fingerprints. . In practise, it is usually difficult to take a good quality fingerprint image, as these may be degraded and corrupted with noise due to many factors including variations in skin and impression conditions. This degradation can result in a significant number of spurious minutiae being created and genuine minutiae being ignored. *I*mage enhancement techniques are employed prior to minutiae extraction to obtain a more reliable estimate of minutiae locations. In recent years, some new methods have been introduced to the finger print image recognition system to recognize finger print images in order to get better results . In this paper, Finger Print Image recognition and a methods used for minutiae extraction and matching , pros and cons of this method are discussed.

Keywords: *Image Recognition , finger print, Minutiae, pixel features , Crossing number, Biometrics*

1. INTRODUCTION

Biometric identification using fingerprints matching have been used for last many years and are most widely used form of biometric identification. Despite this widespread use of fingerprints, there has been little statistical work done on the uniqueness of fingerprint minutiae. More specifically, identifying the characteristics of minutiae in fingerprint is a critical task and is thus an active area of research. In Biometric applications , Finger print images are used to identify an individual and verify their identity.A fingerprint image is a pattern which consists of two regions, foreground and background. The foreground contains all important information needed in the automatic fingerprint recognition systems. However, the background is a noisy region that contributes to the extraction of false minutiae in the system. To avoid the extraction of false minutiae, there are many steps which should be followed such as preprocessing and enhancement. One of these steps is fingerprint segmentation.

Fingerprint segmentation is the process by which the foreground is separated from the image background. The result of fingerprint segmentation is a fingerprint image in which the background is removed .

The aim for fingerprint segmentation is to separate the foreground from the background. Due to the nature and the poor quality of fingerprint image, the finger print segmentation becomes an important and challenging task. Fingerprint segmentation is an important step in the automatic fingerprint recognition systems because it improves the fingerprint images so that features can be extracted from these images by the automatic fingerprint recognition systems.

2. FINGER PRINT IMAGE AND MINUTIAE

A fingerprint image is a pattern which consists of two regions, foreground and background. The foreground contains all important information needed in the automatic fingerprint recognition systems. In general, the fingerprint of an individual is unique and is formed from an impression of the pattern of ridges on a finger. A ridge can be defined as a single curved segment, and a valley is the region between two adjacent ridge. The term minutiae refer to the local discontinuities in the ridge flow pattern and provide the features that can be used for biometric identification. The characteristics such as orientation and location of minutiae are usually taken into account when performing fingerprint matching. A typical example of fingerprint, ridges, valleys and minutia is shown in Fig 1 below.

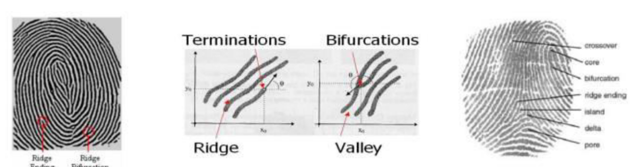


FIG 1

3. FINGER PRINT RECOGNITION

Fingerprint recognition is the process of comparing a fingerprint against another fingerprint to determine if the impressions are from the same finger. It is very difficult to mark all the minutiae accurately as well as rejecting false minutiae because of the presence of noise in fingerprints.

Fingerprint recognition systems consist of the following parts :

1.Sensing or Image acquisition
2.Pre-processing
3.Feature or minutiae extraction
4.Matching

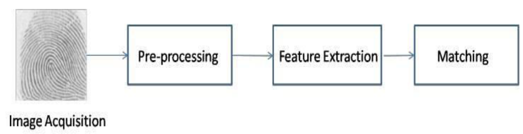


Figure 2. Fingerprint Recognition System

Sensing or Image Acquisition

The acquisition of a fingerprint images was accomplished by using off-line sensing or live-scan. Off-line sensing is defined as ink-technique. Live-scan scanners become presently more frequent, because of its simplicity in usage. There is no need for ink. The digital image is directly acquired by pressing against the surface of the scanner.

Pre-processing

To simplify the task of minutiae extraction and make it more easy and reliable, some preprocessing techniques are applied to the raw input image. Enhancement and segmentation of the fingerprint are the most commonly methods performed in the preprocessing step.

Feature extraction

After preprocessing step, the segmented and enhanced fingerprint is further processed to identify the main and distinctive minutiae. Most of the minutiae extraction methods necessitate the fingerprint gray-scale image to be transformed into a binary image. The acquired binary image is forwarded to a thinning stage to reduce the thickness of the ridge to one pixel ridge. Afterwards, the minutiae are simply detected by a simple image scan.

