Improving latent fingerprint matching performance by orientation field estimation using localized dictionaries

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***Abstract*— Orientation field estimation by using dictionaries approach has shown great performance for latent fingerprints. In this proposed system, we use prior knowledge of fingerprints structure to improve the latent fingerprints matching performance. Considering in account the fact that at different locations of fingerprints ridge orientations have different characteristics, this system propose a localized dictionaries-based orientation field estimation algorithm, in which noisy orientation patch at a specified location found by a local estimation approach is replaced by closet orientation patch in the local dictionary at the same location.Dictionary from reference orientation patches is formed using a set of orientation fields, which is extracted from good quality fingerprints. Before using localized dictionaries latent fingerprint image pose needs to be known by pose estimation algorithm. Proposed system develops an automatic region segmentation algorithm for latent fingerprints with strong structured noise or overlapping fingerprints**

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

I.INTRODUCTION

Latent fingerprints are usually used to validate a person's identity because of its unique characteristics. Latent fingerprints are impressions of fingers left on objects or surfaces. Such impressions are usually not directly visible. There are some challenges in latent fingerprints matching like complex background, large distortion, and Partial fingerprint. By taking the reference from spelling correction techniques in natural language processing, system propose a A created by prior knowledge of fingerprint structure. For that dictionary of reference orientation patches is constructed using a set of orientation fields taken from high quality fingerprints. For orientation field estimation of latent fingerprints, ridge orientation and ridge frequency are important parameters. In this system, we try to use stored prior knowledge of fingerprints to improve the performance. Considering the fact that that ridge orientations at different locations of fingerprints have different characteristics, this system developed a localized dictionaries-based orientation field estimation algorithm, a number of orientation patches extracted from real fingerprints are clustered to form a dictionary fingerprint orientation field estimation algorithm based on prior knowledge of fingerprint structure. Latent fingerprints play an important role in identifying criminals in many cases. So there is requirement of enhancing latent fingerprint to identify the actual criminals. In this method, latent fingerprint is enhanced using prior knowledge of fingerprint structure.

A. PROBLEM DEFINITION

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) Initially orientation field is estimated using techniques such as local Fourier analysis.

2) The pose of the fingerprint is estimated using a probabilistic voting algorithm which is based on the spatial distributions of orientation patches in co-ordinate system.

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.

B. MOTIVATION OF THE PROPOSED APPROACH

The proposed approach belongs to the family of dictionary based regularization. The difference from the approach in [10] 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

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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 [10], 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.

II. LITERATURE SURVEY

1. Hybrid Fuzzy Logic and Neural Network Model For Fingerprint Minutiae Extraction (Vijay Kumar Sagar and Koh Jit Beng Alex) [1999] They discovered fuzzv-neuro technology in fingerprint recognition for the extraction of fingerprint features such as minutia. This combined fuzzy and neural network model does minutiae extraction in two stages, a fuzzy logic at front-end and a neural network at back end.

2. Fingerprint Image Enhancement using Filtering Techniques (S Greenberg, M. Aladjem, D. Kogan and I. Dimitrov) [2000] S.Greenberg et al has proposed two ways for fingerprint image enhancement. In first method they use local histogram equalization, Wiener filtering, and image binarization. In second a unique anisotropic filter is used for grayscale enhancement. The results are better than other systems in terms of efficiency and time.

3. On Latent Fingerprint Enhancement (SoweonYoon, Jianjiang Feng and Anil K. Jain) [2010] Yoon et al. [13] proposed a latent fingerprint enhancement algorithm which requires region of interest (ROI) which is manually markesand singular points. They proposed orientation field estimation algorithm, which fits orientation field model to templete orientation field which is obtained from skeleton obtained from a commercial fingerprint SDK matcher.

4. Paulino A.A, Feng.J and Jain A.K [2011] They Proposed a Latent fingerprint matching by descriptor based Hough transform. In this approach the minutiae template in stored in database for further usage. Given a latent fingerprint and a corresponding rolled fingerprint, we extract more features from both fingerprints, align them in the same coordinate system, and compute a matching score between these two fingerprints. The matching approach uses minutiae and orientation field from both latent and its corresponding rolled prints.

