

Survey on Fingerprint Recognition Using Minutiae Based Technique

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ABSTRACT: Fingerprint is a physiological characteristic which is one of the biometric recognition system. Fingerprint is unique and it will not change over time. It helps to identify people using the uniqueness of each one's fingerprint. This paper is a study based on the fingerprint recognition using Minutiae based matching techniques. The recognition processes is done in different steps like capturing the fingerprint image, enhancing it and then verify or identify it by matching the fingerprint with one's own self or with the different fingerprint images in the database.

KEYWORDS: Fingerprint Recognition, Biometric Recognition, Feature Extraction, Matching, Database

I. INTRODUCTION

Biometrics is an automated recognition of individuals based on their behavioural and biotic appearances. Recognition system has become popular in this era since it gives effective and a secured confirmation to a particular person. Fingerprint recognition is one among the most commonly used biometric recognition. Biometrics includes face, iris, fingerprints, voice, palms, hand geometry, retina, handwriting, gait etc. [3].

Fingerprints significance is its perpetuity and uniqueness throughout the life time. Finger print patterns offer more secure and consistent personal identification than passwords, id-cards or key can provide. Examples of such an application are computers and mobile phones equipped with fingerprint recognition devices. Fingerprint based password protection are being executed to replace fixed password defence methods.

Fingerprint recognition captures the digital image of the human fingerprint. Biometric recognition system uses the features which are unique for recognition and there is less availability of two humans having the same feature. Personal identification based on fingerprint recognition is one of the biometric systems with most reliable results [5]. Minutiae based technique is used for fingerprint verification. Minutiae pairs of two fingerprints are matched to get the matching score.

II. FINGERPRINT

A fingerprint is a feature of a finger with the strong evidences, it is believed that each fingerprint in this world is unique and so each person has a unique fingerprint with a permanent unique characteristic [11]



Fig 1: Fingerprint

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2.1 FINGERPRINT RECOGNITION

Fingerprint recognition is based on two steps: Fingerprint verification and Fingerprint Identification. Fingerprint verification is to match the fingerprints, this method is mainly used to verify a person's authenticity and it is a one-to-one matching process. Fingerprint identification is mainly used to check any one's identity with his/her fingerprint. This process is called one-to-many matching [9]

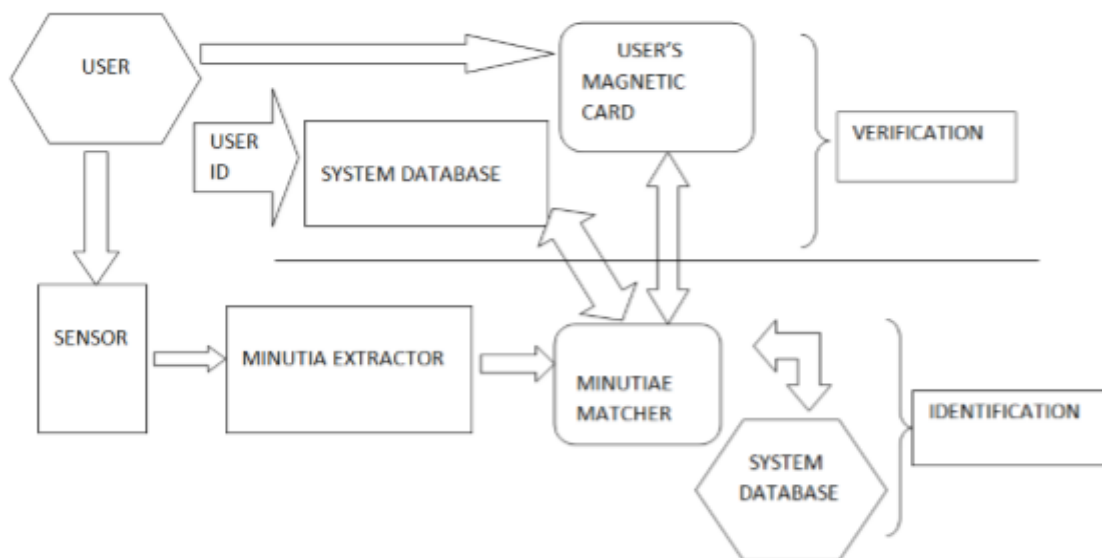


Fig 2 :Fingerprint Verification And Identification[11]

2.2 STEPS INVOLVED IN FINGERPRINT RECOGNITION

- a. **Fingerprint Acquisition:** Fingerprint scanner is used to read the fingerprint image and collect the data.



