RECTIFICATION OF THE DISTORTED FINGERPRINT

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Abstract - *Biometric fingerprint recognition system has most reliable for robust recognition in the world. The fingerprint is one of the most important in the biometric system. Distortion in the fingerprints can cause major problems which may affect the accuracy of the fingerprint and can cause false match of the fingerprint. Distortion detection can be viewed as two class classification problem, for which the ridge orientation map and period map of a fingerprint are used as the feature vector and Naive Bayes classifier is used to perform the classification task.*

***Key Words*: Fingerprint, Distortion, Feature Vector, Recognistion, Biometric, Classification.**

1. INTRODUCTION

Biometric authentication includes retina, fingerprint, face, ear, hand and DNA, etc. Biometric identifiers characterize both physical and behaviours of peoples. The physical characteristic identifies the shape and composition of the body like fingerprints, face, retina, DNA and ear features, etc. The behavioural characteristics identify the behaviours of a person like typing rhythm, gait, gestures and voice.

Usually, a fingerprint[1] of a person can neither be lost nor be stolen. The spoofing [2] is a method used to unlock the data which is locked by another person by mimicking the biometric trait. By detecting the amount of illumination of white light in the finger, the fingerprint scanner determines the persons fingerprint is genuine or fake. Minutiae [3] is most important feature for their stable and robust feature. Ridge endings and ridge bifurcations are essential because of the discontinuity. A simple threshold based classification method is applied to the ridge endings gives a good accuracy. In case of altered [4] fingerprints, the ridge patterns are examined in a large number of altered fingerprints database. A threshold is applied to match the genuine fingerprint. Fingerprint privacy [5], using gradient based method the ridge endings and ridge bifurcations are extracted for a fingerprint.

2. RELATED WORK

Due to the vital importance of recognizing distorted fingerprints, researchers have proposed a number of methods which can be coarsely classified into four categories. It is essential to routinely detect distortion through Fingerprint attainment so that tremendously distorted fingerprints can be discarded.

Several researchers have proposed to detect improper force using specially designed hardware [6], [7], [8]. Bolle et al. [6] proposed to detect excessive force and torque exerted by using a force sensor. They showed that controlled fingerprint acquisition leads to improved matching performance [7]. Fujii [8] proposed to detect distortion by detecting deformation of a transparent film attached to the sensor surface.

Dorai et al. [9] proposed to detect distortion by analyzing the motion in video of fingerprint. However, the above methods have the following limitations:

(i) they require special force sensors or fingerprint sensors with video capturing capability;
(ii) they cannot detect distorted fingerprint images in existing fingerprint databases; and
(iii) they cannot detect fingerprints distorted before pressing on the sensor

The most popular way to handle distortion is to make the fingerprint matcher tolerant to distortion [10], [11], [12], [13], [14], [15]. In other words, they deal with distortion on a case by case basis, i.e., for every pair of fingerprints to be compared.

For the most widely used minutiae-based fingerprint matching method, the following three types of strategies have been adopted to handle distortion:

(i) assume a global rigid transformation and use a tolerant box of fixed size [10] or adaptive size [9] to compensate for distortion;
(ii) explicitly model the spatial transformation by thin plate spline (TPS) model [12]; and
(iii) enforce constraint on distortion locally [14]. Various methods for handling distortion during matching have also been used in image-based matcher [13] or skeleton-based matcher [15]. However, allowing larger distortion in matching will inevitably result in higher false match rate. For example, if we increased the bounding zone around a minutia, many non-mated minutiae will have a chance to get paired. In addition, allowing larger distortion in matching will also slow down the matching speed.

Ross et al. [16], [17] learn the deformation pattern from a set of training images of the same finger and transform the template with the average deformation. They show this leads to higher minutiae matching accuracy. But this method has the following limitations: (i) By considering the multiple images of the same finger it is not convenient in some applications and existing fingerprint databases usually hold only one image per finger; and Still if multiple images per finger are obtainable, it is not essentially sufficient to cover a variety of skin distortions.

Senior and Bolle [18] developed an interesting method to remove the distortion before matching stage. This method is based on an assumption that the ridges in a fingerprint are constantly spaced. So they deal with distortion by normalizing ridge density in the whole fingerprint into a fixed value. Since they did not have a distortion detection algorithm, they apply the distortion rectification algorithm to every fingerprint.

Compared to the other methods reviewed above, Senior and Bolle method has the following advantages:

(i) it does not require specialized hardware;
(ii) it can handle a single input fingerprint image; and
(iii) it does not require a set of training images of the same finger.

However, ridge density is neither fixed within a finger nor fixed across fingers. In fact, several researchers have reported improved matching accuracy due to incorporating ridge density information into minutiae matchers [19], [20].

Simply normalizing ridge density of all fingerprints will lose discriminating information in fingerprints and may improve impostor match scores. Furthermore, without any constraint on validity of orientation map, this method may generate fingerprints with fixed ridge period but strange orientation map. Compare to the first limitation, the second limitation is even more harmful, since it will reduce genuine match scores.

These limitations were not found in [18] since the algorithm was tested only on a small database consisting of six fingers and finger rotation was not considered. Our method shares the advantages of Senior and Bolle method over other methods, meanwhile overcomes some of its limitations. Our method is based on statistics learnt from real distorted fingerprints, rather than on the impractical assumption of uniform ridge period made in [18].