III.PROPOSED SYSTEM

Our algorithm is proposed to reconstruct the orientation fields of component prints by modelling fingerprint orientation fields and then correcting it using dictionary based approach. For this approach, we utilize the orientation knowledge of component fingerprints, which are manually marked by fingerprint examiners. The proposed orientation field estimation algorithm consists of two phases dictionary construction stage and orientation field estimation stage. In the first stage, a set of good quality fingerprints of various different patterns such as loop, whorl and arch is manually selected and their orientation fields are used to construct a dictionary of orientation patches.In the second stage, orientation field of given fingerprint image is automatically estimated using the following steps:

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

2) Dictionary lookup:

In this stage for each initial orientation patch, we looked up in dictionary for retrieving a list of candidate reference orientation patches

3) context-based correction: The noisy orientation patch is corrected using context based information Based on candidate orientation patch

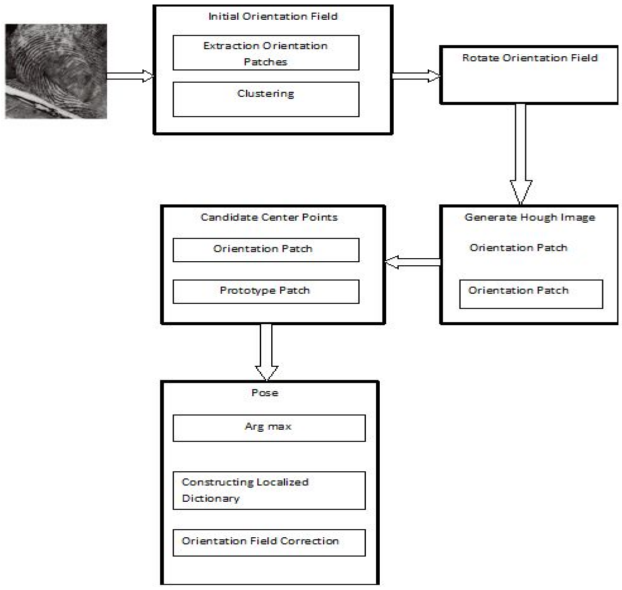

Figure 1: Block diagram of system architecture

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 smaller as compared to global dictionary.

MATHEMATICAL MODEL OF PROPOSED SYSTEM

1) Binarization technique for noise removal
2) Orientation Field Estimation.
3) Finger Center Estimation Algorithm.
4) Pose Estimation Algorithm.
5) Localized Dictionary based algorithm

Let the system be described by S,
S= {D, BT, OF, FC, PE, LDBA, O}

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Where
S: is a System.
D: is set of Datasets
BT: Binarization technique.
OF: Orientation Field Estimation.
FC: Finger Center Estimation Algorithm.
PE: Pose Estimation Algorithm.
LDBA: Localized Dictionary based algorithm.
O: Output.

Activity
D= {d1, d2,…….dn}
LD= {Dictionary}
Y= {BT, OF, FC, PE, LDBA }
Z= {O}
D: is set of Datasets
LD: Set of Localized Dictionary.
Y: Set of System Modules.
Z: Output
State diagram

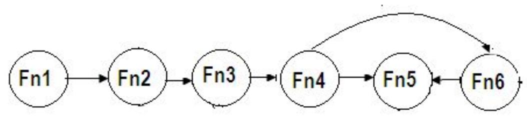

Figure 2: State diagram

Fn1: is set of Datasets
Fn2: Binarization technique
Fn3: Orientation Field Estimation
Fn4: Finger Center Estimation Algorithm
Fn5: Pose Estimation Algorithm
Fn6: Localized Dictionary based algorithm

IV IMPLMENTATION DETAILS

A. Image Enhancement

Enhancement of fingerprint image is very important to latent images, due to their unclear structures. The purpose of an enhancement algorithm is to modify the clarity of the ridges and valleys .The Pre-processing is incorporated for enhancement of the Latent fingerprint image quality. The Pre-processing methods include 6 Categories.

1. Greyscale conversion: Fingerprint image is converted into grayscale form.
2. Binarization: Binarization is process of converting gray-scale fingerprint image into Binary images.
3. Segmentation: The Segmentation is the differentiation of fingerprint image into foreground blocks and background blocks.
4. Thinning: Thinning is a process in which fingerprint image is converted to 1 pixel fingerprint image. This is mostly used for Ridges clearing.
5. Smoothing: Noise removal is done on fingerprint image.
6. Feature extraction: Thinned image is useful for extracting the features such as orientation field and minutae.

B.Pose estimation

Given an input fingerprint, the initial orientation field is estimated and rotated by various angles. For each rotated version, a finger center is estimated by probabilistic voting. The one with the highest value is chosen as the finger center and the corresponding rotation angle is determined as the finger direction. The initial orientation field *O* is estimated by the local Fourier analysis approach in [6]. To deal with strong noise, at most two strongest orientations are estimated for each 16×16 block. The probability of the finger center at position *x* (we use *x* to represent finger center *(x, y)*) is estimated by accumulating the voting, $p\ (x\ |\Psi^*\ v)$, of all the available initial orientation patches in the fingerprint image as follows:

$$A(x) = \sum_{v} p\left(x\,|\,\Psi^*, v\right).$$

Ψ is the most similar prototype patch of orientation patch *o* at location *v* in *O*.

