A Study of Latent Fingerprint Matching Approaches

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ABSTRACT
Fingerprint based identification is one of the most mature and proven technique compare to the all biometric technique. In crime sense fingerprints have been extensively used for identification of criminals. Fingerprints are classified as rolled, plain and latent fingerprints. Latent fingerprints are lifted from surface of objects that are unintentionally touched by person. Latent means poor quality of images or unclear image i.e. smudgy, blurred, moist, small area or fingerprints that contains fewer amount of minutiae. Matching latent fingerprints over rolled or plain fingerprints that is difficult task. Therefore, it is necessary to extract all fingerprint features that are present in latent fingerprint images for accurate matching. Although tremendous progress has been made AFIS (Auto-mated Fingerprint Identification System), this system works well only in that case where rolled and plain fingerprint images. There-fore, semi-automatic system is feasible for feature extraction of la-tent images i.e. some human intervention is allowed during feature extraction from latent fingerprint images. Before feature ex-traction performed it is necessary to improve the quality of la-tent image because they are lifted from any surface and it is easy to extract features from improved quality of latent images. Then outputs candidates are matched over rolled fingerprint images by using fully automatic system. This paper presents study of various techniques that are useful for latent fingerprint matching.

General Terms
Biometric, Pattern Matching and Machine Intelligence

Keywords
Fingerprint features, Latent, AFIS, Matching, Segmentation.

1. INTRODUCTION
Biometrics is useful for identifying an individual based on his or her physiological or behavioral characteristics, has the capability to reliably distinguish between authorized person and an imposter. Among all biometrics (e.g., face, fingerprint, hand geometry, iris, retina, signature, voice print, facial thermo gram, hand vein, gait, ear, odor, keystroke dynamics [1]), fingerprint-based identification is one of the most mature and proven technique. The early 20th century, fingerprints have been extensively used for identification of criminals by the various forensic departments around the world. But, Fingerprints also have a number of disadvantages as compared to other biometrics. For example, approximately 4 percent of the population does not have good quality fingerprints, hard workers get regular scratches on their fingers which poses a difficulty to the matching system, finger skin peels due to weather, fingers develop natural permanent pleats (lines), temporary pleats are formed when the hands are inserted in water for a long time, and also dirty fingers cannot be properly imaged with the existing fingerprint sensors [1].

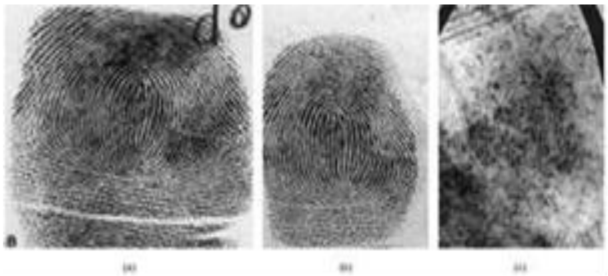

Fig 1: Three types of fingerprint images: (a) rolled, (b) plain, and (c) la-tent fingerprints from the same finger in NIST SD27 [2].

Over the years, extensive research has been done in matching rolled and slaps fingerprints with each other. On the other hand, latent fingerprint recognition is a major research challenge, especially in forensic applications. As shown in Fig. 1, latent fingerprint is a special type of fingerprint that is lifted from the Surface using chemical processes [2]. They are important evidence and useful for identifying criminals.

However, it is difficult to process them due to following challenges or covariance's:

- Poor quality of latent impression due to which unclear friction ridge information is available [2].
- Small area or cutting- edge area of the fingerprint
- Presence of background noise due to the chemical process that is used for lifting the fingerprint from any surface and
- Nonlinear distortion in fingerprint ridge patterns [2].

Latent fingerprints obtained from crime scenes have served as crucial evidence in forensic identification for more than 100 years. While the wide distribution of Automated Fingerprint identification System AFIS in law enforcement agencies has significantly improved the accuracy and throughput of fingerprint identification manual interference is still necessary in latent feature extraction and verification stages. The steps of manual latent identification are analysis, comparison, evaluation, and verification. This commonly referred to as the ACE-V procedure in latent fingerprint literature[2].

