International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Impact Factor (2012): 3.358

A Survey Based on Fingerprint Recognition - Minutiae

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Abstract: ***Fingerprints are the most common authentic biometrics for personal identification, especially for forensic security. A minutiae matching is widely used for fingerprint recognition and can be classified as ridge ending and ridge bifurcation. For Fingerprint thinning, the block filter is used, which scans the image at the boundary to preserves the quality of the image and extract the minutiae from the thinned image. FPR provides reliable and better performance than the existing technique. The False Matching Rate (FMR) is better compared to the existing algorithm. Usually a technique called minutiae matching is used to be able to handle automatic fingerprint recognition with a computer system***

Keywords: ***Fingerprint Recognition, Block Filter Method, Minutiae extraction, False Matching Ratio (FMR), False Non Matching Ratio (FNMR)***

1. Introduction

A. What is Biometric?

Biometric is the science of establishing the identity of an individual based on the physical, chemical or behavioral attributes of the person. Human have used fingerprints for personal identification for many decades. A fingerprint is the pattern of ridges and valleys on the surfaces of a fingertip whose formation is determined during the first seven months of fetal development. Automatic fingerprint recognition technology has now rapidly grown beyond forensic applications and into civilian applications. Now a days, most civil and criminal AFISs accept live-scan digital images acquired by directly sensing the finger surface with and electronic fingerprint scanner. No ink is required in this method, and all that a subject has to do is to press his/her finger against the flat surface of a live-scan scanner.

B. What is Fingerprint Recognition?

A fingerprint is the representation of the epidermis of a finger it consists of a pattern of inter-leaved ridges and valleys. At the local level, other important features, called minutiae can be found in the fingerprint patterns. Minutiae refers to the various ways in which the ridges can be discontinuous. For example, a ridge can abruptly come to an end (termination), or can divide into two ridges (bifurcation). A good quality fingerprint contains 25 to 80 minutiae depending on sensor resolution and finger placement on the sensor. The false minutiae are the false ridge breaks due to insufficient amount of ink and cross-connections due to over inking. It is difficult to extract reliably minutiae from poor quality fingerprint impressions arising from very dry fingers and fingers mutilated by scars, scratches due to accidents, injuries. Minutiae based fingerprint recognition consists of thinning, minutiae extraction, minutiae matching and computing minutiae score.

C. Techniques for Fingerprint Recognition - Following are some of the Techniques:

1. **Minutiae Extraction based Technique** - Mostly accepted finger scan technology is based on minutiae. Minutiae based techniques produce the fingerprint by its local features, like termination and bifurcation when minutiae points match between two fingerprints, so fingerprints are match. This approach has been genuinely studied, and it is the backbone of the current available fingerprint recognition products.
2. **Pattern Matching or Ridge Feature based Technique** - Feature extraction are established on series of ridges as averse to different points which design the basis of pattern matching techniques over minutiae extraction. Minutiae points can be change by wear and tear and the main drawback are that these are acute to proper adjustment of finger and need large storage for templates.
3. **Correlation based Technique** - Correlation based technique is used to match two fingerprints, the fingerprint are adjusted and computed the correlation for each corresponding pixel. They can match ridge shapes, breaks etc. Main disadvantages of this method are its computational complication and less tolerance to non-linear distortion and contrast variation.
4. **Image based Technique** - This technique attempt to do matching which based on the global features of an all fingerprint images.

2. Survey Based on Different Techniques

Many authors and researchers used various types of techniques for fingerprint Recognition

G. Sambasiva Rao, C. NagaRaju, L. S. S. Reddy and E. V. Prasad, [1] proposed fingerprint identification technique using a gray level watershed method to find out the ridge present on a fingerprint image by directly scanned fingerprints or inked impression. Jinwei Gu, Jie Zhou, and Chunyu Yang, [2] proposed a method for fingerprint

verification which includes both minutiae and model based orientation field is used. It gives robust discriminatory information other than minutiae points. Fingerprint matching is done by combining the decisions of the matchers based on the orientation field and minutiae.