Pose Estimation Algorithm:
Input: Input Fingerprints
Output: Pose detection
1) Initialize images
2) For arch patch in image *I*,
Extract maximum curvature point and straight ridge
3) Draw perpendicular to the finger direction is defined as the center.
4) Generate Pose
5) Draw Pose and Generate image

C. Initial Orientation Field Estimation

The initial orientation field of fingerprint image is obtained by local estimation algorithms, such as gradient based and slit-based approaches. The dominant orientation in a 16 x 16 block is calculated by selecting the peak in the magnitude spectrum of the local image. In latent fingerprint images, the initial orientation field contains noise. In further stages the noisy orientation field is improved using prior knowledge of good quality fingerprints.

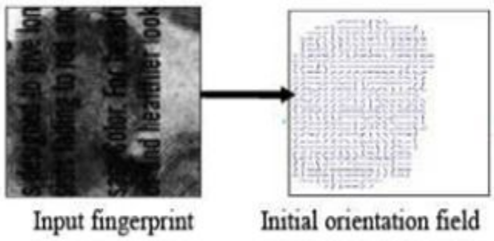

Figure 3: Initial orientation field estimation

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Using the pose estimated by the pose estimation algorithm, the initial orientation field is registered into the finger coordinate system with the finger center being the origin and the finger direction being *y*-axis. Then the registered orientation field is regularized by localized dictionaries lookup and context-based correction. Firstly, the registered orientation field is partitioned into a set of overlapping orientation patches. Then, at each location *u*, the top-*N*c (empirically set as 6) candidate patches in the localized dictionary *Du* which are most similar to the initial orientation patch *o* are selected with diversity examination

D. Dictionary Construction

The dictionary is formed from number of orientation patches which are of equal size. An orientation patch consists of *b* x *b or*ientation elements and an orientation element refers to the dominant orientation in a block of size *16* x *16* pixels. Dictionary is constructed from orientation patches obtained from high quality fingerprints. Since the direction of the latent fingerprint is unknown; each orientation patch is rotated by 21 different angles to generate additional orientation patches. By using these orientation patches, a dictionary of reference orientation patches is created by using a greedy algorithm this greedy algorithm is explained below.

1. The first orientation patch is added into empty the dictionary.
2. Then test whether the next orientation patch is different from all the orientation patches in the dictionary. If it is different, it gets added into the dictionary; else, the next orientation patch is taken for testing.
3. Repeat step 2 until all orientation patches has been tested.

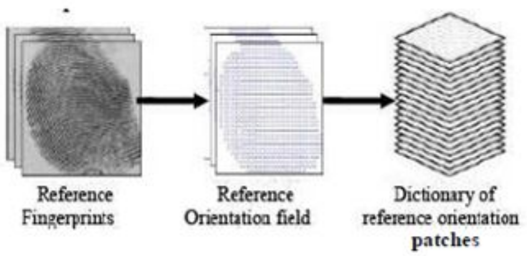

Fig 4: Dictionary construction

E .Dictionary Lookup

In this stage for each initial orientation patch, we looked up in dictionary for retrieving a list of candidate reference orientation patches, which are placed in sorted manner 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.

F. 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.

V RESULTS

Preprocessing module:

In this module first fingerprint image is loaded, and then it gets converted into grey scale image. After grayscale conversion this grayscale image converts into binary form using binarization. After binarization image converted into skeletonized form

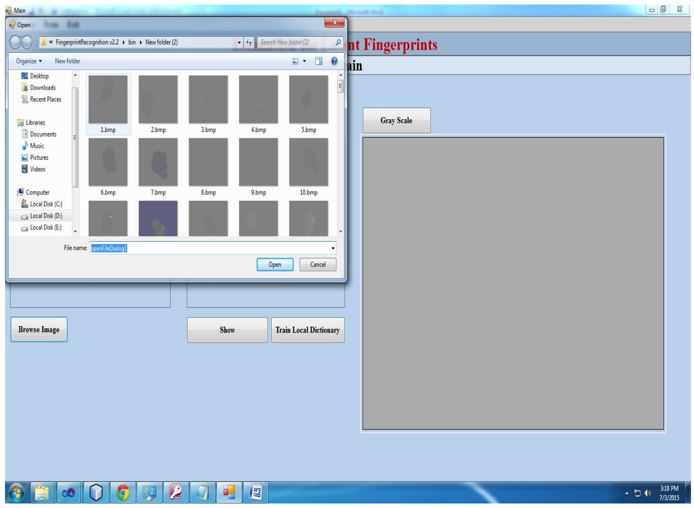

Figure 5: Feature display

In this module we extract features from fingerprint such as minuets and orientation field. These features are useful for fingerprint matching

Training localized dictionary:

In this module we maintain dictionary of orientation patches which are obtained from high quality fingerprints

