# Minutiae Fingerprint Reconstruction To Image

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**Abstract -** In finger print matching, the set of minutia points is considered to be the most distinctive feature for fingerprint representation and is widely used. The original fingerprint image from which minutiae were extracted, it was believed that the minutiae set does not contain sufficient information to reconstruct. To reconstruct fingerprint images from their minutiae representations, recent studies have shown that it is indeed possible. Improving the template interoperability, and improving fingerprint synthesis, reconstruction techniques demonstrate the need for securing fingerprint templates. But, there is still a large gap between the matching performance obtained from original fingerprint images and their corresponding reconstructed fingerprint images. In terms of orientation patch and continuous phase patch dictionaries to improve the fingerprint reconstruction, in this paper, the prior knowledge about fingerprint ridge structures is encoded. While the continuous phase patch dictionary is used to reconstruct the ridge pattern, the orientation patch dictionary is used to reconstruct the orientation field from minutiae. Experimental results on three public domain databases (FVC2002 DB1_A, FVC2002 DB2_A, and NIST SD4) demonstrate that the proposed reconstruction algorithm outperforms the state-of-the-art reconstruction algorithms in terms of both: 1) spurious minutiae and 2) matching performance with respect to type-I attack (matching the reconstructed fingerprint against the same impression from which minutiaeset was extracted) and type-II attack (matching the reconstructed fingerprint against a different impression of the same finger).

**Keywords***:* Fingerprint reconstruction, orientation patch dictionary, continuous phase patch dictionary, minutiae set, AM-FM model.

## 1. INTRODUCTION

Fingerprints are ridge and valley patterns present on the surface of human fingertips. The purported uniqueness of fingerprints is characterized by three levels of features. Global features, such as pattern type, ridge orientation and frequency fields, and singular points, are called level-1 features. Level-2 features mainly refer to minutia points in a local region; ridge endings and ridge bifurcations are the two most prominent types of minutiae. Level 3 features include all dimensional attributes at a very fine scale, such as width, shape, curvature and edge contours of ridges, pores, incipient ridges, as well as other permanent details. Among these three types of features, the set of minutia points (called minutiae) is regarded as the most distinctive feature and is most commonly used in fingerprint matching systems. The purpose of interoperability of matching algorithms, an international standard ISO/IEC 19794-2 has been proposed for minutiae template representation. To evaluate fingerprint matching algorithms using this standard minutiae template format, FVC-on Going, a well-known web-based automated evaluation platform for fingerprint recognition algorithms, has set up a benchmark. However, it has been demonstrated that it is indeed possible to reconstruct the fingerprint image from the minutiae; It was believed that it is not possible to reconstruct a fingerprint image given its extracted minutiae set. The reconstructed image can be matched to the original fingerprint image with a reasonable high accuracy. There is still a room for improvement in the accuracies, particularly for type-II attack. To make the reconstructed fingerprint resemble the original fingerprint, the aim of fingerprint reconstruction