Matching

Algorithms that extract important and efficient minutiae, will improve the performance of the fingerprint matching techniques. The features extracted of the input image are compared to one or more template that was previously stored in the system database. Therefore the system returns either a degree of similarity in case of identification or a binary decision in case of verification.

4. Minutiae Marking and Extraction :

To mark and extract the minutia, the key steps are as follows:

Fingerprint Ridge Thinning: Ridge Thinning is done to eliminate the redundant pixels of ridges till the ridges are just one pixel wide. This is done using the morphological thinning function. bwmorph(binaryImage,'thin',Inf). The thinned image is then filtered, again using three morphological functions to remove some H breaks, isolated points and spikes using the bwmorph(binaryImage, 'hbreak', k); bwmorph(binaryImage, 'clean', k) and bwmorph(binaryImage, 'spur', k).

Minutiae Marking: After the fingerprint ridge thinning, the next step is to mark minutia points. This can be done in three ways: 1) for each 3x3 window, if the central pixel is 1 and has exactly 3 one-value neighbors, then the central pixel is a ridge branch (Figure 7a). If the central pixel is 1 and has only 1 one-value neighbor, then the central pixel is a ridge ending Suppose both the uppermost pixel with value 1 and the rightmost pixel with value 1 have another neighbor outside the 3x3 window, so the two pixels will also be marked as branches.

False Minutiae Removal: This stage focuses on removing any false minutia, e. g., any false ridge breaks due to noise. For this purpose, the average inter-ridge width D is estimated at this stage. The average inter-ridge width refers to the average distance between two neighboring ridges and for each row it is given by:

Inter ridge distance = sum all pixels with value 1 / row length

Finally an averaged value over all rows gives D. Then, all the thinned ridges in the fingerprint image are labeled with a unique ID for further operation using morphological operation BWLABEL. Seven types of false minutia are specified in this paper as described in Table 1. For better results, this paper considers all the seven cases unlike the other similar works done. The minutiae and after removing false minutiae for the above two finger print images is shown in Figure 3.

TYPE	DESCRIPTION
m1	A spike piercing into a valley.
m2	A spike falsely connects two Ridges.
m3	Two near bifurcations located in The same ridge
m4	The two ridge broken points have nearly

	the same orientation and a short distance.
m5	This is alike the m4 case with the Exception that one part ofvthe broken ridge is so short that another termination is generated.
m6	This case extends the m4 case But with the extra property that a third ridge is found in the middle of the two parts of the broken roidge.
m7	Only one short ridge found in the threshold window

