IJCSE International Journal of Computer Sciences and Engineering Open Access
Research Paper Vol.-7, Issue-5, May 2019 E-ISSN: 2347-2693

An Approach for Scaling Up Performance of Fingerprint Recognition

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DOI: https://doi.org/10.26438/ijcse/v7i5.457461 | Available online at: www.ijcseonline.org

Accepted: 17/May/2019, Published: 31/May/2019

***Abstract*—**Biometric Recognition System plays vital role in aspect of security. Among all physiological and behavioral biometric modalities, current study focuses on fingerprint recognition from physiological biometric modality. Fingerprint recognition plays key role in success of user authentication to verify and identify an individual with matching of his/her fingerprint. It is one kind of pattern recognition method which acquires the set of minutiae features from an individual finger image and compare it with the minutiae features available in template image. This research paper focuses on the challenges resides in fingerprint authentication, limitations in methodology used for processing, proposed research model to solve these limitations, Significant of proposed research work show the solution of challenges with implemented work using FVC2000 and FingerDOS databases.

***Keywords*—**Fingerprint Recognition, Orientation Estimation, Image Enhancement, Thinning, Minutiae Extraction, Core Point Detection

I. INTRODUCTION

In the era of information security biometric is the most secure and appropriate method for encouraging the person recognition and identification. It authenticates a person based on physiological (material or behavioral) characteristics of the person.

Fingerprint authentication is the most famous and widely adopted biometric over a century because it remains unique and consistent over time [1]. It is popular because used in many sectors like government, national and international security, law enforcement agencies and so on for making safe and secure world [2].

A fingerprint image contains mainly two types of features: ridge flow information and minutiae. In fingerprint image, ridge flow information is defined by the ridges and valleys pattern. The minutiae are mainly referred as ridge ending and ridge bifurcation which contains the disconnection in fingerprint impression. There are overall 150 types of minutiae types identified. In the analysis of fingerprints, the ridge flow information and minutiae play vital role for showing the two fingers are not same. In a full fingerprint, average 70 to 150 minutiae are there. The numbers of minutiae in a fingerprint image are differing from one finger to another and problems affected to matching processes and success level of fingerprint recognition are: The same finger images capture during different session can be basically different, finger plasticity creates the distortion (Cold finger, Dry/oily finger, High or low moisture), the overlapping is done among query and template finger and match partial fingerprint because of displacement of finger on scanner, different pressure and skin conditions like cuts to fingerprint, manual working that would damage or affect fingerprints(construction, gardening), noisy fingerprint image or poor quality image can create problems for feature extraction because of missing features. Yet, the displacement of fingerprint and lower quality images make the fingerprint recognition task is challenging task [3].

II. CHALLENGES IN FINGERPRINT RECOGNITION

The challenging problems in fingerprint recognition is the fingerprint matching process. Because the matching process decide an overall performance as well as success and failure rate of fingerprint recognition.

The work in fingerprint recognition is on-going study in nature to make more optimization for user authentication hence it is important to know the essential factors that are liable to improve the matching fingerprint image and improve the accuracy level.

By the literature studies, following points have been observed which are required to address for improvement of research activities in fingerprint recognition domain.

- ✓ Fingerprint contains background noise means random noise during image acquisitions.
- ✓ Distortion caused by the finger plasticity like in Dry/oily finger lead fragmentation and cold finger lead low contrast within ridges, high or low moisture fingerprints connect parallel ridges and leads to smudge marks.
- ✓ Different pressure as well as skin conditions like cuts on finger, manual working like (gardening, constructing) would damage or mark finger, existence of bruises or wounds, creases may cause disorder flow of ridges and valley.

Therefore, it is required to enhance quality of finger image automatically before going for further processes of fingerprint verification. To, overcome these problems or to increase the quality of an image the effective per-processing techniques are highly required.

The further research states some more factors which affect the performance of features extraction and matching phases in fingerprint verification are:

- ✓ Small overlap within query and template finger image is generated because of High displacement/or rotation of finger image.
- ✓ Noisy fingerprint image or poor quality image can create problems for feature extraction phase which extracts spurious or missing features.
- ✓ Large intra-class variations and small intra-class variations are two known properties of fingerprints. Large intra-class variations check that the variability in same finger's different impression are large or not. In oppose small interclass variations check that how much similarity between two different images.
- ✓ Higher processing time during matching.

To, overcome this problems effective post-processing techniques are highly required.

III. COMPARATIVE STUDY ON PRE-PROCESSING AND POST-PROCESSING

After literature review and comparative study done on pre-processing and post-processing phases, find out different techniques, methods and algorithms are used in it. Also states use of techniques and problems associated with its. The below Table 1 shows complete analysis of each phase of pre-processing and post-processing.

