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RESEARCH ARTICLE

Improving Latent Fingerprint Matching Performance by Orientation Field Estimation using Localized Dictionaries

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Abstract— ***Dictionary based orientation field estimation approach has shown great performance for latent fingerprints. In this paper, we use prior knowledge of fingerprints structure to improve the latent fingerprints matching performance. Considering the fact that ridge orientations at different locations of fingerprints have different characteristics, we propose a localized dictionaries-based orientation field estimation algorithm, in which noisy orientation patch at a location output by a local estimation approach is replaced by real orientation patch in the local dictionary at the same location.Dictionary of reference orientation patches is constructed using a set of orientation fields, which is extracted from high quality fingerprints***

The precondition of applying localized dictionaries is that the pose of the latent fingerprint needs to be estimated. Experimental results on challenging latent fingerprint datasets show the proposed method outperforms previous ones markedly

Keywords— ***Latent fingerprint matching, Orientation field, Dictionary, Pose estimation, Hough transform, Markov random field***

I. INTRODUCTION

Latent fingerprints are impressions of fingers left on objects or surfaces. Such impressions are usually not directly visible. There are many challenges in matching such as large distortion, unclear ridges, and complex background etc. Inspired by spelling correction techniques in natural language processing, we propose a novel fingerprint orientation field estimation algorithm based on prior knowledge of fingerprint structure. Latent fingerprints play a crucial role in identifying criminals in many cases. So an effective method to enhance latent fingerprint is necessary to identify the actual culprits.

Problem Statement

We propose a robust fingerprint registration algorithm, which is based on probabilistic voting of all local orientation patches, and a robust fingerprint orientation field estimation algorithm, which is based on localized dictionaries of orientation patches. The outline of the whole system is shown in Fig. 1. Both the registration algorithm and the orientation field estimation algorithm consist of an off-line learning module and an on-line estimation module. In the offline learning stage, the spatial distributions of a set of prototype fingerprint orientation patches and a set of localized dictionaries of orientation patches are learnt based on a set of registered training orientation fields. Given an input fingerprint, the online estimation stage consists of the following steps:

1) An initial orientation field is estimated using local Fourier analysis.

2) The pose of the fingerprint is estimated using a probabilistic voting algorithm which is based on the spatial distributions of prototype orientation patches.

3) Candidate orientation patches are found for each patch in the registered initial orientation field by looking up the localized dictionaries.

4) The final orientation field is determined based on context information.

Motivation of the Proposed Approach

The proposed approach belongs to the family of dictionary based regularization. The difference from the approach in [1] is that, instead of a single dictionary, a set of localized dictionaries are used here. The use of localized dictionaries is motivated by the fact that ridge orientations in different regions of fingerprints have different characteristics. While ridge orientations in the central region of fingerprints are very diverse depending on fingerprint pattern types, ridge orientations in the peripheral region lack variety. In addition, the orientation patches in four different peripheral regions are different from each other. Such characteristics of fingerprint orientation fields have its physiological cause according to fingerprint formation theory. Thus, instead of using a single dictionary of orientation patches for the whole fingerprint as [1], we can construct a separate dictionary of orientation patches for each location. Each dictionary contains only orientation patches which are likely to appear at the corresponding location. By using localized dictionaries to correct noisy orientation fields, we hope that both the non-word errors and the real word errors can be reduced.

II. LITERATURE SURVEY

A. Orientation Field Estimation

Most fingerprint orientation field estimation approaches consist of two steps: local estimation, followed by regularization (or smoothing). In literature survey, we provide a brief review of representative approaches of each step and describe the motivation of our approach.

Local Estimation

Gradient-based, slit-based and local Fourier analysis are the three most widely used local estimation approaches. Gradient-based approaches compute pixel wise gradients and estimate local ridge orientation based on the gradients of local neighborhood. Slit-based approaches analyze the intensity variances along a set of orientations and choose the best orientation according to some measures. Local Fourier analysis approaches compute the Fourier transform of local fingerprint image and estimate dominant ridge orientation by analyzing the magnitude spectrum.

Regularization Based on Local Smoothness

Several orientation field regularization approaches are based on this local smoothness assumption. Low-pass filtering based method is the most commonly used smoothing method. A problem with this approach is that it is difficult to choose a proper size of the filtering window. To resolve the problem, multi-resolution orientation fields are used in several approaches. However, such approaches cannot handle the cases where the initial orientation field is significantly different from the true orientation field. Other commonly used smoothing methods are based on Markov random field (MRF) models and variation approaches. These approaches cannot deal with very poor quality fingerprints either, since they are also based on the simple local smoothness assumption.

