Segmentation of Overlapped Region using Morphological Processing

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Abstract

In a un - controlled environment such as crime scene, collecting valid fingerprints is a very challenging task, due to the fact that fingerprints are often superimposed with some background. In some cases the background may be another fingerprint due to multiple touches by a person, resulting into segments of the overlapped fingerprints. In order to use existing fingerprints recognition systems for identifying such fingerprints, a method for separation of overlapped fingerprints is the current need. This separation takes few steps like segmentation of overlapped region, feature extraction and separation. This paper presents a novel method for segmentation of overlapped region based on morphological image processing. The algorithm is tested on overlapped fingerprints from simulated overlapped fingerprints database. Results indicate that the proposed algorithm is satisfactory for good quality images and it requires improvement for poor quality fingerprints in the overlapped region.

Keywords: *Overlapped fingerprints, ridge orientation, segmentation, fingerprint patterns.*

1. Introduction

Personal identification based on fingerprints is widely accepted both in civilian and forensic applications. Fingerprints biometric is used as an evidence by law enforcement agencies. In comparison with other biometric traits like face, iris etc., fingerprints recognition systems offer many advantages. Fingerprints scanners are comparatively cheap, require less memory for the storage of fingerprints templates, and involve less processing time in matching process. Accuracy of fingerprint recognition systems is highly dependent on the quality of fingerprints [1].

Fingerprints that are collected under guidance or controlled environment exhibit better quality as compared to those collected from uncontrolled environment. In uncontrolled environment such as crime scene, fingerprints are lifted through chemical processing and they are invariably poor quality images and they generally contain some artefacts [2]. Thus the task of identification of these fingerprints becomes a challenge both by fingerprints experts and automatic recognition systems. Recognition of poor quality fingerprints is a very serious challenging task. Thus before feeding these fingerprints images to recognition systems, they are processed, which involves, enhancement, noise filtering and segmentation etc. State-of-the-art fingerprint recognition systems perform well for good quality fingerprints, however, they are do not perform very well for poor quality fingerprints.

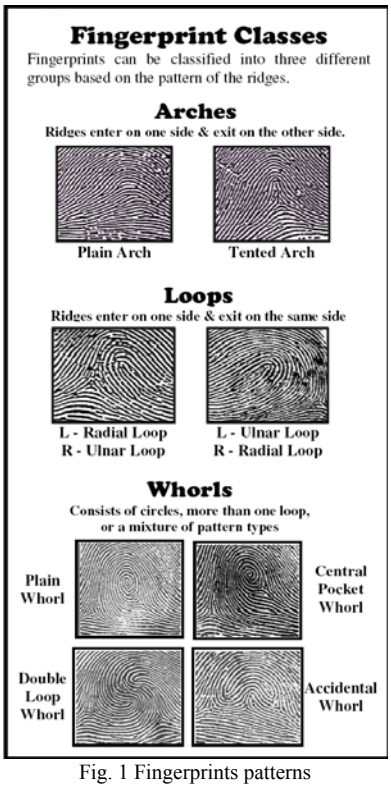

Fig. 1 Fingerprints patterns

Fingerprint recognition algorithms extract features from fingerprints image and convert them into suitable

templates, and compare them with templates stored in database. Fingerprints database is populated with fingerprints that are acquired through fingerprint enrolment process. Fingerprints features are defined at different levels, level 1 features : Singular points, they are the core and delta regions of fingerprints, level 2 features : Minutia, these represent discontinuity in the ridge flow such as ridge ending and ridge bifurcation, level 3 features: Ridge features, these include features like sweat pores, incipient ridges and inter ridge distance etc [1].

Level 1 feature are used in fingerprints analysis at coarse level. Most of the fingerprints recognition systems are designed utilizing minutiae feature and these systems are the most accurate ones and socially accepted. However minutiae based fingerprints recognition algorithms are very complex and involve rigorous false minutiae filtering process. Fingerprint recognition systems intended for detection of fake fingerprints and liveliness detection etc, are based on level 3 features such as sweat pores [3]. Utilization of level 3 features by recognition algorithms demands high resolution fingerprints scanners, which are costly.