Table 1. Comparative Study on Pre-Processing and Post-Processing

Techniques or Methods	Use of Methodology	Problems
Normalization [4]	It removes the noise which is created by scanner and decrease the discrepancy in gray-level values beside ridges and valleys.	To find out an accurate constant value for mean and variance.
Orientation Estimation [5]	It indicates the direction of ridges, essential for image enhancement, core point detection and minutiae extraction phase.	Filter-bank based approach, waveform projection, and spectral estimation do not provide as much accurate results.
Image Enhancement [6]	Used to connect broken ridges and remove noises between the ridges and improve the ridge and valley contrast.	Histogram Equalization improves the clarity of an image but doesn't change structure of ridge while FFT Based is enhancing the image using frequency only.
Binarization [7]	Covert the fingerprint image in 1-bit binary image, partitioning an image into foreground and background.	Global thresholding method is not suitable whenever the background enlightenment is not clear.
Thinning [8] [9]	Process reduces the width of ridge pattern to just a single pixel.	Sequential and parallel algorithms are iterative thinning algorithms while medial axis algorithms are non-iterative thinning algorithms. The non-iterative algorithms are efficient in computation time but are responsible for creating noisy skeleton.
Minutiae Extraction [10]	Extract minutiae like ridge ending and bifurcation from thinned binarized image.	Two ways are used: morphology operators and crossing number. The method based on morphology operator is used when the image is pre-processes using morphology operator.
Remove False Minutiae [11]	Due to lacking of ink and over inking create a spurious minutiae like false ridge break and cross connection of ridges.	
Core Point Detection [12] [13]	It is used for classification as well as matching rotated images.	An Orientation Field, Multi-Resolution, Curvature and Poincare Index are existing core point detection algorithms. The lower result and detect the false core point in lower quality images is the limitation of this method.
Minutiae Matching [14] [15]	Match the template finger with input finger.	The two approaches are used minutiae based and pattern based approach. Minutiae based approach use only local features while pattern-based approach use global features.

IV. PROPOSED RESEARCH MODEL

To design and develop a reliable algorithm for fingerprint recognition is the main objective of proposed research work. An algorithm needs to extract a set of discerning and invariant features for compare two fingerprint images. These features are called as minutiae points. It is essential to extracts especially the correct and exact minutiae points which are vital in identifying a person. It is more adverse that, improper image acquisition, noise contrast deficiency, geometrical deformation and transformation erect reliable minutiae but detection is excessively rigid. As well as due to poor quality finger images sometimes, the false suitable minutiae can be cancelled while the minutiae i.e. spurious minutiae can be generated.

To overcome these problems and in order to further enhance an overall performance of fingerprint verification algorithm, scope of improvement is possible in processes of pre-processing phase like orientation estimation, image enhancement, binarization, thinning. As well as processes in post-processing phase like minutiae extraction, remove false minutiae, core point detection and minutiae matching.

It is expected that after giving contribution in enhancing the several stages of pre-processing and post-processing phase, the overall accuracy level of proposed fingerprint recognition algorithm will increase up to next level.

The proposed research plan is divided in mainly three phases. The following Figure 1 shows the proposed research plan for fingerprint verification.

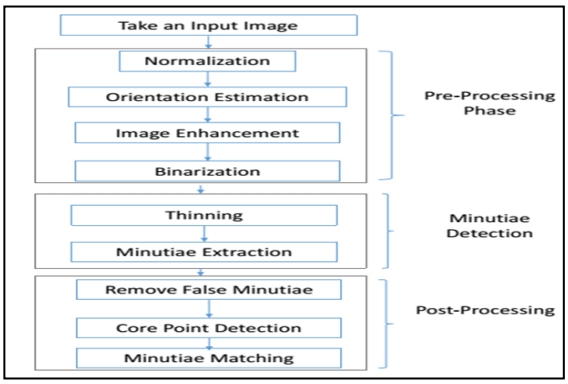

Figure 1. Proposed Research Model

V. SIGNIFICANT OF PROPOSED RESEARCH WORK

In this research performance of the fingerprint recognition is improved based on proposed and implemented work. The proposed work is divided into two parts pre-processing and post-processing. The goal of pre-processing phases is to remove noise and make clear finger image which is suitable for feature extraction in post-processing phase.

First major challenge in fingerprint recognition system is poor quality images. The performance of the fingerprint recognition is influenced by the quality of an image. To, overcome this problem at initial level use the normalization method which remove the noise which is created by the pressure given on scanner. As well as at image enhancement phase proposed research used the O'Gorman filter and also enhanced it for improving the quality of an input image. The performance is also compared with most famous image enhancement method called as Gabor filter. The result prove that enhanced O'Gorman filter connect broken ridges, remove noises between the ridges and improve the ridge and valley contrast [16] [20].