Regularization Based on Surface Fitting

Some researchers view orientation field regularization as a surface fitting problem and use general functions, such as, polynomials and Fourier series, to represent fingerprint orientation fields. To address the special discontinuity pattern of singular region, several specific models are proposed, such as the zero-pole model, point-charge model, phase portrait model and quadratic differentials. However, these models are quite general in the sense that they can represent arbitrary orientation fields. Without any constraint on the valid range of parameters, these approaches will generate invalid fingerprint orientation fields in the case of severe noise.

Regularization Based on Dictionary Lookup

Orientation field regularization using a dictionary of real orientation patches is proposed. This method uses an orientation patch dictionary constructed from a set of real fingerprint orientation fields to represent the prior knowledge of fingerprints. Noisy orientation patches outputted by a local estimation approach are replaced by the closest orientation patches in the dictionary. Experimental results on the NIST SD27 latent fingerprint database showed that this approach performs much better than two regularization approaches which are based on smoothing and global surface fitting, respectively.

B. Fingerprint Pose Estimation

In this subsection, we first review several approaches which are related to pose estimation and then describe the motivation of the proposed approach.

Region Mask Based Approach

Pose estimation is relatively simple in the case of rolled fingerprints and slap fingerprints. When a rolled fingerprint is complete and has good quality, the barycenter of the foreground region can be used as the fingerprint center and the direction of the left and right boundaries can be used as the fingerprint direction. For slap fingerprints, a similar approach can be used. However, this type of approach cannot deal with fingerprints which are of poor quality, incomplete, or have irregular shape.

Distinctive Point Based Approach

The requirement of fingerprint indexing is that different impressions of the same finger can be aligned well, while the requirement of statistical modelling is that all fingerprints can be aligned well. Thus, popular fingerprint registration approaches based on some distinctive point (northernmost loop singularity, maximum curvature point or point whose neighbouring orientation field meets some properties) do not meet our requirement. In addition, distinctive point detection approaches cannot properly work when the distinctive region is very noisy or not available, which is very common in latent fingerprints.

Focal Point Based Approach

The location of focal point is defined as the crossing point of straight lines normal to ridges. Since these lines usually do not cross at a single point, the average position or barycentre is used. Since multiple curvature centres might be detected, a separate evaluation step is used to choose the optimal one. Similar to the distinctive point based approach, focal point based approach cannot perform properly when the corresponding area is not available or very noisy.

Motivation of the Proposed Approach

To incorporate the above idea into an algorithm, we can learn the relative distributions of various orientation patches with respect to finger centre in off-line training stage. Given a novel orientation field, we can make prediction based on each orientation patch, accumulate all the predictions and finally detect the peak as the most possible pose.

Such an approach is a type of Hough transform. Hough transform is a general method which has been successfully used to solve a number of computer vision problems, including line detection, arbitrary shape detection , instance detection , object detection , and action recognition . Different from those algorithms, the object here is fingerprint and the voting elements are orientation patches.

III. PROPOSED SYSTEM

Our algorithm reconstructs the orientation fields of component prints by modelling fingerprint orientation fields and then correcting it using dictionary based approach. In order to facilitate this, we utilize the orientation cues of component fingerprints, which are manually marked by fingerprint examiners. This additional mark-up is acceptable in forensics, where the first priority is to improve the latent matching accuracy. The proposed orientation field estimation algorithm consists of an offline dictionary construction stage and an online orientation field estimation stage. In the offline stage, a set of good quality fingerprints of various pattern types (arch, loop, and whorl) is manually selected and their orientation fields are used to construct a dictionary of orientation patches. In the online stage, given a fingerprint image, its orientation field is automatically estimated using model based and dictionary based approach, the proposed orientation field estimation algorithm consists of an off-line dictionary construction stage and an on-line orientation field estimation stage. In the off-line stage, a set of good quality fingerprints of various pattern types (arch, loop, and whorl) are manually selected and their orientation fields are used to construct a dictionary of orientation patches. In the on-line stage, given a fingerprint image, its orientation field is automatically estimated using the following steps:

1) Initial estimation: The initial orientation field is obtained using a local orientation estimation method, such as local Fourier analysis.

2) Dictionary lookup: The initial orientation field is divided into overlapping patches. For each initial orientation patch, its six nearest neighbours in the dictionary are viewed as candidates for replacing the noisy initial orientation patch.

3) context-based correction: The optimal combination of candidate orientation patches is found by considering the compatibility between neighbouring orientation patches.

In the following subsections, we first describe the off-line dictionary construction and then present the three steps in the on-line orientation field estimation algorithm.