1. **Analysis:**- In this step analyses the latent fingerprint to deter-mine whether sufficient ridge information is present in the image to be processed and to mark the features along with the associated quality information [2].
2. **Comparison:-** In this step an examiner compares a latent image to a reference print to ascertain their similarity or dissimilarity.

3. **Evaluation:-** After Comparison classify the fingerprint pair as individualization (identification or match), exclusion (no match), or inconclusive.
4. **Verification:** Then lastly the examiner independently re-examinations a fingerprint pair in order to verify the results of the first examiner.

Latent fingerprints are unintentional impressions left by fingers on surfaces of objects. While massive progress has been made in plain and rolled fingerprint matching techniques, the latent fingerprint matching continues to be a difficult problem. As compared to plain or rolled fingerprint matching, the main difficulties in latent fingerprint matching are due to poor quality of ridge impressions, small or cutting-edge finger area, and large non-linear distortion.

2. LITERATURE SURVEY

A variety of automatic fingerprint matching algorithms have been proposed in the pattern recognition literature. This chapter provides a survey of existing approaches for automatic fingerprint matching. Most of these algorithms have no difficulty in matching good quality fingerprint images, but matching low quality and partial fingerprints remains a challenging problem.

Jain et al. proposed an algorithm to match latent fingerprint images with full fingerprint images. Fig 2 shows schematic diagram of proposed system. The fingerprints were manually segmented and minutiae and ridge flow were labeled. Matching was performed using the ridge flow and minutiae ground truth provided by the experts. On using the ground truth minutiae for full fingerprints, they reported 98% retrieval at rank 25 [3].

Feng et al. proposed a multi stage filtering technique on large scale fingerprint database to reduce the search space and hence the computation time. They used ridge pattern, singular points, and orientation field for pruning the search space. On matching 258 latent fingerprints with a database of 10, 258 rolled fingerprints, they reported a threefold increase in matching speed and also the rank-1 accuracy increased from 70.9% up to 73.3% [5].

Yoon et al. proposed the latent fingerprint enhancement algorithm. On the manually selected Region of Interest ROI and core point, the proposed algorithm fits the orientation model to a coarse orientation field obtained by commercial SDK. The enhancement algorithm clearly improved the matching accuracy of the latent fingerprint matching system [6].

Heeseung Choi et al. proposed a new latent fingerprint segmentation algorithm that identifies the region of interest, namely the friction ridge pattern, and suppresses the background. The segmentation algorithm utilizes both ridge orientation and frequency features. A flowchart of the proposed method, they considered a fingerprint as a texture pattern (oriented line pattern within a certain valid range of frequency), and utilize both fingerprint orientation and frequency information to segment latent. The main difficulty in latent fingerprint segmentation is the presence of structured noise. The orientation tensor approach is used to extract the symmetric patterns of a fingerprint as well as to remove the structured noise in background. Local Fourier analysis method is used to estimate the local frequency in the latent fingerprint image and locate fingerprint region by considering valid frequency regions. Candidate fingerprint (foreground) regions are obtained for each feature (orientation and frequency) and then an intersection of these regions is used to localize the latent fingerprint region [7].

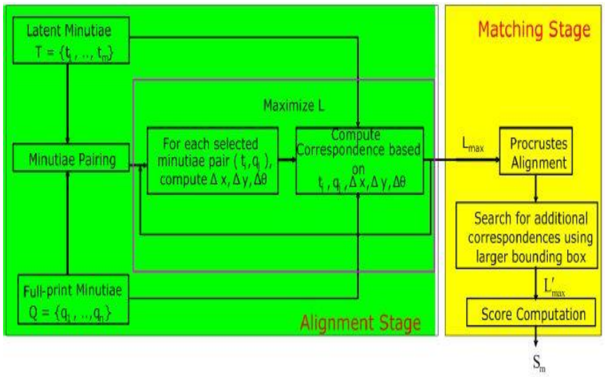

Fig 2: Schematic diagram of the proposed minutiae-base matcher for matching latent images to full-print images [3].