Second major challenge in fingerprint recognition system is displacement of fingerprint which give false result at the time of fingerprint matching. To overcome this problem used orientation estimation which represent the direction of ridge flow. It is mainly used for ridge enhancement as well as for singular detection. The proposed research work used the most widely adapted Gradient based orientation estimation and also enhanced it. The performance is done using comparison of existing gradient based method with enhanced gradient based method and prove that proposed enhanced method give better result [17] [20].

Third major challenge in the fingerprint is makes the ridge ends and ridge bifurcation more visible and distinguishable from the image. The binarization and thinning process is used for that purpose. The binarization is the way which convert the gray-scale image into binary image means black and white image which distinguish the fingerprint image in ridge part and non-ridge part. In proposed research work apply global threshloding, famous otsu thresholding and local adaptive thresholding using different matrix size like 5x5, 9x9, 15x15. The comparison above method prove that local adaptive thresholding apply with 9x9 matrix size give better performance [18] [20].

Fourth major challenge is computational time, the thinning process is used to reduce the size of pattern width up to 1-pixel and thin the image which is become appropriate for minutiae extraction. As well as it reduces the execution time for feature extraction process. In proposed research work the zhnag-suen's algorithm is implemented and also enhanced it. The performance of enhanced zhang-suen's algorithm is compared with existing zhang-suen's as well as Hilditch's algorithm. The comparison proves that enhanced zhang-suen's algorithm give best result [19] [20].

The thinned skeleton image is become input image for extracting the minutiae points. In proposed work extract ridge ending and ridge bifurcation as minutiae. The minutiae points are extracted from the skeleton image using Rutovitz Crossing Number (CN) method [21].

Fifth major challenge is remove the spurious minutiae which are extracted at the time of feature extraction stage. In proposed research work used some condition to remove that spurious minutiae [21].

A two final major challenges in fingerprint recognition are most important that is reducing false positive during minutia detection and matching of unequal number of minutia features. These problems are arrived because of rotation of fingerprint. To, overcome these problem used core point detection using famous Poincare Index method as well as enhanced it to found the exact core point [21] [22]. Then after in proposed work apply minutiae based approach for matching fingerprint images. In that combine two approaches: approach based on alignment and approach based on local minutiae: radius: 50px from central minutiae, which reduce false positive minutiae matching. As well as it provides better results while comparing minutia sets of different sizes as well as in slightly different orientation during the matching process [21].

VI. EXPERIMENTAL ENVIRONMENT

To test the experimental result and performance of proposed algorithm used two databases FVC2000 [23] and FingerDOS [24] database as well as measure it with different measurement standard like FMR, FNMR and execution time to complete the recognition and overall accuracy of recognition level. The implemented proposed algorithm is tested on a machine with an Intel(R) Core (TM)2 Duo CPU T6570 @ 2.10 GHz, 1.99 GB RAM and using the JAVA language. The following table shows the overall comparative study of results generated with various methods on different data set.

VII. CONCLUSION AND COMPARATIVE RESULT ANALYSIS

The fingerprint can be used as signature for a person because the friction ridge skin on fingers is a unique characteristic of an individual and that does not change over the time. In this modern era, the demand of reliable personal authentication is growing. The fingerprint recognition become solution which provides the high accuracy, ease of use, and high throughput. It is used in many applications like forensic, government, border crossing, entrance to amusement parks, and accessing laptops and mobile phones and so on.

Even though the widespread use and success of fingerprint recognition technology, there remain certain limitations and concerns about fingerprint recognition. This proposed work has made an attempt to address some of these challenging issues.

The following Table 2 shows the comparison of proposed fingerprint recognition algorithm with existing algorithms and prove that the proposed algorithm gives better performance in terms of FMR, FNMR, Accuracy and execution time.

Table 2. Comparison of Fingerprint Recognition Algorithms

Author	Database	FMR / FAR	FNMR / FRR	EER	Accuracy	Exe. Time
Lin Hong et al., 1997 [25]	700 images taken 10 images from 70 persons		15%			1.4 Sec.
F. A. Afsar et al., 2004 [26]	FVC2000 database contains 800 images	1%	7%	5%	92%	12 Sec.
Anil Jain et al.,2007 [27]	410 images, taken 10 images from 41 individuals			4.9 %		
Weiping Chen et al., 2007 [28]	400 fingerprints taken from 4 impressions from 100 persons			2.44 %		
Manvjeet Kaur et al.,2008 [29]	FVC2000				75%	
Ishpreet Singh Virk,2012 [30]		0.06%	6.9%			
Florence Francis-Lothai et al.,2016[31]	FVC2002-Db1a database				81.16%	
	FingerDOS database				89.78%	
Proposed Algo., 2017 [21]	FVC2000-Set B	2.22%	1.6%		98.09%	3.62 Sec.
	FingerDos -3600 images	0%	2.61%		98.69%	0.86 Sec.

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