Paradigm shift in fingerprint recognition on pressure variation and impact of information system in crime reduction

Rajendra Kumar
Vidya College of Engineering, Meerut
rajendra04@gmail.com

Saurabh Sharma
Vidya College of Engineering, Meerut
sam7sai@gmail.com

ABSTRACT

- *Fingerprint identification from a random offline fingerprint image has become a very actively studied field in biometric systems. This paper investigates the possibility to prepare a framework of applying the latent fingerprint obtained from a crime scene to be shared in a central data base. These fingerprints may be extremely useful to reduce the crimes from a country. In this approach each citizen is supposed to put his/her fingerprint in an organization during entry. This fingerprint will be matched to the central database for checking whether the fingerprint of that citizen matched with any finger print taken from a crime scene. The information system of an organization thus will be able to reveal the suspicious citizens causing to be investigated for further action. The quality of the fingerprint images greatly affects the performance of the minutiae extraction. The photo graph taken from different distances, uneven surface, different finger pressure, dust particles pose problems during recognition process. Improper finger pressure and uneven surface are the major cause to produce breaks in curves in a fingerprint. In order to improve the performance of the system, many researchers have been made efforts on the image enhancement algorithms. Most of the fingerprint recognition algorithms are based on minutia matching features. Therefore, minutiae extraction is one of the important steps in fingerprint verification algorithms. In this paper we present an algorithm to fill the broken curves on a fingerprint due to low finger pressure and uneven surface. Our proposed approach eliminates false minutiae that connect broken curves in fingerprint.*

KEYWORDS

- **Biometrics**
- **Minutiae**
- **Ridge**
- **Furrows**
- **FRR**
- **FAR**
- **m_connectivity**
- **m_margin**

1. Introduction

The term "biometrics" [1] is commonly used today to refer to the authentication of a person by analyzing the physical characteristics (like fingerprints) or behavior characteristics. Fingerprint matching is one of the widely used biometric techniques in automatic personal identification or verification, because of its robustness and its justified implementation cost.

When we talk about the performance of biometric systems high FRR (false rejection rate) and low FAR (false acceptance rate) are our major concerns. False Rejection Rate and False Acceptance Rate are complementary in determining how severe a biometric device is in allowing access to individuals. In general, biometric devices commonly include features to allow for sensitivity settings or variable threshold.

2. Background

The fingerprints obtained from the crime scenes are of very bad quality because these are left unintentionally. Such fingerprints are called latent fingerprints. Poor quality fingerprint images lead to missing and spurious minutiae that degrade the performance of fingerprint matching system. The importance of image processing concepts cannot be ruled out to make a biometric method robust. However, the performance of a minutiae extraction algorithm relies heavily on the quality of the input fingerprint images. Some special treatment is done to reveal such fingerprints. The most obvious structural characteristic of a fingerprint is the pattern of interleaved ridges and branches that often run in parallel. Other important features called minutiae (the end point and branching point) refer to ridge discontinuities. The minutiae are characteristic features of fingerprints that conclude their uniqueness. These are some special points in the fingerprint responsible for identification. In general, they are termed as ridge endings and ridge bifurcation. Most frequently the minutiae types can be separated by terminations, where a ridgeline ends, and bifurcations, where a ridge bifurcates forming a branch. The minutiae can be used in fingerprint matching since they represent unique details of the ridge flow and are considered as a proof of identity. However, shown by intensive researches on fingerprint recognition, their ridges and burrows do not distinguish fingerprints, but by Minutia, which are some abnormal points on the ridges.

3. Why we do not get good quality fingerprint images

Several factors determine the quality of a offline fingerprint image [5]: skin conditions (e.g. dryness, wetness, dirtiness, temporary or permanent cuts and bruises), user cooperation, uneven surface, etc. Some of these factors cannot be avoided and some of them vary along the time.

Practically, the quality of a fingerprint image depends on the clearness of separated ridges by valleys and the uniformity of the separation. Although the change in physical conditions such as temperature and pressure might influence a fingerprint image in different ways, the humidity and oily finger dominate the overall quality of the fingerprint [2]. Dry skin tends to cause inconsistent contact of the finger ridges over the surface at crime scene, causing broken ridges and many white pixels replacing ridge structure (see Fig. 1 (c)). Opposing to the valleys on the oily skin tend to fill up with moisture, causing them to appear black in the image similar to ridge structure.

Figure 1. (a) **Oily Image**

Oily Fingerprint Image: Although the separation of ridges and valleys is clear in an oily fingerprint image, but some portion of valleys are filled up causing them to appear dark or neighboring ridges stand close to each other in many regions. The oily fingerprint tends ridges to be very thick.