Jianjiang Feng et al. proposed a new method which fuses the two types of fingerprints which are rolled and plain fingerprints. The rolled fingerprints are of larger size and contain more minutiae and plain fingerprints are less affected by distortion and have clearer ridge structure, this can improve the accuracy of latent matching. To fuse the rolled and plain fingerprints they considered three different levels as rank, score and feature levels. In rank level, two rank level fusion methods are adopted: highest rank and Borda count. In the highest rank method, fingers are sorted with respect to the higher rank of plain and rolled fingerprints. The Borda count method uses the sum of the ranks of plain and rolled fingerprints to sort fingers. In the Score level, five score level fusion rules are tested: min, max, sum, product and boosted max. The purpose of the boosted max is to boost the score of genuine matches. In the feature level, three types of region are identified: common region and the rolled-only region, the ridge orientation and quality of the rolled fingerprint are adopted. In the plain only region, the ridge orientation and quality of the plain fingerprint are adopted. The eventual goal of fusing rolled and plain fingerprints is to obtain full fingerprints of high quality [8].

Soweon Yoon et al. proposed a latent fingerprint enhancement algorithm, which only requires minimal markup (ROI and singular points) to improve the automatic matching accuracy. The orientation field of the latent is estimated by RRANSAC which is effectively used to find a correct orientation field model in the presence of noise and distortion. The estimated orientation field is used to enhance ridge structures by Gabor filtering. Given a set of orientation element groups as the input, hypotheses for residual orientation field are built based on the randomized Random Sample Consensus (R-RANSAC) algorithm. Generally, RANSAC algorithms consist of three basic steps: (i) select a set of initial data points randomly, (ii) build a hypothesis, and (iii) evaluate the hypothesis. A set of data points that are consistent with a given hypothesis is called consensus set. The proposed algorithm significantly improved the matching performance of a commercial matcher when the enhanced latent fingerprint image is fed into the matcher [9].

Soweon Yoon et al. proposed a latent fingerprint enhancement algorithm which requires manually marked region of interest (ROI) and singular points. The core of the proposed enhancement algorithm is a novel orientation field estimation algorithm, which links orientation field model to coarse orientation field estimated from skeleton outputted by a commercial fingerprint SDK. Most orientation field estimation algorithms consist of two steps: initial estimation using a gradient based method followed by regularization. For regularization a simple weighted averaging filter or more complicated model-based methods are used. For effective regularization, it is better to use only reliable initial estimate or to give it larger weight. However, very limited information is available at this stage to estimate the reliability of initial estimate. To overcome this limitation, they estimate a coarse orientation field from skeleton image generated by a commercial SDK. This coarse orientation field is further regularized by fitting an orientation field model to it. The matching accuracy of the commercial matcher was significantly improved [10].

3. METHODOLOGY

The latent fingerprint is matched with rolled fingerprint images is crucial task, because in latent fingerprint images are not much clear to extract easily all features for matching with rolled or plain fingerprint image. The problems arises in latent prints are,

a. Sometimes more noise is present in the image

b. Some images having highly distorted prints.

c. May be overlapped with other prints or contain any dust particles.

d. Poor Quality latent which do not have any clear ridge structure.

e. Latent prints contain the ridge breaks, spikes, etc.

For this it is necessary to overcome this entire problem before processing for matching, by using noise reduction algorithm it is possible to reduce noise present in images. The overview of system is shown in Figure 3, Firstly take latent image and rolled fingerprint image as an input and performing feature marking step in which all the available features of input latent print are marked then extract all features of rolled fingerprint such as minutiae, orientation field and quality map[2],[4].Minutiae consists of five attributes, namely x, y, minutiae direction, type and quality, where x and y represent the position of the minutiae. The quality of minutiae is defined as reliable or unreliable. Orientation field and quality map are obtained by dividing the whole image into blocks of size 16 * 16 pixels and assigning a single orientation and quality value to each block [4].