Fig3: Fingerprint Acquisition Using Fingerprint Scanner

- b. **Segmentation:** Segmentation separates the fingerprint image foreground from the background that is used to obtain a close segmentation curve.

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Fig 4: Segmentation[13]

- c. **Fingerprint Enhancement** is carried out to remove the noise from fingerprint image.

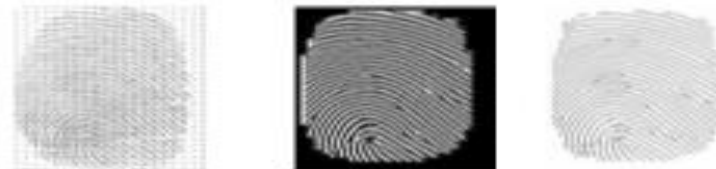


Fig 5:a)Original image b)Enhanced Image c)Noise removal image

- d. **Feature Extraction:** Feature extraction and template generation are based on series of ridges as opposed to discrete points which forms the basis for Pattern Matching Techniques.
- e. **Matching:** The two Fingerprint images are matched with the help of extracted local features depending upon the obtained matching score two finger prints are declared as matched or not matched [15]

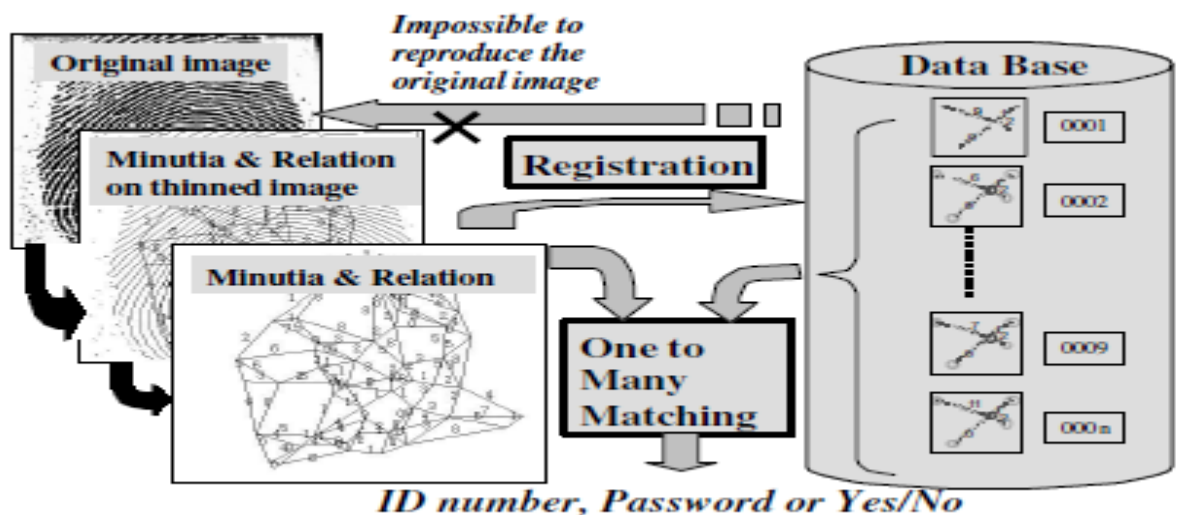


Fig 6: Feature extraction and Matching [9]

2.3 TECHNIQUES FOR FINGERPRINT RECOGNITION

Correlation-based Matching: Two fingerprint images are correlated between corresponding pixels, defines various displacements and rotation.

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Fig7: Matching Two Fingerprints in correlation based matching[2]

Minutia-based Matching: Finds the alignment between the template input minutia, sets results in a maximum number of minutia pairings.