from a given minutiae set. A successful reconstruction technique demonstrates the need for securing fingerprint templates. Such a technique would also be useful in improving the matching performance with ISO templates as well as addressing the issue of template interoperability. It also could be used to improve synthetic fingerprint reconstruction and restore latent fingerprint images. Existing reconstruction algorithms essentially consist of two main steps: i) orientation field reconstruction and ii) ridge pattern reconstruction. The orientation field, which determines the ridge flow, can be reconstructed from minutiae and/or singular points. In, a set of minutiae triplets was proposed to reconstruct orientation field in triangles without using singular points. The algorithm proposed by Feng and Jain predicts an orientation value for each block by using the nearest minutia in each of the eight sectors. The approaches in reconstructed orientation field from minutiae to improve the matching performance. The orientation field was reconstructed from the singular points (core and delta) using the zeropole model. However, the orientation field in fingerprints cannot simply be accounted for by singular points only. Cappelli et al. proposed a variant of the zeropole model with additional degrees of freedom to fit the model to the minutiae directions. However, the orientation field reconstructed based on zero-pole model cannot be guaranteed when the singular points are not available. However, these orientation reconstruction approaches, based on given minutiae, do not utilize any prior knowledge of the fingerprint orientation pattern and may result in a non-fingerprint-like orientation field. The other step in fingerprint reconstruction is ridge pattern reconstruction based on the reconstructed orientation field. The ridge pattern reconstruction proposed only generates a partial skeleton of the fingerprint, which is obtained by drawing a sequence of splines passing through the minutiae. This method was further improved by using linear integral convolution to impart texture-like appearance and low-pass filtering to get wider ridges. However, it can only generate a partial fingerprint, and the resulting ridge pattern is quite different from that of the target fingerprint. The approach proposed is able to reconstruct a full fingerprint image from minutiae points. An image is first initialized by local minutiae prototypes, followed by iterative Gabor filtering with the estimated orientation field and predefined ridge frequency to generate ridge pattern. However, this approach introduces many spurious minutiae around the intersections of regions generated from different minutiae; these spurious minutiae cannot be controlled. Feng and Jain utilized the amplitude and frequency modulated (AM-FM) model to reconstruct fingerprints, where the phase, consisting of continuous phase and spiral phase (corresponding to minutiae), completely determines the ridge structure and minutiae. Continuous phase reconstruction is therefore a critical step in the AM-FM model based fingerprint reconstruction. The continuous phase was obtained by a piecewise planar model. However, the piecewise planar model introduced many spurious minutiae and resulted in visible blocking effects during the continuous phase reconstruction. Instead of using piecewise planar model, Li and Kot reconstructed continuous phase from a binary ridge pattern generated using Gabor filtering with the reconstructed orientation field and predefined ridge frequency; the continuous phase was obtained by subtracting spiral phase from the phase of the binary ridge pattern.