Architecture Block Diagram

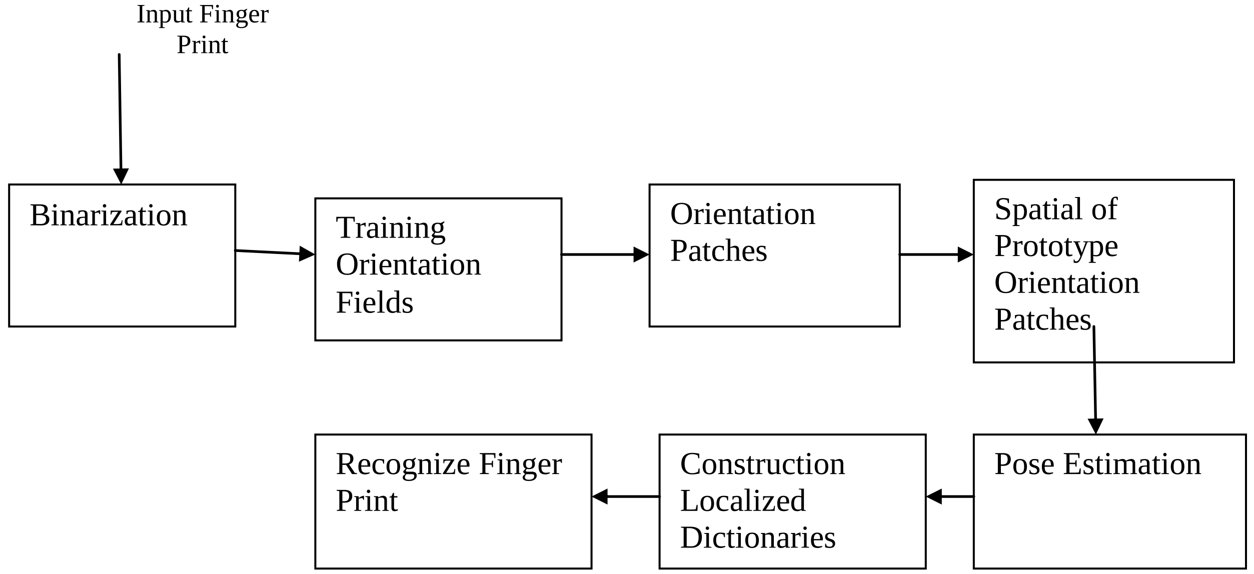


Fig 1Block diagram of system architecture

IV. SYSTEM DESIGN

A. Dictionary Construction

The dictionary consists of a number of orientation patches of the same size. An orientation patch consists of *b* x *b* *ori*entation elements and an orientation element refers to the dominant orientation in a block of size *16* x *16* pixels. Construct a dictionary of orientation patches from a set of high-quality fingerprints (referred to as reference fingerprints). The orientation fields of these fingerprints are estimated using a state-of-the-art algorithm. The direction of the latent fingerprint is unknown; each orientation patch is rotated by 21different angle to generate additional orientation patches. Given these orientation patches, a greedy algorithm is employed to construct a set of reference orientation patches, which forms the dictionary. The greedy algorithm is described below.

1. The first orientation patch is added into the dictionary, which is initially empty.
2. Then test whether the next orientation patch is different from all the orientation patches in the dictionary. If yes, it is also added into the dictionary; otherwise, the next orientation patch is tested.
3. Repeat step 2 until all orientation patches has been tested. The number of reference orientation patches in the dictionary depends on the number of reference orientation fields and the size of the patch.

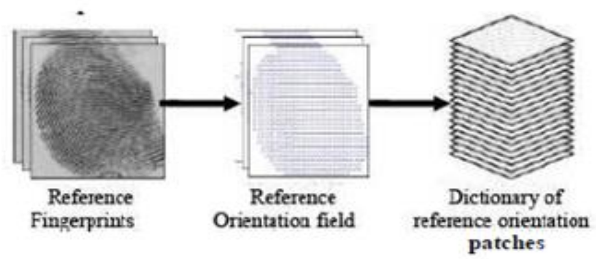


Fig 2 Dictionary construction

B. Quality Estimation

Here the network has been structured for quality estimation in latent fingerprints. Supervised training involves a mechanism of providing the network with the desired output by manually providing the desired output with the inputs. When the input latent image is given, the network then processes the inputs and compares its resulting outputs against the desired output.

Given a set of training data, each marked as belonging to one of two categories, as either good or bad quality latent. An SVM training algorithm build a model that assigns new examples into one category or the other. In addition to performing linear classification, SVMs can efficiently perform a nonlinear classification. The output is finally obtained whether the input latent is good or bad quality fingerprint.

