*EEC-521/CIS 634- SOFTWARE ENGINEERING*

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**Learning Fingerprint Reconstruction: From Minutiae to Image**

**ABSTRACT:**

The set of minutia points is considered to be the most distinctive feature for fingerprint representation and is widely used in fingerprint matching. It was believed that the minutiae set does not contain sufficient information to reconstruct the original fingerprint image from which minutiae were extracted. However, recent studies have shown that it is indeed possible to reconstruct fingerprint images from their minutiae representations. Reconstruction techniques demonstrate the need for securing fingerprint templates, improving the template interoperability, and improving fingerprint synthesis. But, there is still a large gap between the matching performance obtained from original fingerprint images and their corresponding reconstructed fingerprint images. In this paper, the prior knowledge about fingerprint ridge structures is encoded in terms of orientation patch and continuous phase patch dictionaries to improve the fingerprint reconstruction. The orientation patch dictionary is used to reconstruct the orientation field from minutiae, while the continuous phase patch dictionary is used to reconstruct the ridge pattern. 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 minutiae set was extracted) and type-II attack (matching the reconstructed fingerprint against a different impression of the same finger).

**EXISTING SYSTEM:**

* 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 existing work, 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.
* In another existing work, 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.

**DISADVANTAGES OF 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.

**PROPOSED SYSTEM:**

* 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.
* The goal of fingerprint reconstruction is to reconstruct a gray-scale fingerprint image based on an input se.
* In this paper, a dictionary-based fingerprint reconstruction method is proposed. Two kinds of dictionaries are learnt off-line as prior knowledge: 1) orientation patch dictionary and 2) continuous phase patch dictionary. For an input fingerprint minutiae set, the orientation patch dictionary is used to reconstruct the orientation field from the minutiae set, while the continuous phase dictionary is used to reconstruct the ridge pattern. In addition, the spurious minutiae introduced in the reconstructed fingerprint are removed using the global AM-FM model.

**ADVANTAGES OF PROPOSED SYSTEM:**

* Given the prior knowledge of orientation pattern (*i.e.*, orientation patch dictionary), the orientation field reconstructed from the proposed algorithm is better than the method proposed in existing; the singular points obtained from the proposed algorithm are very close to the original ones.
* Experimental results demonstrate that the proposed algorithm performs better than two state of- the-art reconstruction algorithms.
* Use of prior knowledge of orientation pattern, *i.e.*, orientation patch dictionary, which provides better orientation field reconstruction, especially around singular points.
* 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.
* Use of local ridge frequency around minutiae.

**SYSTEM ARCHITECTURE:**



**MODULES:**

* Am-Fm Fingerprint Model
* Dictionary Construction
* Orientation Field Reconstruction
* Fingerprint Reconstruction
* Fingerprint Image Refinement

**MODULE DESCRIPTION:**

**Am-Fm Fingerprint Model:**

The AM-FM fingerprint model proposed by Larkin and Fletcher represents a fingerprint image *I* as a hologram, *i.e.*, consisting of 2D amplitude and frequency modulated fringe pattern: *I (x, y)* = *a(x, y)* + *b(x, y)* cos*(ψ(x, y))* + *n(x, y),* (1) where *a(x, y)*, *b(x, y)* and *n(x, y)* are, respectively, the offset, amplitude and noise, which make the fingerprint realistic, and *ψ(x, y)* is the phase which completely determines the ridge structures and minutiae of the fingerprint.

**Dictionary Construction:**

*1) Orientation Patch Dictionary:* The orientation patch dictionary proposed by Feng et al. for latent enhancement is directly utilized as prior knowledge of ridge flow for orientation field reconstruction. The orientation patch dictionary *DO*, consisting of a number of orientation patches, is constructed from a set of high quality fingerprints (50 rolled fingerprint images). An orientation patch consists of 10×10 orientation elements with each orientation element referring to the dominant orientation in a block of size 16 × 16 pixels.

*2) Continuous Phase Patch Dictionary:* The continuous phase patch dictionary, which includes a number of continuous phase patches (without spirals), is constructed through the following steps: i) Fingerprint selection and processing, ii) Orientation patch clustering, iii) Fingerprint patch clustering, iv) Orientation and frequency fields estimation.

**Orientation Field Reconstruction:**

The orientation field is considered only in the foreground region of a fingerprint which is determined by dilating the convex hull of the input minutiae points with a disk-shape mask with a radius of 32 pixels. The image is divided into non-overlapping blocks of size 16 × 16 pixels. For the blocks containing minutiae, their orientations are simply replaced by the directions of their corresponding minutiae (modulated by *π*). Since the minutiae points are usually non-uniformly distributed (sparsely distributed in some regions), it is difficult to select representative orientation patches from *DO* in the region without minutiae or with one or two minutiae. Orientation patch dictionary, therefore, cannot be used to reconstruct the orientation field directly. In order to address this problem, orientation density is introduced, and the orientations of blocks with low orientation density values are interpolated iteratively using Delaunay triangulation.

**Fingerprint Reconstruction:**

The continuous phase patch dictionary is used to reconstruct fingerprint image patches based on the reconstructed orientation field and ridge frequency field. Global optimization is then adopted to obtain the reconstructed fingerprint image.

1. *Fingerprint Patch Reconstruction:* For a patch *p* of size 48 × 48 pixels in the initial image (only the reconstructed orientation field and ridge frequency field are available), its orientation field *θp* with 3 × 3 blocks and average frequency *f p* are obtained from the reconstructed orientation field and frequency field. The minutiae can be added by combining the continuous phase patch and the spiral phase computed from the minutiae in a patch.
2. *Fingerprint Image Reconstruction:* The fingerprint image reconstruction can now be viewed as a combinatorial optimization problem similar to fingerprint orientation reconstruction.

**Fingerprint Image Refinement:**

We adopt the global AM-FM model to remove the spurious minutiae from the reconstructed image *I.* The block wise orientation field is expanded to pixel-wise orientation field. The orientation unwrapping method proposed in is adopted to obtain the unwrapped orientation field *Ou*. For orientation field with singular points, there are horizontal discontinuity segments, which will introduce discontinuity in the unwrapped orientation field and then in the phase image. After all discontinuity segments have been considered, Gabor filtering is used to smooth the fingerprint region around these discontinuity segments, and demodulation is used again to obtain the final phase image and then final reconstruction.

**SYSTEM REQUIREMENTS:**

**HARDWARE REQUIREMENTS:**

* System : Pentium IV 2.4 GHz.
* Hard Disk : 40 GB.
* Floppy Drive : 1.44 Mb.
* Monitor : 15 VGA Colour.
* Mouse : Logitech.
* Ram : 512 Mb.

**SOFTWARE REQUIREMENTS:**

* Operating system : Windows XP/7.
* Coding Language : C#.net
* Tool : Visual Studio 2010
* Database : SQL SERVER 2008

**REFERENCE:**

Kai Cao and Anil K. Jain, *Fellow, IEEE*, “Learning Fingerprint Reconstruction: From Minutiae to Image”, **IEEE TRANSACTIONS ON INFORMATION FORENSICS AND SECURITY, VOL. 10, NO. 1, JANUARY 2015.**