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Enhanced Latent Fingerprint Segmentation through Dictionary Based Approach

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Abstract— The accuracy of latent finger print matching compared to roll and plain finger print matching is significantly lower due to background noise, poor ridge quality and overlapping structured noise in latent images. In this paper the proposed algorithm is dictionary-based approach for automatic segmentation and enhancement towards the goal of achieving "lights out" latent identifications system. Total variation decomposition model with L1 fidelity regularization in latent finger print image remove background noise. A coarse to fine strategy is used to improve robustness and accuracy. It improves the computational efficiency of the algorithm.

Keywords- Latent finger print, image decomposition, ROI, segmentation, ridge enhancement.

I. INTRODUCTION

Latent fingerprints refer to fingerprints got from the surfaces of objects acknowledgeable touched or handled by a person typically at crime scenes. Compared to rolled and plain finger prints, latent finger print is typically poor in quality and complex background noise. Due to this problem latent finger print accuracy is much lower.

The main challenging problem in latent identification system is how to automatically extract reliable features in latent, especially latent with poor quality. The various features are proposed like ROI (Region of Interest), singular points and minutiae detection.

The human factor issue in latent examinations has raised some reliability and repeatability. Brandon Mayfield case is involved to identify mistakes based on latent matching. The lights out capability develop a fully automatic latent feature extraction module. This is highly desirable to

(i) Increase the throughput of latent matching systems,

(ii) Improve repeatability of latent feature extraction and,

(iii) Increase the compatibility

Between features extracted in the latents and features extracted in reference images.

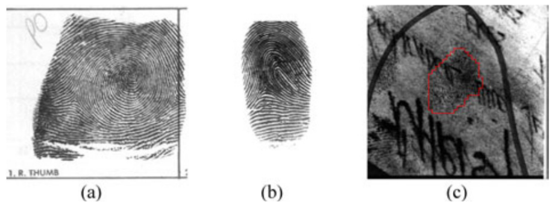

Figure.1Three types of fingerprint images. (a) Rolled fingerprint, (b) plain fingerprint, (c) latent fingerprint with foreground (friction ridge pattern) highlighted by red outline. Notice the presence of different types of noise and distortion in (c).

Commonly rolled/plain print matching or latent matching typically contains a number of modules, including region of interest (ROI) Segmentation (separating friction ridge from background), enhancement, feature extraction, and matching.

To address the two main difficulties in latent fingerprint matching, namely presence of structured noise and poor quality of ridge structure, we propose a dictionary-based segmentation and enhancement of latent fingerprint. To remove the structured noise, the total-variation model with L1 fidelity regularization is used to decompose a latent into a texture part and a cartoon part. The main contributions of this paper are as follows:

1. Ridge structure dictionary is proposed for latent segmentation and enhancement. The dictionary is learnt from high quality fingerprint patches.

2. The ridge quality of a patch is defined as the structural similarity between the patch and its reconstruction from the learnt ridge structure dictionary. Orientation and frequency fields of a patch are estimated from its reconstruction.

3. To balance robustness and accuracy, a coarse to fine strategy is proposed which uses dictionaries at two levels of resolution (64×64 and 32×32).

4. The proposed segmentation and enhancement algorithms outperform published algorithms and can also significantly boost the performance of a state of the-art commercial latent matcher on two latent databases (NIST SD27 and WVU DB).

II. RELATED WORK

Various researches have been reported in this related work based on segmentation and enhancement of latent finger print [2]-[6]. The idea of "Latent Fingerprint Enhancement via Robust Orientation Field Estimation" demonstrates the improvement of the automatic match accuracy and it is effective which help to find a correct orientation for latent fingerprint algorithm. [1].Hence it improved the performance of the orientation field.

The Short Time Fourier Transform (STFT) improves the evaluation of the enhancement algorithm. The STFT analyses consider the improvement only in matching the accuracy of the poor quality print [15]. It uses some set of data base images for analysis purposes, which shows 17% of improvement in recognition rate.

The Adaptive Directional Total Variation (ADTV) is derived for the latent fingerprint segmentation. It gives better accuracy in segmentation and enhancement process. Hence it increases the performance of the latent fingerprint feature detection and matching.