Figure 1. (b) **Neutral Image**

Figure 1. (c) Dry Image

Neutral Fingerprint Image: Generally, such image has no special properties such as presence of oil and dryness. There is no need of preprocessing steps in case of online image.

Dry Fingerprint Image: The ridges are rough locally and there are many broken curves in the ridges.

4. Our Proposed Model

In order to reduce crimes, our proposed model collects the latent fingerprints from the crime scenes captured by a high quality camera. The digitized fingerprints are stored in a central database, which are accessed zone wise. When a citizen enters in an organization, he has to put his fingers on scanner connected to an information system shared by a zonal database of fingerprints. If the fingerprints of the citizen are matched to any latent fingerprint stored in existing database then that citizen is suspicious and he/she is supposed to be interrogated by the police. There are maximum chances that such person may be criminal. Our proposed model is

Shown by figure 2.

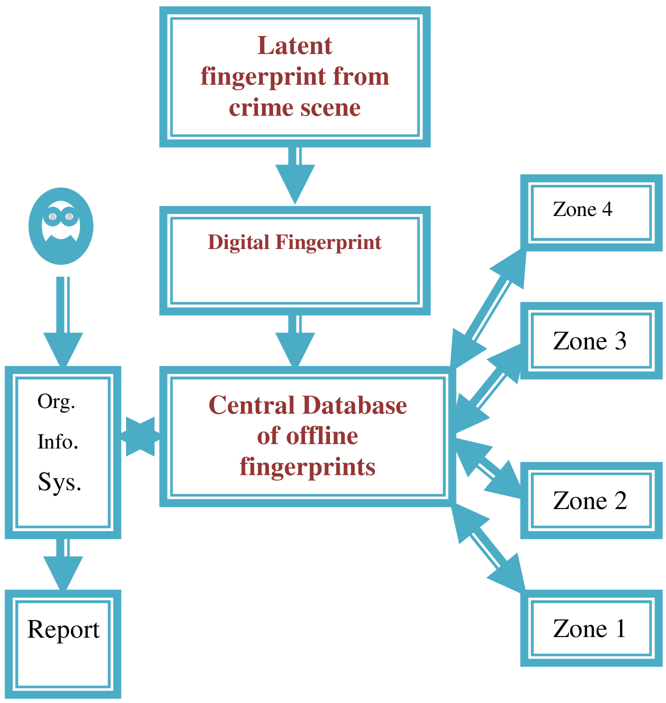

Figure 2. Our proposed model

5. Manipulations with fingerprint image

The performance of a fingerprint image-matching system depends greatly on the quality of the input fingerprint images [1]. Acquisition of good quality images is very important (especially in case of latent fingerprints), but due to some environmental factors or user's body condition, a significant percentage of acquired images are of unacceptable quality for a computerized identification system in practice [2]. The poor quality images produce many spurious minutiae and many genuine minutiae may be ignored. Therefore an image enhancement algorithm is necessary to increase the performance of the minutiae extraction algorithm.

When the feature extraction is performed using the operations binarization and thinning, the triangles, bridges, spurs, opposing minutiae, ladders are some of the structures leading to invalid minutiae detection. Gray level based feature extraction methods such as the ridge base approach are proposed by Maio and Maltoni [4] can eliminate many of the sources of error that are caused by binarization and thinning operations.

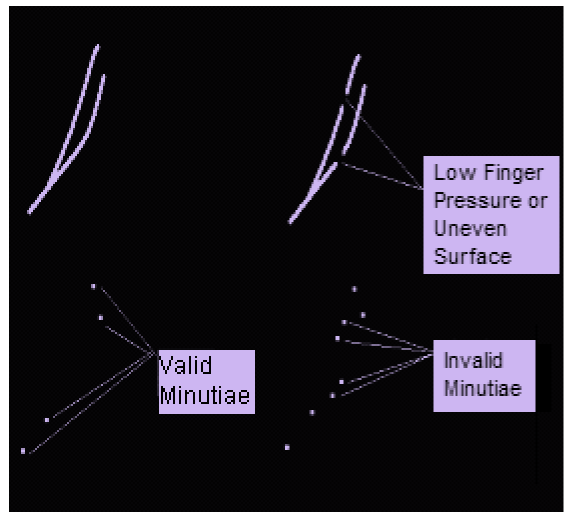

Figure 3. Extraction of invalid minutiae due to presence of dust particles or cut on finger

6. Extractions of valid and invalid minutiae

The basic reason behind false minutiae is the presence of dust particles, oily fingers, dry fingers, and cut on finger. Dry finger may fail to produce a complete line/curve up to the actual end points. As a result the break points create false (invalid) minutiae as seen in figure 4(a). These false minutiae significantly affect the accuracy of matching if they are simply regarded as genuine minutia. Therefore some algorithms of removing false minutia are crucial to keep the fingerprint verification system efficient.