3.1 Baseline Matching Algorithm

After feature extraction, minutiae matching between latent and rolled fingerprint using Baseline Matching Algorithm consist of following steps [2],

a. Local Minutiae Matching: In this step similarity between each minutia of latent and rolled fingerprints is computed.

b. Global Minutiae Matching: In this step most takes similar pairs found in step 1 as an initial minutia pair and then by applying Greedy approach used to find minutiae matching pairs in decreasing order.

c. Score Computation: Then finally compute the matching score of each minutiae pair and takes highest score between latent and rolled print.

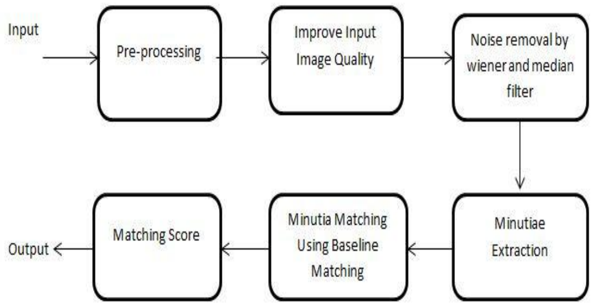

Fig 3: Overview of System

Along with this method there is need to find additional features of latent fingerprints.

3.2 Additional Features

Following are the additional features also computed for improving accuracy of matching, because in law enforcement database bad images also contains therefore this features are useful , Figure 4 shows how the original image features are extracted. The additional features are as following [2],

a) Reference Point

b) Ridge Quality Map

c)Ridge Flow Map

d)Ridge Wavelength Map

e)Skeleton

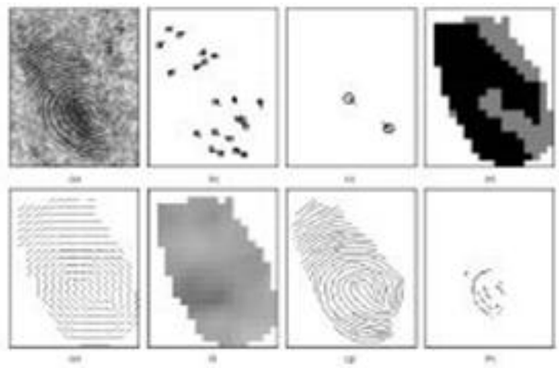

Fig 4: Features in a latent fingerprint: (a) grey-scale image, (b) minutiae, (c) singular points (cores), (d) ridge quality map (darkness indicates high-quality level), (e) ridge flow map, (f) ridge wavelength map, (g) skeletonized image, and (h) dots and incipient ridges [2].

3.3 Problem Arises in Latent Fingerprint Matching Approach

There are number of techniques for latent to rolled or plain fingerprint matching but some problem arises are,

1) Poor quality of latent images which do not contain any clear ridge structure.

2) Latent prints contain the ridge breaks, spikes, etc.

3) Preprocessing techniques need to enhance the ridge features.

4) Sometimes required filtering techniques to remove useless ridges and various noise.

5) Latent prints may be overlapped with other prints or contain any dust particles.

6) Each fingerprint contains different type of noise.
7) It is difficult to extract all necessary features from latent image.
8) Numbers of algorithms are available for plain fingerprint matching but it is quite difficult to match latent prints with rolled fingerprint prints.
9) Need to implement one common technique that can remove each type of noise.
10) Need to improve quality of ugly type of latent prints.
11) Difficult to maintain large amount of data

4. OBJECTIVE

Our objective is to implement system discussed above by making some crucial changes. We take NIST SD27 database; this database contains 1000ppi latent fingerprint images and paired rolled fingerprint images. Firstly we need to improve quality of latent prints then by using noise filtering techniques remove noise of latent image then processing it for feature extraction and matching over rolled fingerprint image..

5. CONCLUSION

The latent fingerprint images are found unintentionally in crime sense. Match this fingerprint over original rolled or plain images is very difficult task. Due to poor quality of image is processed under various stages to obtain clearer image for matching with paired image. Here we studied various approaches that are available for latent fingerprint matching. Our goal is to enhance quality of ugly type latent prints also matching accuracy over rolled fingerprint image.

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