For image segmentation and estimation of fingerprint by ridge orientation a systematic method is used [2]. Since the ridge structure is taken by using the Gabor filter method, which improves the matching performance. This systematic method automatically removes the broken ridge. Thus it provides the accuracy in the minutiae detection.

Some of the systematic methods are used for computation of the directional field and singular point of the fingerprint. By using the averaged square gradient and singular-point-extraction the error rate of singular point is improved for the purposes of detecting the low quality fingerprint.

The K-mean Singular Value Decomposition (K-SVD) is used for adaptive dictionaries to achieve the spares single representation [4]. The problem of the scalability in K-SVD is more complement so it can be improved in future.

Latent fingerprint enhancement algorithm is used for finding the region of interest (ROI) and Singular Point (SP) [1]. It improves the accuracy matching for fingerprint which obtains the multiple orientation elements for each image block.

III. PROPOSED ALGORITHM

While current automated fingerprint identification systems have achieved high accuracy in matching rolled/plain prints, latent matching still remains to be a challenging problem and requires much human intervention. The goal of this work is to achieve accurate latent segmentation, which is an essential step towards achieving automatic latent identification. Existing fingerprint segmentation algorithms performs poorly on latent prints, as they are mostly based on the assumptions that are only applicable for rolled/plain fingerprints.

However, the proposed algorithm still does not work well on very poor quality latent fingerprint images. Latent fingerprints found at crime scenes provide crucial evidence to law enforcement agencies. The latents are typically searched against a large fingerprint database which is the collection of rolled/plain fingerprints of previously apprehended criminals. Due to the poor quality of the latents, latent examiners perform manual feature markup and

Visual verification between the latent and the candidate fingerprints from the database.

The latent finger print segmentation and enhancement consists of the following steps:

(i) Latent decomposition
(ii) Coarse level estimation of quality map and orientation and frequency fields.
(iii) Fine level estimation of quality map and orientation and frequency fields.
(iv) Segmentation and enhancement.

A “Lights-Out” mode for latent identification is desired to reduce the burden on latent examiners and to introduce a level of consistency in fingerprint matching, particularly in searching ever growing fingerprint database.

The proposed module latent matching or search is still a challenging problem due to presence of complex background noise and poor quality of friction ridge structure in many latents proposed an automatic latent segmentation and enhancement algorithm based on image decomposition and coarse to fine ridge structure dictionaries. The two different latent fingerprint databases, NIST SD27 and WVU DB, in conjunction with three different COTS matchers show that the proposed algorithm is able to improve the performance of two COTS ten print matchers and can even boost the performance of a state-of-the-art latent matcher by weighted match score fusion. However, the proposed algorithm still does not work well on very poor quality latent fingerprint images.

3.1. Algorithm Overview

The proposed algorithm consists of an off-line dictionary learning stage and on-line stage for segmentation and enhancement. In the off-line stage, two types of dictionaries are learnt:

i) a coarse-level dictionary with patch size of 64 × 64 pixels which is used for coarse estimation of ridge quality map, orientation and frequency fields, and

ii) 16 fine-level dictionaries with patch size of 32 ×32pixels which are used for fine estimation of ridge quality map, and orientation and frequency fields computation;

Given the dictionaries, on-line latent segmentation and enhancement consists of the following steps:

3.1.1. Latent decomposition:

Input latent is decomposed into cartoon and texture images via local total variations, the cartoon image is discarded. The relative reduction rate before and after filtering the image with the low-pass filter measures the local oscillatory behavior which is given by

$$\lambda\sigma(x) = \frac{LTV\sigma(f)(x) - LTV\sigma(L\sigma * f)(x)}{LTV\sigma(f)(x)}$$

where, Lσ is an σ-sized low-pass filter, x belongs to the cartoon part. The relative reduction rate is $\lambda\sigma(x)$

3.1.2. Coarse level estimation of quality map and orientation and frequency fields.

The texture image is divided into overlapping patches of size 64 × 64 pixels. The sparse representation of p can be obtained by solving the following optimization problem using orthogonal matching pursuit. The approximation can be calculated as,$\hat{p} = D_s^c \alpha$, where α is given by

$\alpha = (D_s^{cT} D_s^c)^{-1} D_s^{cT} p$. The residual vector can be calculated as r(p) = p - $\hat{p}$ = p - D_s^{cT} α'

3.1.3. Fine level estimation of quality map and orientation and frequency fields.

The texture image is divided into overlapping patches of size 32 × 32 pixels. Each patch has 32 ×16 or 16 ×32 overlapping pixels with each of its four connected neighboring blocks. For each patch, the coarse ridge orientation value is first used to index the corresponding fine-level dictionary.