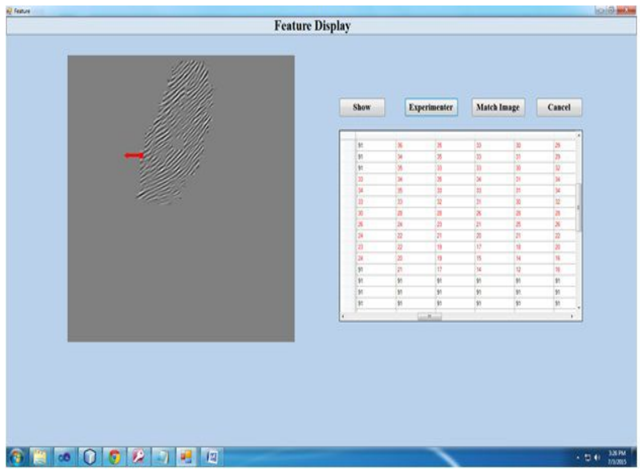

Figure 6: Fingerprint verification

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Fingerprint verification:
In this module we recognize fingerprint by doing matching of minutes. In result we get matching fingerprints along with identification rate.

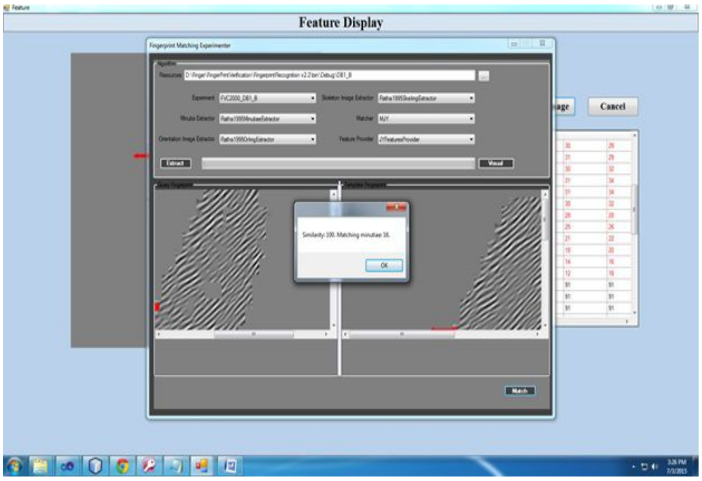

Figure 7: Fingerprint verification

VI PERFORMANCE RESULTS

1) Databases

Matching experiments were conducted on the NIST Special Database 27, which consists of 258 latent fingerprint images and their corresponding 500 mated rolled fingerprint images. This is the database which is publically available containing mated latent and rolled prints. NIST SD27 contains images of three different qualities, termed "good", "bad", and "ugly". NIST SD27 is the most widely used public domain latent fingerprint database, which is composed of 258 latent fingerprints and corresponding rolled ones. Most latents in NIST SD27 are of very poor quality, with unclear ridge structures, complex background and overlapping patterns.

2) Performance evaluation

Finally, the Cumulative Match Characteristic (CMC) curve is used to evaluate the matching performance. The CMC curves on the NIST SD27 latent database and the three subsets are shown in Fig. 4 for fourdifferent orientation field estimation approaches (manual marking, the proposed algorithm with manually marked pose, the proposed algorithm with automatically estimated pose, GlobalDict, FOMFE, and STFT).

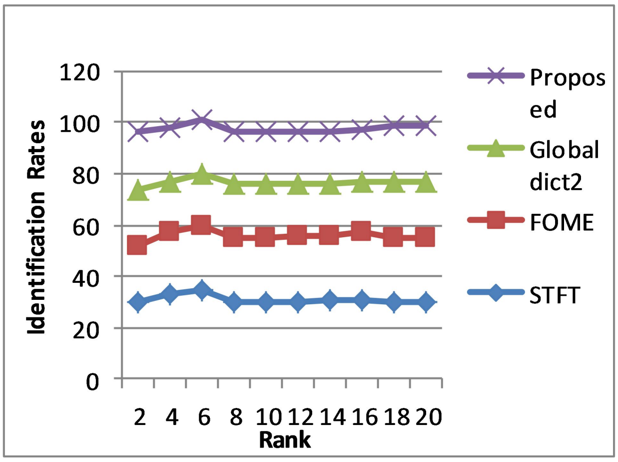

Fig 8: Result analysis

VII. CONCLUSIONS AND FUTURE WORK

This system proposed a robust orientation field estimation algorithm for latent fingerprint enhancement taking reference of spelling correction techniques in natural language process. 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. However, we propose to extend our work as follows.

1) Developing an automatic region segmentation algorithm for latent fingerprints with strong structured noise or overlapping fingerprints.

2) Development of indexing algorithm to speed up latent matching.

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