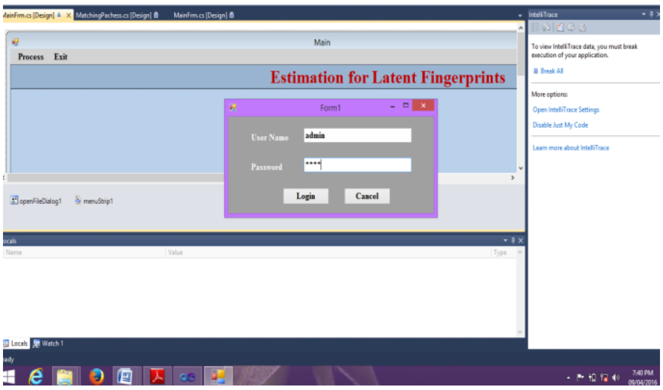
## 2. EXISTING SYSTEM

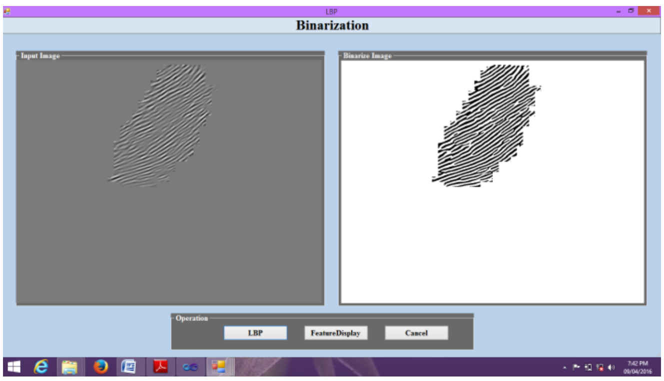
Although several fingerprint reconstruction algorithms have been proposed, the matching performance of the reconstructed fingerprints compared with the original fingerprint images is still not very satisfactory. That means the reconstructed fingerprint image is not very close to the original fingerprint image that the minutiae were extracted from. An important reason for this loss of matching performance is that no prior knowledge of fingerprint ridge structure was utilized in these reconstruction approaches to reproduce the fingerprint characteristics. In the literature, such prior knowledge has been represented in terms of using orientation patch dictionary and ridge structure dictionary for latent segmentation and enhancement. In this paper, our goal is to utilize a similar dictionary-based approach to improve the fingerprint reconstruction from a given minutiae set. Two dictionaries are constructed for fingerprint reconstruction: 1) orientation patch dictionary and 2) continuous phase patch dictionary. The orientation patch dictionary is used to reconstruct the orientation field from a minutiae set, while the continuous phase patch dictionary is used to reconstruct the ridge pattern. Instead of reconstructing continuous phase and spiral phase globally, we propose to reconstruct fingerprint patches using continuous phase patch dictionary and minutiae belonging to these patches; these patches are optimally selected to form a fingerprint image. The spurious minutiae, which are detected in the phase of the reconstructed fingerprint image but not included in the input minutiae template, are then removed using the global AF-FM model. The proposed reconstruction algorithm has been evaluated on three different public domain databases, namely, FVC2002 DB1_A, FVC2002 DB2_A and NIST SD4, in terms of minutiae set accuracy with respect to the given minutiae set and matching performance of the reconstructed fingerprint. Experimental results demonstrate that the proposed algorithm performs better than two state of the-art reconstruction algorithms. The superior performance of the proposed algorithm over can be attributed to: 1) Use of prior knowledge of orientation pattern, i.e., orientation patch dictionary, which provides better orientation field reconstruction, especially around singular points. 2) The sequential process which consists of (i) reconstructing locally based on continuous phase patch dictionary, (ii) stitching these patches to form a fingerprint image and (iii) removing spurious minutiae. Instead of generating a continuous phase and then adding spiral phase to the continuous phase globally, this procedure is able to better preserve the ridge structure. 3) Use of local ridge frequency around minutiae.