Robert Hastings, [3] developed a method for enhancing the ridge pattern by using process of oriented diffusion by adaptation of anisotropic diffusion to smooth the image in the direction parallel to the ridge flow. The image intensity varies smoothly as one traverse along the ridges or valleys by removing most of the small irregularities and breaks but with the identity of the individual ridges and valleys preserved. V.Vijaya Kumari and N.Suriyanarayanan, [4] proposed a method for performance measure of local operators in fingerprint by detecting the edges of fingerprint by detecting the edges of fingerprint images using five local operators namely Sobel, Roberts, Prewitl, Canny and LoG. The edge detected image is further segmented to extract individual segments from the image.

Raju Sonavane and B. S. Sawant, [5] presented a method by introducing a special domain fingerprint enhancement method which decomposes the fingerprint image into a set of filtered images then orientation field is estimated. A quality mask distinguishes the recoverable and unrecoverable corrupted regions in the input images are generated using the estimated orientation field, the input fingerprint image is adaptively enhanced in the recoverable regions. M. R. Girgisa, A. A. Sewisyb and R. F. Mansourc, [6] proposed a method to describe a fingerprint matching based on lines extraction and graph matching principles by adapting a hybrid scheme which consists of a genetic algorithm phase and a local search phase. Experimental results demonstrate the robustness of algorithm.

Eric P. Kukula, Christine R. Blomeke, Shimon K. Modi, and Tephen J. Elliott, [7] proposed a method to investigate the effect of five different force levels on fingerprint matching performance, image quality scores, and minutiae count between optical and capacitance fingerprint sensors. Three images were collected from the right index fingers of 75 participants for each sensing technology. The results reveal a significant difference in image quality score based on the force level and each sensor technology, yet there is no significant difference in minutiae count based on the force level of the capacitance sensor. The image quality score, shown to be effected by force and sensor type is one of many factors that influence the system matching performance, yet the removal of low quality images does not improve the system performance at each force level.

Luping Ji, Zhang Yi, [8] proposed a method for estimating four direction orientation field by considering four steps, (i) Preprocessing fingerprint image, (ii) determining the primary ridge of fingerprint block using neuron pulse coupled neural network, (iii) estimating block direction by projective distance variance of a ridge, instead of a full block, (iv) correcting the estimated orientation field. Duresuoquian Miao, Qingshi Tang, and Wenjie Fu, [9] used principal graph algorithm by kegl to obtain principal curves for auto fingerprint identification system. From principal curves, minutiae extraction algorithm is used to extract the minutiae of the fingerprint. The experimental results shows curves obtained from graph algorithm are smoother than the thinning algorithm.

Xifeng Tong, Songbo Liu,Jianhua Huang, and Xianglong Tang, [10] proposed a method to overcome non linear distortion using Local Relative Error Descriptor (LRLED). The algorithm consist of three steps (i) a pair wise alignment method to achieve fingerprint alignment, (ii) a method minutiae pair set is obtained with a threshold to reduce non-matches finally, (iii) the LRLED based similarity measure. LRLED is good at distinguishing between corresponding and non corresponding minutiae pairs and works well for fingerprint minutiae matching. Alessandra Lumini, and Loris Nann, [11] developed a method for minutiae based fingerprint and its approach to the problem as two - class pattern recognition. The obtained feature vector by minutiae matching is classified into genuine or imposter by support vector machine resulting remarkable performance improvement.

L. Lam S W Lee, and C Y Suen, [12] presented a method, thinning is the process of reducing thickness of each line of patterns to just a single pixel width. The requirements of a good algorithm with respect to a fingerprint are i) the thinned fingerprint image obtained should be of single pixel width with no discontinuities ii) Each ridge should be thinned to this central pixel iii) noise and singular pixel should be eliminated iv) no further removal of pixel should be possible after completion of thinning process. Mohamed. S. M and Nyongesa.H, [13] presented fingerprint classification system using Fuzzy neural network. The fingerprint features such as singular points, positions and direction of core and delta obtained from a binarised fingerprint image. This method is producing good classification results.