There exist special ridge flow patterns in fingerprints and form different patterns, they are left loop, right loop, arch, tented arch, whorl as shown in fig 1. These patterns are utilized for fingerprints indexing. There also exist some rare patterns in fingerprints such as plain whorl, central pocket whorl, double loop whorl and accidental whorl, these patterns leads to the complexity of recognition algorithms. One of the critical factors that affect the speed of fingerprint matching algorithms is number of candidate fingerprints in the database. The performance of matchers can be significantly improved by fingerprints indexing, it is classification fingerprints into different classes based on common features for each class. Fingerprints ridge patterns are utilized in coarse level indexing [4], and ridge features such as orientation are used in fine level indexing.

Fingerprint recognition systems are deployed in many applications like entry control, attendance monitoring, net banking etc. However, Fingerprints are the only accepted biometric traits adopted by law enforcement agencies for convicting a person in crime detection. Fingerprints lifted from the crime scene are generally having unclear ridge patterns with some background with complex noise, so feature extraction is a very challenging task. These fingerprints are known as latents, and continuity in the ridge patterns in such fingerprints is vital to the matching results, thus needs some method of recovering ridge patterns.

Fingerprints recognition systems include modules for segmentation, noise filtering and enhancement etc. Segmentation is essential operations on fingerprints lifted from crime scene which contain unwanted background objects. All the objects in the scene are the candidate background objects. One special situation is where, the background object is yet another fingerprint. Whenever an object is touched multiple times either by a same person or different people, there are chances of multiple impressions in that region, resulting overlapped fingerprints [5], Fig 2. Shows overlap of only two fingerprints. However, in practice there could be any number of fingerprints overlapped.

Fig. 2 Example of overlapped fingerprints image

Fingerprint recognition technology has achieved tremendous success in law enforcement applications, however they still demonstrate limitations in recognizing latents, despite the ingenious and improvised methods of fingerprints recognition. Existing fingerprints recognition systems are designed to recognize individual fingerprints, therefore recognition of overlapped fingerprints is a challenging task. State-of-the-art fingerprints recognition systems do not have any in built capability of separating overlapped fingerprints. Thus there is a need for pre processing module that separates overlapped fingerprints into component fingerprints.

Remainder of the paper is organized into 5 sections; Section 2 gives methodology of separation of overlapped fingerprints, Section 3, presents method of segmentation of overlapped region in overlapped fingerprints based on morphological operation. Section 4 presents results obtained on different overlapped fingerprints. Finally, paper concludes in Section 5, gives the highlights of limitations of proposed work and future enhancement.

2. Methodology for separation of overlapped fingerprints

Major steps (Fig. 3.) in the separation of overlapped fingerprints [5] [6] [7] [8] are as given below.

i. Segmentation of overlapped fingerprints image into overlapped and non overlapped regions
ii. Feature extraction
iii. Feature classification
iv. Enhancement and separation

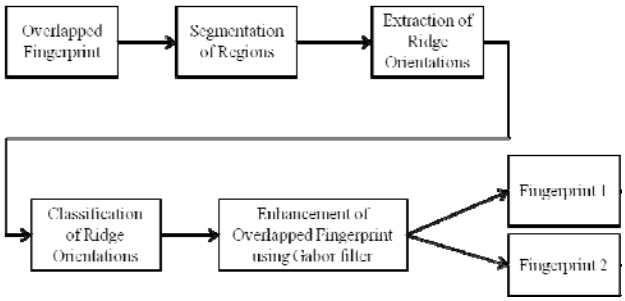

Fig. 3 Modules for separation of overlapped fingerprints

Segmentation of regions into overlapped and non overlapped regions is essential to facilitate extraction of reliable features. Fingerprint ridge orientation feature is one most useful feature in fingerprint recognition methods, which is utilized in enhancement, indexing and segmentation etc., also it is an important feature in overlapped fingerprints separation. Plethora of techniques is suggested in the literature for reliable extraction of fingerprint ridge orientation [9]. Extraction of ridge orientation in non overlapped region is performed using gradient based methods, it is straightforward since there is only one dominant ridge orientation pertaining to single fingerprint. The overlapped region constitutes intersection of ridges of two fingerprints having different orientations; therefore overlapped region is a mixture of two dominant ridge orientations which alleviates the complexity of orientation extraction. For overlapped region, methods that are based on modelling are explored. In order to select suitable method for ridge orientation extraction, it is essential to identify overlapped and overlapped regions.