The fine estimation of ridge quality map, orientation and frequency fields are computed as coarse estimations.

3.1.4. Segmentation and enhancement

The final quality map Q is computed as the average of coarse level quality and fine level quality by,

$$Q = ½(Q^c + Q^f)$$

The quality map Q is then normalized to the range [0,1]. The orientation and frequency parameters of the filter are tuned based on the fine-level orientation field (υf) and the average frequency of coarse-level frequency field and fine level frequency field (ffþfc)the standard deviation of the Gaussian envelope in the Gabor filter The coarse quality map and fine quality map are combined for latent segmentation. In the foreground of texture image, Gabor filtering based on the orientation and frequency fields applied for latent enhancement.

V. ARCHITECTURAL DIAGRAM

The analysis of Image decomposition ROI segmentation and enhancement using coarse to fine strategy to increase accuracy of latent finger print image. The overview of proposed latent segmentation and enhancement architecture is been shown in fig.2

The latent finger print image is been acquired. Then image decomposition method is used to get the output as textured image. Coarse to fine strategy is used to estimate texture image.

Dictionary construction method using this estimation consists of two types 1. coarse and 2. fine strategy.

Initially the off-line coarse dictionary construction is used and the finger print image is acquired. The path extraction method is applied get training samples of image the finally dictionary learning method is applied to get the outcomes of dictionary elements. The data are been sent to coarse level and quality map, orientation and frequency field are estimated in it.

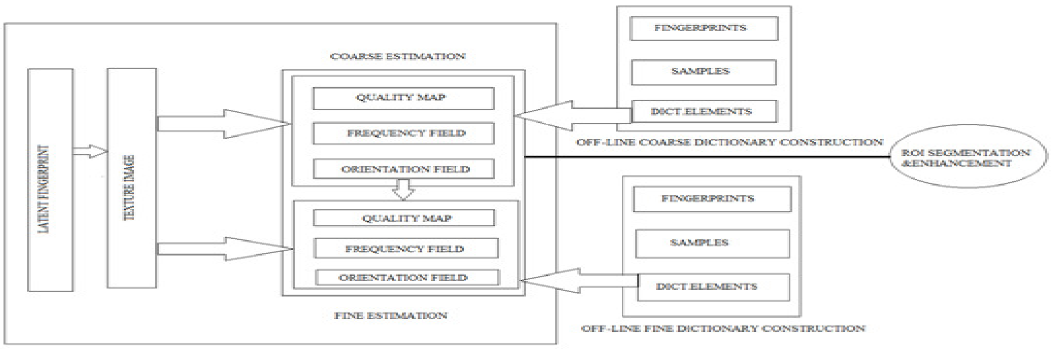

Figure.2 Proposed Latent Segmentation and enhancement architecture

Then apply the same process for the off-line fine dictionary. The off-line fine dictionary construction is used and the finger print image is acquired. The path extraction method is applied get training samples of image the finally dictionary learning method is applied to get the outcomes of dictionary elements. The data are been sent to coarse level and quality map, orientation and frequency field are estimated in it.

The result of latent segmentation and enhancement are derived by combining the coarse estimation and fine estimation which are represented as ROI segmentation.

VI. CONCLUSION

The new method has been proposed to improve the computational efficiency of the algorithm. A coarse to fine strategy is used to improve robustness and accuracy. The latent finger print matching compared to roll and plain finger print matching, accuracy is significantly lower due to background noise, poor ridge quality and overlapping structured noise in latent images. In this paper the proposed algorithm is dictionary-based approach for automatic segmentation and enhancement towards the goal of achieving "lights out" latent identifications system. Obtaining the ROI segmentation and enhancement through coarse to fine ridge strategy.

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