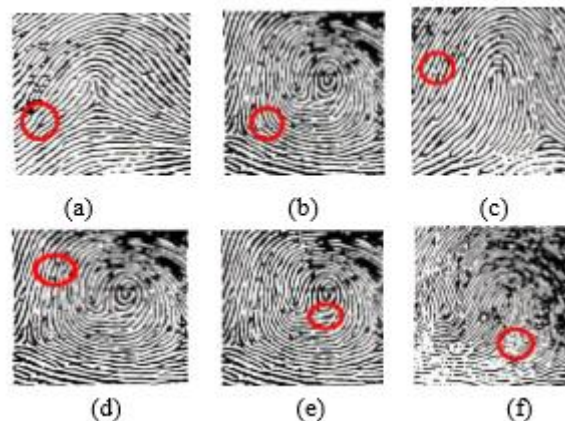


Fig8:Fingerprint Minutiae (a) Bifurcation (b) Spur (c) Ridge Ending (d) Bridge (e) Lake (f) Dot [9]

Pattern-based Matching: Compare the basic fingerprint patterns it means arch, whorl, loop are compared with template to determine the degree to which they match. [11]

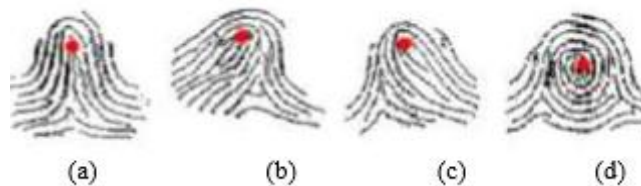


Fig9:a) arch b) right loop c) left loop d) whorl[9]

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III. LITERATURE REVIEW

Minutiae-based fingerprint verification system uses the Salil Prabhakar et al, [5] proposed the feedforward of the original grayscale image in the feature verification stage, this stage re-examines the minutia's spatial neighbourhood in the image. Feature classification stage assigns labels to each detected minutia (ridge ending and ridge bifurcation), matching accuracy is improved with the proposed minutiae verification stage. Feature vectors are extracted and the Learning Vector Quantizer (LVQ) learns the characteristics of minutiae and nonminutiae regions. Finger images GT database is used because the minutiae ground truth is marked in it. The proposed minutiae verification is more effective for poor quality images. LVQ method consumes less storage and is faster over nearest neighbour method. Minutiae classification uses a rule-based scheme and the overall matching accuracy is improved.

In order to permit authentication of an individual identity the method proposed by Seiichi Hiratsuka and Yukio hoshino[6] for fingerprint feature extraction and comparison algorithm is a modification of AFIS. As a result of the researcher, 1 in 64 billion fingerprints are same as another on a minutia-based. Fingerprint system is the best tool for law enforcement investigations. The fingerprint identification algorithm identifies distorted image using Minutia and relation method. Fingerprint identification is done by the specialist and Inked fingerprint or photographed fingerprint is scanned, on the other hand fingerprint authentication is done by the system automatically by scanning the surface of live finger directly. Finger Through and FingerRecorder are developed for door control and attendance system.

Tatsat naik et al [11], presented the different stages of Finger recognition. The stages in Minutia extraction are pre-processing, minutia extraction and post processing stage. In the pre-processing stage, fingerprint image is enhanced to remove noise. The substages in pre-processing stage are image enhancement, image binarization, image segmentation. Image enhancement methods are histogram equalization and Fast Fourier transform. Locally adaptive threshold method is used to binarize the image. Block direction estimation, segmentation by direction intensity and ROI extraction by Morphological operation are the steps involved in Image segmentation. After the pre-processing stage, Minutia extraction is divided into fingerprint ridge thinning used to eliminate the redundant pixels of the ridges and minutia marking uses crossing number concept. Parallel thinning algorithm is used for extraction. Minutia matcher aligns the two fingerprint images to match the ridges, to determine whether the two minutia sets are same or not. In the post-processing stage the false minutia is removed. This paper proposed a representation for bifurcation to unify terminations and bifurcation. Performance is evaluated using the two performance evaluation indexes: FRR and FAR. False Rejection Rate is the biometric system may incorrectly reject an access to attempt an authorized user and False Acceptance Rate may incorrectly accept an access attempt of an unauthorized user. FVC2000 database is used to experiment testing.