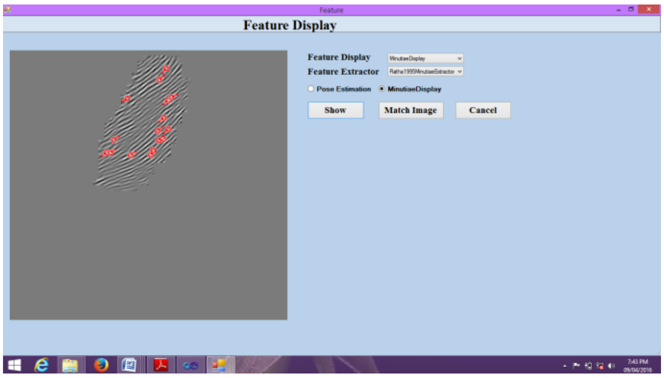
## 3. PROPOSED SYSTEM

Fingerprint matching systems generally use four types of representation schemes: grayscale image, phase image, skeleton image, and minutiae, among which minutiae-based representation is the most widely adopted one. The compactness of minutiae representation has created an impression that the minutiae template does not contain sufficient information to allow the reconstruction of the original grayscale fingerprint image. This belief has now been shown to be false; several algorithms have been proposed that can reconstruct fingerprint images from minutiae templates. These techniques try to either reconstruct the skeleton image, which is then converted into the grayscale image, or reconstruct the grayscale image directly from the minutiae template. However, they have a common drawback: Many spurious minutiae not included in the original minutiae template are generated in the reconstructed image. Moreover, some of these reconstruction techniques can only generate a partial fingerprint. In this paper, a novel fingerprint reconstruction algorithm is proposed to reconstruct the phase image, which is then converted into the grayscale image. The proposed reconstruction algorithm not only gives the whole fingerprint, but the reconstructed fingerprint contains very few spurious minutiae. Specifically, a fingerprint image is represented as a phase image which consists of the continuous phase and the spiral phase (which corresponds to minutiae). An algorithm is proposed to reconstruct the continuous phase from minutiae. The proposed reconstruction algorithm has been evaluated with respect to the success rates of type-I attack (match the reconstructed fingerprint against the original fingerprint) and type-II attack (match the reconstructed fingerprint against different impressions of the original fingerprint) using a commercial fingerprint recognition system. Given the reconstructed image from our algorithm, we show that both types of attacks can be successfully launched against a fingerprint recognition system. Different fingerprint recognition systems store minutiae based fingerprint templates differently. Some store them inside a small token; some can be found in a server database. As the minutiae template is very compact, many take it for granted that the template does not contain sufficient information for reconstructing the original fingerprint. This paper proposes a scheme to reconstruct a full fingerprint image from the minutiae points based on the amplitude and frequency modulated (AM-FM) finger print model. The scheme starts with generating a binary ridge pattern which has a similar ridge flow to that of the original fingerprint. The continuous phase is intuitively reconstructed by removing the spirals in the phase image estimated from the ridge pattern. To reduce the artifacts due to the discontinuity in the continuous phase, a refinement process is introduced for the reconstructed phase image, which is the combination of the continuous phase and the spiral phase (corresponding to the minutiae). Finally, the refined phase image is used to produce a thinned version of the fingerprint, from which a real-look alike gray-scale fingerprint image is reconstructed. The experimental results show that our proposed scheme performs better than the-state-of-the-art technique. A minutiae-based template is a very compact representation of a fingerprint image, and for a long time, it has been assumed that it did not contain enough information to allow the reconstruction of the original fingerprint. This work proposes a novel approach to reconstruct fingerprint images from standard templates and investigates to what extent the reconstructed images are similar to the original ones (that is, those the templates were extracted from). The efficacy of the reconstruction technique has been assessed by estimating the success chances of a masquerade attack against nine different fingerprint recognition algorithms. The experimental results show that the reconstructed images are very realistic and that, although it is unlikely that they can fool a human expert, there is a high chance to deceive state-of-the-art commercial fingerprint recognition systems. Most fingerprint-based biometric systems store the minutiae template of a user in the database. It has been traditionally assumed that the minutiae template of a user does not reveal any information about the original fingerprint. In this paper, we challenge this notion and show that three levels of information about the parent fingerprint can be elicited from the minutiae template alone, viz., 1) the orientation field information, 2) the class or type information, and 3) the friction ridge structure. The orientation estimation algorithm determines the direction of local ridges using the evidence of minutiae triplets. The estimated orientation field, along with the given minutiae distribution, is then used to predict the class of the fingerprint. Finally, the ridge structure of the parent fingerprint is generated using streamlines that are based on the estimated orientation field. Line Integral Convolution is used to impart texture to the ensuing ridges, resulting in a ridge map resembling the parent fingerprint. The salient feature of this noniterative method to generate ridges is its ability to preserve the minutiae at specified locations in the reconstructed ridge map. Experiments using a commercial fingerprint matcher suggest that the reconstructed ridge structure bears close resemblance to the parent fingerprint.