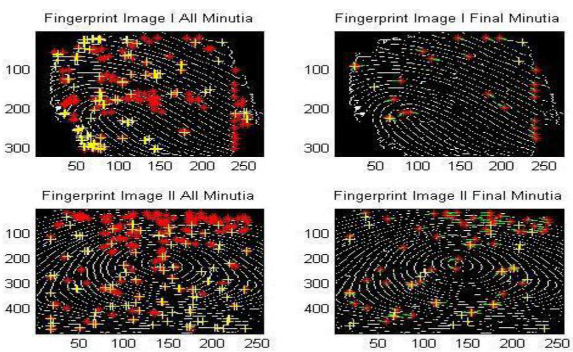


Fig 3

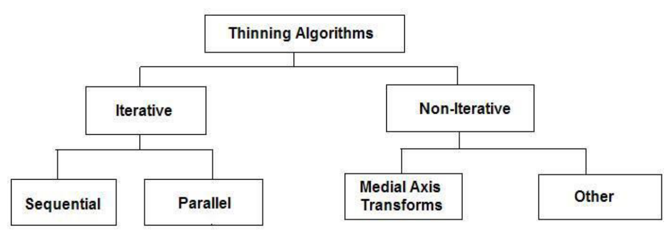
MINUTIAE MATCHING

After minutiae extraction for the two fingerprint images, the next step is to match the Minutiae. For this purpose, an elastic string based iterative ridge alignment algorithm is used. In this algorithm first the minutiae's of two fingerprints are aligned and then the percentage of the matched minutia pairs is computed. In the alignment stage, the two fingerprint images to be matched are taken and any one minutia from each image is chosen. Then the similarity of the two ridges associated with the two referenced minutia points are calculated using the standard cross-correlation formula. If the similarity is larger than a threshold (0.8 chosen in current paper, as maximum is 1), each set of the minutia is transformed to a new coordination system whose origin is at the referenced point and x-axis is coincident with the direction of the referenced point. To better understand, let M (x, y, θ) be the reference minutia (say from I_1). Then for each fingerprint, all other minutiae (x_i, y_i, θ_i) is translated and rotated with respect to the M . The above implementation was an effort to understand how Fingerprint Recognition is used as a form of biometric to recognize identities of human beings. It includes all the stages from minutiae extraction from fingerprints to minutiae matching which generates a match score. Various standard techniques are used in the intermediate stages of processing.It is implemented for two different fingerprints shown above in this paper and the percentage of matching of minutia is computed. For the two finger prints the percentage match obtained is 34.6154%, which when matched with a threshold limit (say 90%) can say that the two fingerprints matches or not. As the % match obtained is less than the threshold so the finger prints do not match which is correct.

5. THINNING

Thinning is a process of extracting a skeleton from an object in a digital image. A skeleton of an image can be thought of as a one-pixel thick line through the middle of an object which preserves the topology of that object. Thinning is a fundamental preprocessing step in many image processing and pattern recognition algorithms . Thinned images (skeletons) are easier to process and they reduce processing time for the subsequent operations. Many thinning algorithms have been developed in the past three decades. Two major approaches of thinning digital patterns can be categorized into iterative boundary removal algorithms and non-iterative distance transformation algorithms .

Iterative boundary removal algorithms delete pixels on the boundary of a pattern repeatedly until only unit pixel-width thinned image remains. Non-iterative distance transformation algorithms are not appropriate for general applications since they are not robust, especially for patterns with highly variable stroke directions and thicknesses. Thinning based on iterative boundary removal can be divided into sequential and parallel algorithms .



In sequential algorithms, the pixels are examined for deletion in a fixed sequence in each iteration, and the deletion of pixel p in the n^{th} iteration depends on all operations

performed so far, i.e. on the results of $(n_{th}\ 1)^{th}$ iteration; as well as on the current pixel in the n iteration. In a parallel algorithm,the deletion of pixels in the n^{th} iteration depends only in the results of the n^{th} iteration; therefore, all pixels are examined independently in the parallel manner in each iteration The behavior of a thinning algorithm is determined by its structuring element. Structuring elements are policies which define the situations at which foreground pixels will be set to background and hence deleted. Thinning is used in but not limited to applications that process handwritten and printed characters, fingerprints and palm prints, chromosomes and biological cell structures, and circuit diagrams.

Generally, fingerprint recognition systems work by matching minutiae extracted from probe data, to reference minutiae and it consists of the following stages: fingerprint acquisition, image pre-processing (fingerprint segmentation, enhancement, and orientation field estimation), fingerprint classification, minutiae detection and matching . Fingerprint thinning is an important image enhancement processing step in an Automatic Fingerprint Identification System (AFIS). It plays an equally significant role with fingerprint classification and enhancement in practical AFIS. It can significantly improve the recognition performance of an AFIS. Binary image thinning has been studied extensively in literature. While some researchers have developed sequential algorithms , the main focus is in parallel thinning algorithms, which are efficient and fast. Raju and Xu in their study of parallel thinning algorithms compared Zhang-Suen, Guo-Hall and One Pass Thinning Algorithm (OPTA) for character recognition. They found that Guo-Hall outperformed the two other algorithms in terms of skeleton quality. While OPTA is faster than the other two algorithms, its skeleton quality is not as good compared to those of the other two algorithms. Gupta and Kaur compared Zhang-Suen, Abdulla et al and a multipass iterative boundary removal algorithm based on. They found that the mutlipass algorithm produced better results than Zhang-Suen and Adbulla et al with regards to connectivity and spurious branches of numerical patterns.

6. CONCLUSIONS

Minutiae Extraction and matching heavily influences the performance of fingerprint recognition system. In recent years, some new methods have been introduced to the minutiae extraction and matching in order to get better disposal results. Thinning plays a very important role in the prepro-cessing phase of automatic fingerprint recognition/identification systems. The performance of minutiae extraction relies heavily on the quality of skeletons used. A good fingerprint thinning algorithm can depress image noise and promote the robustness of the minutiae extraction algorithm which helps improve the overall performance of the system. Many thinning algorithms have been devised and applied to a wide range of applications including, Optical Character Recognition (OCR), biological cell structures and fingerprint patterns.Choosing both minutiae extraction and thinning algorithms for a particular application is very difficult. All minutiae extraction and thinning algorithms are not suitable for all applications. Appropriate algorithm for particular application must be chosen.

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