Fingerprint recognition should tolerate the alignments like translation and rotation of the image. Reference points used for fingerprint classification are a unique landmark that is core and delta points (singular points). PI method is sensitive to noise and does not detect the reference point in plain arch. Another method to detect fingerprint finds the maximum curvature of singular points, this method is also ineffective and sensitive to poor quality image. Manhua Liu et al [9] propose an algorithm to locate a unique reference point and compute a unique reference orientation. The reference point localization is based on scale space analysis of Poincare index (PI) and orientation variance (OV). The reference orientation calculates the analysis of orientation differences between the radial directions from the reference points and local ridge orientations along radials. Except the finest scale it computes the orientation fields of varying scales, nonlinear smoothing method gives better performance by filtering impulse noise and noise caused by scars and ridge breaks etc., Experimental results show that the algorithm locates the reference points and compute reference orientation for all types of fingerprints and its performs with high accuracy.

Tsai-Yang Jea et al [10] handled an important challenge in matching incomplete or partial fingerprints, the presented approach uses localized secondary features derived from minutiae information. One-to-one correspondence of secondary features is obtained by the flow network-based matching technique. Minimum-cost flow (MCF) problem for fingerprint matching is applied to secondary feature matching and brute-force matching for derived minutiae

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features. Two different methods, heuristic rule and neural network are proposed to calculate the similarity scores for the information on the overlapping areas feature points.

Vipul Awasthi et al [14] proposed a technique for fingerprint analysis using minutiae extraction, it goes through the stages of image pre-processing and post-processing. Image reading, RGB to Gray image, image enhancement, binarization are done in the pre-processing stage then thinning, termination and bifurcation extraction are performed before post-processing finally false minutiae is done in the post-processing phase. Automatic fingerprint recognition systems rely on minutiae-based matching.

Fingerprint quality control software fails to detect an altered image if the area is small. S. Mousmi, Dr. T. Meyappan [15] propose a system to overcome the disadvantage. Quality latent fingerprints are given to AFIS for a search to match with the state in the database, in order to establish the unknown identity of deceased persons or suspects in criminal case. The main steps involved in the algorithm are local and global matching. Steps in local matching are to calculate the k nearest neighbour's for each and every point in the patterns, then calculate histogram of pair-wise distance, find the average histogram difference, threshold level, and then compare histogram with threshold. Global matching uses iteration method, mean and standard deviation are calculated, all transformation parameters are shown in the graph. Minutiae extraction algorithm goes through its stages; in the pre-processing stage segmentation is used to remove noise. Next stage is Minutiae extraction where the image is binarized, then thinning of ridge to one pixel wide. Finally post-processing stage removes false minutiae points. Since this algorithm goes through two steps, the accuracy is good and the false acceptance rate is low.

Annapoorani D et al proposed a hybrid method which is a fusion of minutiae based and wavelet statistical features. Minutiae features offer rich information, due to the destruction of image or noise, the performance of the image is poor. Complex matching of images are shown using wavelet. This approach is suitable for authentication with the identities enrolled. [17]

IV. STEPS INVOLVED IN FINGERPRINT RECOGNITION PROCESS

Fingerprint recognition is based on Biometrics system. A biometric system consists of four basic components [4,6]: Sensor module gets the biometric data. Feature extraction where the data is processed to extract features. Matching module where attribute vectors are compared against those in template. Decision making module the user's identity is established or a claimed identity is accepted or rejected.

Biometric personalities have highly consistent and exclusive features that make it best matched for security systems over an outmoded or predictable security system. [8] Identified seven factors that are used to identify a person's physical or behavioural characteristics as a biometric trait to be used in biometric security systems. They are universality (ease of availability in an individual), uniqueness (distinct characteristics), permanence (stability or durability), measurability or collectability (ease of acquisition), performance (quality of being efficient), acceptability (degree of approval) and circumvention (ease use of a substitute).

4.1 Fingerprint recognition using Minutiae based technique

Fingerprint recognition is implemented via histogram equalization techniques. The critical attributes for any biometrics are the number of degree of variation in the chosen index across the human population, since this determines uniqueness its immutability over time and its immunity to intervention and the computational prospects for efficiently encoding and reliably recognizing the identifying pattern. In the whole human population, no two fingerprints are alike in their mathematical detail, even among identical twins. Fingerprint recognition is a method of biometric authentication, based on extraction features of the fingerprint. Each individual has unique fingerprint, the variation even exists between the left and right of the same person. [9]

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The fingerprint recognition using minutiae based technique is in various steps: Pre-processing and fingerprint capturing, this process revises processing in which the quality of image is good. And then the Fingerprint image is resized from the original size of the image. Then the image is converted into grey scale, this process deals with the converting of colour image into grey scale image. Histogram equalization redistributes pixels in order to enhance the overall image. Edge detection generates the minimum feature required to identify the specific fingerprint. Storage processes to arrange the generated features into vector to be ready in processing.