C. Initial Orientation Field Estimation

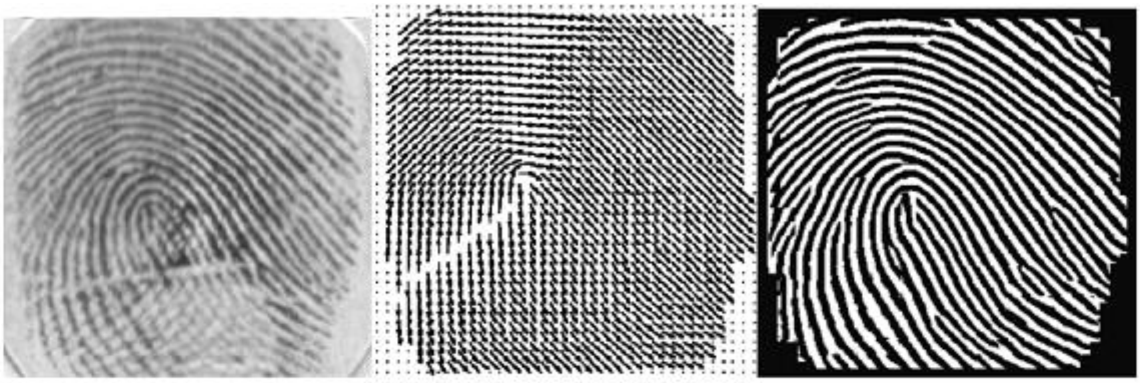
The initial orientation field is obtained using a simple algorithm. Other local estimation algorithms, such as gradient based and slit-based are used. The dominant orientation in a 16 x 16 block is computed by detecting the peak in the magnitude spectrum of the local image. Due to the poor quality of latent's,the initial orientation field is usually very noisy. The problem of correcting a noisy orientation field is left to the later stages, which utilize prior knowledge of fingerprints.

D. Dictionary Lookup

Given an initial orientation patch that contains at least one foreground block, retrieves a list of candidate reference orientation patches from the dictionary, which are sorted according to their similarity with the initial patch. In order to retrieve the correct orientation patches at high rank, proper similarity measure and retrieval strategy need to be designed.

E. Context-Based Orientation Field Correction

After dictionary lookup, *many* candidate patches are generated for each initial patch. Then context-based orientation field correction algorithm is used to select the most proper candidate considering local similarity and neighbourhood compatibility simultaneously.



An illustration of the impact of orientation on fingerprint image restoration, where on the left is a fingerprint image with creases and accidental impression of another person's fingerprint. Based on the estimated orientation field as shown in the middle, the reconstructed image is displayed on the right, which perfectly reduces the problem of crease and latent print.

Fig 3 Result analysis

*Advantages***:** Dictionary lookup using localized dictionaries has two advantages over using a global dictionary:

1) Patches which are not likely to appear in a specific position are avoided.
2) The number of the patches in a localized dictionary is much smaller than the global one.

V. CONCLUSIONS

Inspired by spelling correction techniques in natural language processing, we have proposed a robust orientation field estimation algorithm for latent fingerprint enhancement. A simple local estimation approach is used to obtain an initial orientation field of the latent fingerprint. For each patch in the initial orientation field, candidate patches are found in an orientation patch dictionary learnt from a set of true fingerprint orientation fields. The final orientation field for the latent is obtained by finding the combination of candidates that minimizes an energy function. The experimental results on the challenging NIST SD27 latent fingerprint database showed that the proposed algorithm outperformed two well-known orientation field estimation algorithms.

REFERENCES

[1] IEEE transactions on pattern analysis and machine intelligence, vol. 36, no. 5, may 2014 955 *Localized Dictionaries Based Orientation Field Estimation for Latent Fingerprint* "Xiao Yang, *Student Member, IEEE,* Jianjiang Feng, *Member, IEEE,* and Jie Zhou, *Senior Member, IEEE*

[*2*]S. Yoon, J. Feng, and A. K. Jain, "*Latent fingerprint enhancementvia robust orientation field estimation*," in *Proc. IJCB*, Washington,DC, USA, 2011, pp. 1–8.

[3]Jianjiang Feng, Jie Zhou and Anil K. Jain, *"Orientation Field Estimation for Latent Fingerprint Enhancement,"IEEE Transactions on Pattern Analysis and Machine Intelligence,* Vol 35, No.4, April 2013.

[4] Yuliang He, Jie Tian, Xiping Luo and Tanghui Zhang*, "Image enhancement and minutiae matching in fingerprint verification,"Proceedings of pattern Recognition*, pp. 1349–1360, October. 2002
[5]A.K. Jain and J. Feng, "Latent Fingerprint Matching," *IEEE Transactions on pattern Analysis and Machine Intelligence*, vol.33,no.1, pp.88-100, December 2007.
[6]S. Yoon, J. Feng, and A.K. Jain, *"Latent Fingerprint Enhancement via Robust Orientation Field Estimation,"* Proc. Int'l Joint Conf. Biometrics, 2011.
[7] A.K. Jain and J. Feng, *"Latent Palmprint Matching,"* IEEE Trans. Pattern Analysis and Machine Intelligence, vol. 31, no. 6, pp. 1032- 1047, June 2009.