7. Manipulation to eliminate invalid minutiae

Before minutiae marking two operations fingerprint image Binarization and thinning respectively are performed.

- **Fingerprint Image Binarization** - Fingerprint image binarization is the process to transform the 8-bit Gray level fingerprint image to a 1-bit (binary) image with 0-value for ridges and 1-value for furrows. After this operation, ridges in the fingerprint are tinted with black color while the furrows are white.

- **Thinning** - This turns a binary image to a one pixel wide skeleton image. Thinning operation is must to extract minutiae by determining end points in right way.

- **m_connectivity** – This operation is used to refine the skeleton. This is very important manipulation with thinned fingerprint image to achieve high FRR.

- **m_margin** – We propose the new manipulation m_margin with m_connected thinned fingerprint image to make matching system more robust. This manipulation increases length of curves by adding white pixel at each end. Although the minutiae marking positions are diverted one pixel far away from the actual position, but as a final result FRR is improved due to elimination of some false (invalid) minutiae as shown in figure 4(b). It filters out all the valid end points.

1	0	0	0	0	0	1	0
0	1	0	0	0	1	0	0
0	0	1	0	1	0	0	0
0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0
0	1	0	0	0	1	0	0
0	0	1	0	0	0	1	0
0	0	0	1	0	0	0	1

Figure 4 (a) Thinned image with false minutiae (Blue),

1	0	0	0	0	0	1	0
0	1	0	0	0	1	0	0
0	0	1	0	1	0	0	0
0	0	0	1	0	0	0	0
1	0	0	0	1	0	0	0
0	1	0	0	0	1	0	0
0	0	1	0	0	0	1	0
0	0	0	1	0	0	1	1

Figure 4. (b) Thinned image after m_connectivity

8. Experiments and results

We used a database of 1000 fingerprints of 50 different persons at different pressures. At low pressure we got fingerprints with false minutiae due to discontinuation of curves. To eliminate this kind of false minutiae we manipulated the finger print images by increasing the length of each curve having at lest three pixels as shown in figure 4(b). This way the rate of successful matching is increased by 10% we performed.

The fingerprint images obtained at minimum and maximum pressure are shown in figure 5(a) and (b) respectively.

(a)

(b)

Figure 5. Fingerprint image at (a) minimum pressure (b) maximum pressure

During the experiments we have seen that if the finger pressure difference between the images of the same finger was ± 10% we got 98% result for true matching.

9. Concluding remarks

With the help of our proposed model, the crimes can be reduced by observing the suspicious persons. For this purpose we will have to use a robust fingerprint matching system, which is shared centrally. The performance of fingerprint identification system relies critically on the image quality. Hence, good quality images make the system performance more robust. However, it is very difficult to obtain good quality fingerprint images from the crime scenes. To overcome this problem, the image enhancement/manipulation steps are applied. But, most of the enhancement algorithms are applied equally to images without considering the image characteristics.

References

[1] Stefano Bistarell, Francesco Santini, and Anna Vaccarelli, "An Asymmetric Fingerprint Matching Algorithm for Java Card™"

[2] Eun-Kyung Yun, Jin-Hyuk Hong, and Sung-Bae Cho, "Adaptive Enhancing of Fingerprint Image with Image Characteristics Analysis"

[3] Sharat Chikkerur, Venu Govindaraju, Sharath Pankanti, Ruud Bolle, Nalini Ratha, "Novel Approaches for Minutiae Verification in Fingerprint Images", Proceedings of the Seventh IEEE Workshop on Applications of Computer Vision (WACV/MOTION'05) 0-7695-2271-8/05

[4] D. Maio and D. Maltoni. Direct gray scale minutia detection in fingerprints", *Transactions on PAMI*, 19(1), 1997.

[5] J. Fierrez-Aguilar, L.-M. Mu.noz-Serrano, F. Alonso-Fernandez and J. Ortega-Garcia, " On The Effects Of Image Quality Degradation On Minutiae- And Ridge-Based Automatic Fingerprint Recognition"

[6] Sharath Pankanti Salil Prabhakary Anil K. Jain, "On the Individuality of Fingerprints", 2002

[7] Asker M. Bazen, Martijn van Otterlo, Sabih H. Gerez, Mannes Poel , "A Reinforcement Learning Agent for Minutiae Extraction from Fingerprints", 2004

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