Ching-Tang Hsieh and Chia-Shing –u, [14] has developed anoid method for fingerprint recognition. Ridge bifurcation are used as minutiae and ridge bifurcation algorithm with excluding the noise like points are proposed. Experimental results show the humanoid fingerprint recognition is robust, reliable and rapid. Liu Wei, [15] proposed method for rapid singularities searching algorithm which uses delta field Poincare index and a rapid classification algorithm to classify the fingerprint in to 5 classes. The detection algorithm searches the direction field which has the larger direction changes to get the singularities. Singularities detection is used to increase the accuracy.

Hartwing Fronthaler, Klaus kollreider, and Josef Bigun, [16] proposed fingerprint enhancement to improve the matching performance and computational efficiency by using an image scale pyramid and directional filtering in the spatial domain. Mana Tarjoman, and Shaghayegh Zarei, [17] introduced structural approach to fingerprint classifications by using the directional image of fingerprint instead of singularities. Directional image includes dominant direction of ridge lines. Bhupesh Gour, T. K. Bandopadhyaya and Sudhir Sharma, [18] have developed a method for extraction of minutiae from fingerprint images using midpoint ridge contour representation. The first step is segmentation to separate foreground from background of fingerprint image.

The grayscale intensities in 64x64 regions are normalized to a constant mean and variance to remove the effects of sensor noise and grayscale variations due to finger pressure differences. After the normalization the contrast of the ridges are enhanced by filtering 64x64 normalized windows by appropriately tuned Gabor filter. Processed fingerprint image is then scanned from top to bottom and left to right and transition from white (background) to black (foreground) are detected. The proposed method takes less and do not detect any false minutiae.

Unsang Parh, Sharath Pankanti, and A. K. Jain, [19] proposed Scale Invariant Feature Transformation (SIFT) to represent and match the fingerprint. By extracting characteristic SIFT feature points in scale space and perform matching based on the texture information around the feature points. The combination of SIFT and conventional minutiae based system achieves significantly better performance than either of the individual schemes. Manvjeet Kaur, Mukhwinder Singh, Akshay Girdhar and Parvinder S. Sandhu, [20] have introduced combined methods to build a minutiae extractor and a minutiae matcher. Segmentation with Morphological operations used to improve thinning, false minutiae removal, minutiae marking.

3. Model

A. Definitions

1. Fingerprint: Impression of a finger acquired from digital scanners.
2. Minutiae: Ridge bifurcations and ridge ending in fingerprint image.
3. Core: Centre of the loop or pattern in fingerprint image. It is located where the innermost recurve begins and curve to exit the same way they came in.
4. Delta: It is the area of pattern where there is a triangulation or a dividing of ridges.
5. Loop : The fingerprint image contains only one delta
6. Whorl: The fingerprint image contains 2 or more deltas.
7. Sensitivity: The ability of the algorithm to detect the true minutiae and is represented as 1 – missed minutiae / ground truth number minutiae.
8. Specificity: The ability of the algorithm to reject false minutiae and is represented as 1 – false minutiae / ground truth number minutiae.
9. Spurious Minutiae: It is the type of error that falsely identifies a noisy ridge structure as minutiae.
10. Missed Minutiae: It is the type of error that occurs in failing to detect the existing minutiae when it is obscured by surrounding noise, scars or poor ridge structures.
11. False Minutiae: Points which have been incorrectly identified as minutiae.

False Matching Ratio (FMR) : It is the probability that the system will decide to allow access to an imposter is given in an equation (1)

$$FMR = \frac{\text{False Matches}}{\text{Im poster Attempts}} \quad (1)$$

The imposter attempts are implemented by matching each input image with all the template images. False match was recorded for each imposter attempt when the matching score was greater than the established threshold.