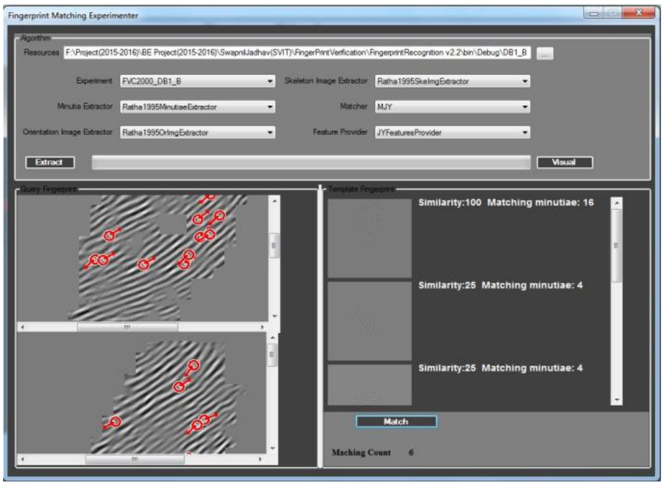
## 4. RESULT



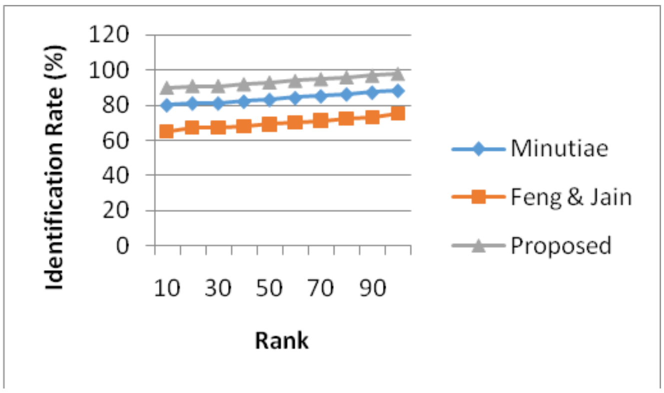






Output




Analysis Graph




The comparative results confirm that the proposed reconstruction algorithm performs better than the two state-off heart reconstruction algorithms of minutiae and feng and jain.

| | Minutiae | Feng & Jain | Proposed |
|---|---|---|---|
| 10 | 80 | 65 | 90 |
| 20 | 81 | 67 | 91 |
| 30 | 81 | 67 | 91 |
| 40 | 82 | 68 | 92 |
| 50 | 83 | 69 | 93 |
| 60 | 84 | 70 | 94 |
| 70 | 85 | 71 | 95 |
| 80 | 86 | 72 | 96 |
| 90 | 87 | 73 | 97 |
| 100 | 88 | 75 | 98 |

## 5. CONCLUSION

The goal of fingerprint reconstruction is to reproduce the original fingerprint image from an input minutiae set. There are essentially three main reasons for studying the problem of fingerprint image reconstruction from a given minutiae set: (i) to demonstrate the need for securing minutiae template, (ii) to improve the interoperability of fingerprint templates generated by different combinations of sensors and algorithms, (iii) to improve fingerprint synthesis. Despite a significant improvement in the performance of reconstruction algorithms over the past ten years, there is still a discrepancy between the reconstructed fingerprint image and original fingerprint image (from which the minutiae template was extracted) in terms of matching performance. In this paper, we propose a reconstruction algorithm that utilizes prior knowledge of fingerprint ridge structure to improve the reconstructed fingerprint image. The prior knowledge is represented in terms of two kinds of dictionaries, orientation patch and continuous phase patch dictionaries. The orientation patch dictionary is used to reconstruct the orientation field from the given minutiae set, while the continuous phase patch dictionary is used to reconstruct the ridge pattern. Experimental results on three public domain fingerprint databases (FVC2002 DB1_A, FVC2002 DB2_A and NIST SD4) show that the proposed reconstruction algorithm outperforms two state-of-the-art reconstruction algorithms [8] and [9] in terms of reconstructed minutiae accuracy and matching performance for both type-I and type-II attacks. Although the reconstructed fingerprints, as shown in Fig. 13, are very close to the original fingerprints from which the minutiae were extracted in terms of orientation field, ridge frequency field and minutiae distribution, it is still difficult to fool a human expert because the reconstructed fingerprints are ideal fingerprints (without any noise) and have the synthetic appearance. Future work will investigate to make the reconstructed fingerprints more realistic. The proposed method for orientation field reconstruction only considers the local orientation pattern. The use of global orientation prior knowledge as well as singular points may further improve the ridge orientation reconstruction. The ridge frequency field used in this paper can be either a fixed priori or reconstructed from the ridge frequency around minutiae. Future work will investigate frequency field reconstruction directly from the minutiae position and direction.

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