Paper	Title	Fingerprint Feature	Method	Algorithm	Technique
[1]	Thinning Methodologies	Arch, Loop, whorl	-	-	Correlation-based matching, Minutiae-based matching, Pattern-based (or image-based) matching
[2]	Fingerprint Matching System	Arch, Loop, Whorl	-	-	Correlation Matching
[3]	Automatic Personal Identification Using Fingerprints	Trifurcation, Opposed bifurcation, Bridge	Histogram Equalization, Fourier Transform	Fingerprint ridge thinning	Minutia based
[4]	A fingerprint verification system based on triangular matching and dynamic time warping	Leftloop, Right loop, Creases, Scars	-	-	Minutiae-based
[5]	Learning Fingerprint Minutiae Location and Type	Ridge Ending, Ridge Bifurcations	-	-	Minutia Based
[6]	Fingerprint Mosaicking	Ridge ending, Bifurcation, Dot, Island, Ridge crossing	-	EER Algorithm	Minutia Based
[7]	Biometrics Personal Identification in Networked Society	Termination, Bifurcation, Ridge, Valley	-	Minutiae Detection & Phase Spectrum Analysis(MDPSA)	Minutia Based
[8]	Minutiae-based Methods	Ridge Ending, Ridge Bifurcations	Fourier Transform	-	Minutiae-based
[9]	Fingerprint Reference Point Detection	Arch, LineFragment, scars	Morbological	Fingerprint ridge thinning	Minutia Based

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[10]	A minutia-based partial fingerprint recognition system	Ridge Ending, Ridge Bifurcations	Morbological	Histogram Equalization	Correlation-based matching, Minutiae-based matching, Pattern-based (or image-based) matching
[11]	Study of fingerprint recognition system	TendedArch, whorl, LineUnit, Line shape, pore	Histogram Equalization, Fourier Transform	Fingerprint ridge thinning	Miutia based

Table-1: Fingerprint recognition

4.2 Fingerprint Recognition using Fast Fourier Transformation

FFT hastily calculates conversions by factorizing the DFT (Design for Testability) matrix into an invention of infrequent (mostly zero) factors. FFT at different levels can be applied for 0.1 to 0.9 and percentage for fingerprint matching will be calculated for each finger [9].FFT computes the DFT and produces exactly the same result as evaluating the DFT definition directly; the only difference is that an FFT is much faster.Evaluating the definition directly requires $O(N^2)$ operations: there are N outputs X_k , and each output requires a sum of N terms. An FFT is any method to compute the same results in $O(N \log N)$ operations. More precisely, all known FFT algorithms require $\Theta(N \log N)$ operations, although there is no known proof that a lower complexity score is impossible.To illustrate the savings of an FFT, consider the count of complex multiplications and additions. Evaluating the DFT's sums directly involves N^2 complex multiplications and $N(N-1)$ complex. The well-known radix-2 Cooley–Tukey algorithm, for N a power of 2, can compute the same result with only $(N/2)\log_2(N)$ complex multiplications and $N\log_2(N)$ complex additions. In practice, actual performance on modern computers is usually dominated by factors other than the speed of arithmetic operations and the analysis is a complicated subject but the overall improvement from $O(N^2)$ to $O(N \log N)$ remains.[16]

Properties of FFT are as follows [16]:Periodicity, Linearity, Shifting property, Time reversal of a sequence, Circular time shift, Circular frequency shift, Circular convolution and Circular correlation



a)Original image b)Enhanced FFT[7]

Fig 10: Fast Fourier Transform

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V. CONCLUSION

Fingerprint recognition is one of the biometric techniques to recognize an individual using his/her fingerprint pattern, as the fingerprint of each and every individual is unique and it makes easier to identify an individual. It helps in removing the spurious minutiae similarly which may also prove to be detrimental in matching fingerprints acceptably. Nowadays biometrics is used majorly for security purposes in many organisations. Fingerprint recognition systems have been demonstrated to be very effective in protecting information and possess in a large area of applications.

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