False Non Matching Ratio (FNMR) : It is the probability that the system denies access to an approved user is given in an equation (2)

$$FNMR = \frac{\text{False Non Matches}}{\text{EnrolleAttempts}} \quad (2)$$

Enrollee attempts are implemented by matching each input image with corresponding template image, hence it is one-to-one matching. A False Non-match was recorded when the matching score between an enrollee and its template was less than the established threshold.

Matching Score : It is used to calculate the matching score between the input and template data is given an equation (3)

$$\text{Matching score} = \frac{\text{Matching Minutiae}}{\text{Max(NT, NI)}} \quad (3)$$

Where NT and NI represent the total number of minutiae in the template and input matrices respectively. By this definition, the matching score takes on a value between 0 and 1. Matching score of 1 and 0 indicates that data matches perfectly and data is completely mismatched respectively.

B. FPR

Figure 1 gives the block diagram of FPR which is used to match the test fingerprint with the template database using Minutia Matching Score.

Fingerprint Image: The input fingerprint image is the gray scale image of a person, which has intensity values ranging from 0 to 255. In a fingerprint image, the ridges appear as dark lines while the valleys are the light areas between the ridges. Minutiae points are the locations where a ridge becomes discontinuous. A ridge can either come to an end, which is called as termination or it can split into two ridges, which is called as bifurcation. The two minutiae types of terminations and bifurcations are of more interest for further processes compared to other features of a fingerprint image.

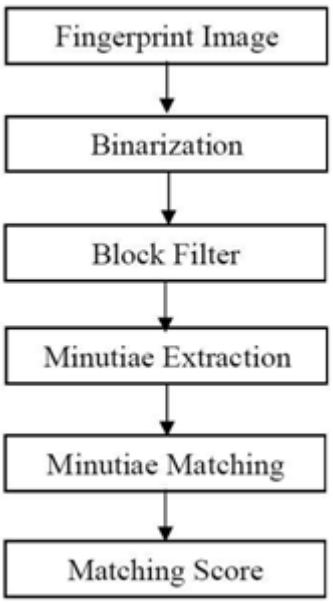

Figure 1: Block Diagram of FPR.

Binarization: The pre-processing of FPR uses Binarization to convert gray scale image into binary image by fixing the threshold value. The pixel values above and below the

threshold are set to '1' and '0' respectively.

Block Filter: The binarized image is thinned using Block Filter to reduce the thickness of all ridge lines to a single pixel width to extract minutiae points effectively. Thinning does not change the location and orientation of minutiae points compared to original fingerprint which ensures accurate estimation of minutiae points. Thinning preserves outermost pixels by placing white pixels at the boundary of the image, as a result first five and last five rows, first five and last five columns are assigned value of one. Dilation and erosion are used to thin the ridges.

Minutiae Extraction: The minutiae location and the minutiae angles are derived after minutiae extraction. The terminations which lie at the outer boundaries are not considered as minutiae points, and Crossing Number is used to locate the minutiae points in fingerprint image. Crossing Number is defined as half of the sum of differences between intensity values of two adjacent pixels. If crossing Number is 1, 2 and 3 or greater than 3 then minutiae points are classified as Termination, Normal ridge and Bifurcation respectively

Minutiae Matching: To compare the input fingerprint data with the template data Minutiae matching is used. For efficient matching process, the extracted data is stored in the matrix format.

4. Conclusion

This paper, we presented Fingerprint matching using FPR. The processing the original fingerprint involves image binarization, ridge thinning, and noise removal. Fingerprint Recognition using Minutiae Score Matching method is used for matching the minutiae points. Usually a technique called minutiae matching is used to be able to handle automatic fingerprint recognition with a computer system.

5. Future Enhancement

We have presented a study covering different automatic fingerprint recognition techniques, presented by the experts in this field. Although may academic and commercial systems for fingerprint recognition exist, there is a necessity for further research in this topic in order to improve the reliability and performances of the current systems. Many unresolved problems still need to be explored and investigated. Thus future work for fingerprint matching lies in introducing new ridge features and better processing on low quality images.

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