Ridge orientations that mixed in overlapped region are classified into two groups, first, comprises orientations of fingerprint1 and second, orientations of fingerprint2, using labelling algorithms.Then overlapped fingerprint is adaptively enhanced using Gabor filters [10]. Separation of overlapped fingerprints into two fingerprints is performed through adaptive enhancement using Gabor filter. First fingerprint is obtained by tuning Gabor filter to the orientations of fingerprint1, second fingerprint by tuning to orientations of fingerprint2.

3. Segmentation of overlapped region

Overlapped fingerprints are natural and inevitable, they are the main evidence of an offender. Thus separation of overlapped fingerprints is very much essential, in order to use state-of-the-art automatic fingerprints recognition systems. As a first step manual marking of overlapped region is adopted in methods presented in literature, however, manual marking demands human intervention with the system. This becomes bottleneck for complete automation recognition systems. Also manual region marking/identification leads to a subjective process and depends upon the expertise of fingerprints examiner. In practice there will be large number of overlapped fingerprints, and manual marking becomes tedious and time consuming job.

Segmentation of overlapped image into overlapped and non-overlapped regions is an important step for selection of suitable method for ridge orientation extraction. This paper presents a method of identification of regions based on morphological processing [11], Fig 4. Shows various steps involved.

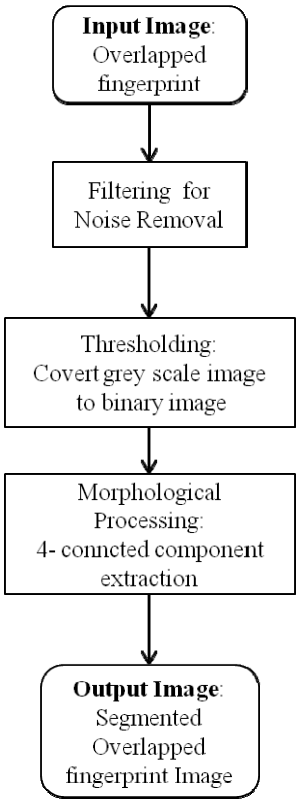

Fig. 4 Flow chart for identification of overlapped region

The proposed work makes following assumptions;

i. There exist only two fingerprints in the overlapped region.
ii. There is no sequencing of fingerprints.
iii. There is no perfect overlap of two fingerprints, in particular, those having same patterns.

4. Results and discussion

In this section, experimental results are presented and demonstrated that the proposed method for segmentation of overlapped fingerprints region into overlapped and non overlapped regions.

Fig 5. Depicts, parameters that are used for describing the pattern of overlap in fingerprints. Important parameters are patterns of individual fingerprints, percentage of overlap area (OA), distance between core points of two fingerprints (D), angle of line connecting two core points with respect to horizontal axis (θ) and quality of fingerprints images in overlap region. The results show that our methodology works fairly well with overlap fingerprints with good quality- proper ridge continuity, containing no scratches. However it is not satisfactory for fingerprints that possess discontinuity of ridges and scratches.

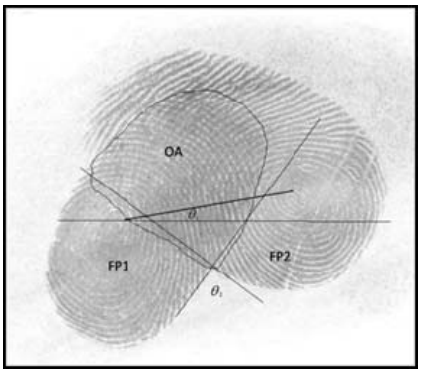

Fig. 5 overlapped fingerprint with parameters (from latent overlapped fingerprint database)

The proposed method is implemented using Matlab 2012a and tested on various images taken from simulated overlapped fingerprints database [12], testing is carried out on different patterns of overlap of two fingerprints. Fig 6 shows detailed segmentation results of overlapped fingerprints and table1 (Appendix) furnishes elaborative results.

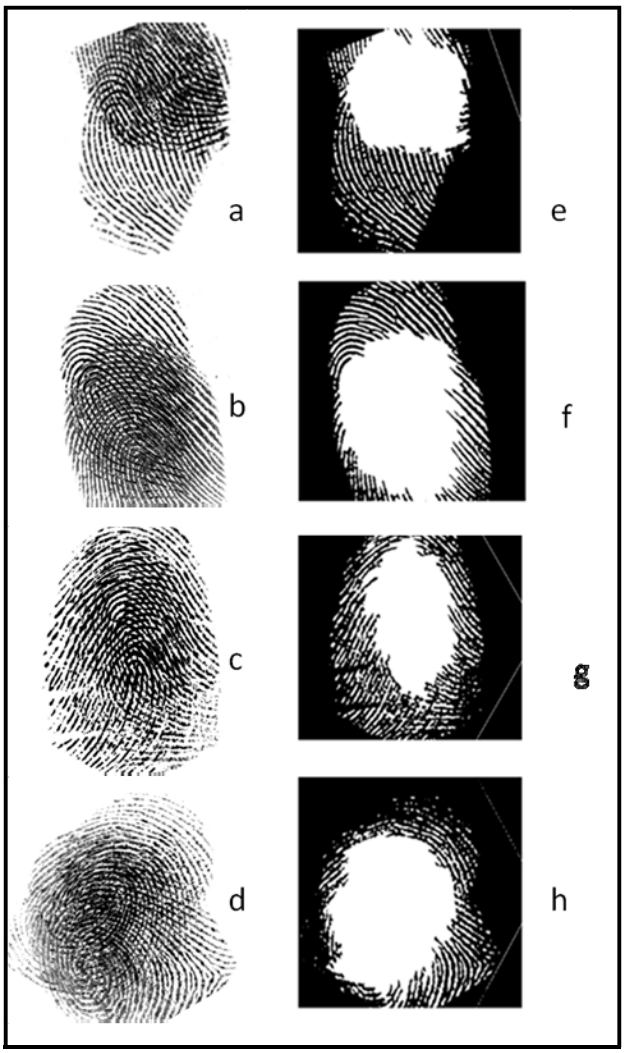

Fig 6: (a), (b), (c) and (d) are input overlapped fingerprints images, (e), (f), (g) and (h) are output fingerprint images respectively.

Fig 7(a) and 7(b) shows the results of manual segmentation. By comparing results of proposed method with those obtained from manual segmentation, through visual inspection of output images, it can be concluded that the proposed method is satisfactory.

Fig 7: (a) Input overlapped fingerprints image, and (b) Output segmented overlapped image

5. Conclusion

Fingerprint recognition systems have made lot of advancements in personal identification systems for controlled environment. However, in an uncontrolled environment they do not perform well, reason is fingerprints collected from an uncontrolled environment such as crime scene often contain complex background and need lot of processing and hence obtaining valid fingerprints is a very serious difficult task due to various challenges, one such challenge is deriving a valid fingerprint from overlapped fingerprints. Overlapped fingerprints occur due to multiple touches to the objects. State-of-the_Art fingerprints recognition systems are not developed to handle such complex fingerprints, thus there is a need of separation of overlapped fingerprints into individual fingerprints. In this paper, as a first step, a method of segmentation of overlapped region based on morphological processing is presented. Method id tested on fingerprints from simulated overlapped fingerprints database. The results indicate that the proposed algorithm is satisfactory for fingerprints with good continuity in ridge lines. However, it requires improvement for poor quality fingerprints.

Appendix

Table1. Results of segmentation of overlapped fingerprints

OF	F1	F2	OA	D	θ_1	θ_2	Q	Results
1	LL	LL	75	13	135	110	DR	PP
2	LL	RL	80	8	130	10	C NS	S
3	LL	A	50	NA	45	NA	C, NS	S
4	RL	LL	70	18	135	110	C,NS	S
5	LL	RL	90	6	180	30	C,NS	PP
6	LL	LL	75	19	160	115	C,NS	S
7	LL	LL	80	9	45	130	DR	S
8	W	LL	60	7	40	80	DR	PP
9	LL	W	40	13	90	110	DR	PP
10	LL	LL	55	20	30	135	DR	
11	RL	LL	100	7	180	70	DR	PP
12	RL	RL	50	5	30	85	C, NS	S
13	RL	LL	25	NA	20	90	C, NS	S
14	A	LL	60	8	85	85	C, NS	S

F1: Pattern of fingerprint1
F2: Pattern of fingerprint2
OA: Percentage of overlap between two fingerprints
D: Distance between core points of overlapped fingerprints
θ_1 : Angle of overlap of two fingerprints
θ_2 : Angle of line connecting core points of overlapped fingerprints with respect to horizontal axis
Q: Quality of fingerprints
DR: Discontinuity in ridges
C: Continuity of ridges
NS: No scratches, S: Satisfactory, PP: post processing is needed.
LL: Left loop, RL: Right loop, W: Whorl, A: Arch

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