Distortion due to finger rotation can be handled by our method. In fact, the proposed method is able to deal with various types of distortion as long as such distortion type is contained in the training set.

In addition, extensive experiments have been conducted to validate the proposed method. The current work is a significant update of our preliminary study in [21], which detects distortion based on simple hand-crafted features and has no rectification functionality.

3. SYSTEM ARCHITECTURE

The distorted fingerprint detection and rectification can be established in following steps which is shown in below Fig.No.1. The proposed rectification algorithms are performed by matching the fingerprints.

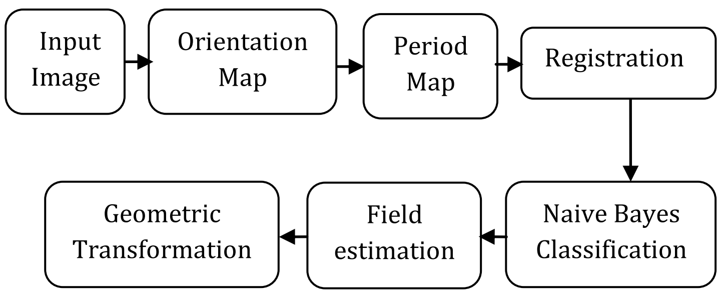

Fig.No.1: System architecture

4. FINGERPRINT DISTORTION DETECTION

The fingerprint distortion can be established in two methods by detecting and rectifying the distorted image. Fingerprint distortion detection can be classified into registered ridge orientation map and period map as the feature vector, by using naive bayes classifier.

4.1 Orientation and Periodic Map

The distortion detection can be viewed as a two- class classification problem, the orientation map and period map of a fingerprint. These two maps are used as feature vector and for classification. The KNN (K-Nearest Neighbour) classifier is trained to perform the field estimation task. The Distortion rectification has a regression problem, where the distorted fingerprints are viewed as inputs and distortion field are viewed as outputs.

The fingerprint registration approach can be classified into two cases. First case, if the upper core point is not detected, then to find the pose information optimization formula is applied.

$$\arg\max_{x,y,\propto,i} ||OrientDiff(RO_i(x,y,\propto),O) \leq \emptyset_t||_0 \text{ ----------(1)}$$

Where x and y denotes the translation parameters, $\propto$ denotes the rotation parameter, i denotes the fingerprint ID, O is the orientation map of the input fingerprint, ROi denotes the orientation map of the ith reference fingerprint, function OrientDiff computes the difference of two orientation maps at each location, $||.||_0$ counts the number of nonzero elements, and $\emptyset_t$ is the threshold.

Second case, if the upper core point is detected in the input fingerprint then the upper core point is taken as the center point of a fingerprint. The orientation map and period map are registered to the fixed coordinate system by using the information of equation (1).

4.2 Feature Vector Extraction

A feature vector can be extracted by registered orientation map and period map of a fingerprint. The grid of period map covers the whole fingerprint whereas the grid of the orientation map covers only the top of the fingerprint. The orientation map does not cover the bottom part of the fingerprint because of the diverse problem occurs on the center of the fingerprint even in the normal fingerprints.

4.3 Classification

The classification is the process of categorization the fingerprints in to positive and negative samples. The distorted fingerprints are classified as positive samples and the normal fingerprints as negative samples. The Naive Bayes classifier is applied to classify the distorted fingerprints.

Naive Bayes classifier

Based on the bayes theorem, Naive Bayes classifier predicts the values based on the likelihood and class prior probability. A Naive Bayes model is easy to build and no complication in parameter estimation. This makes the model useful for the large datasets.

$$P(c\,|\,x) = \frac{P(x\,|c)\,P(c)}{P(x)} \text{ ------------------------------------- (2)}$$

$$P(c\,|\,x) = P(x_1|\,c) \text{ x } P(x_2|\,c) \text{ x......x } P(x_n|\,c) \text{ x } P(c) \text{ -- (3)}$$

Where P(c | x) is the posterior probability, P(c) is the prior probability of class, P(x | c) is the likelihood of the predictor probability and P(x) is the prior probability of predictor.

5. DISTORTED FINGERPRINT RECTIFICATION

A distorted fingerprint may be occurred by applying an unknown distortion field to the normal fingerprint which can also be unknown. The distorted fingerprint problem can be resolved by applying the inverse of the estimated distortion field in to the normal fingerprint. So the regression problem is needed to be address, because it is difficult to find the distortion field of the high dimension image. Distortion field estimation can be done by finding the nearest neighbour among all the distorted reference fingerprints. The level 1 feature namely orientation map and period map can be used to find the similarity of the fingerprints. The computation method to find the similarity of the fingerprints is depending on whether the upper core point can be detected in the input fingerprint.

Field Estimation

The KNN (K- Nearest Neighbour) algorithm is applied to find the field estimation function. This algorithm consists of set of vectors and class labels associated with each other vector and it can work equally well with the arbitrary number of classes.

Implementation

The fingerprint detection can be done by applying the distorted fingerprint image. The orientation map and period map can be viewed as two classification problem. The applied input can be taken as the orientation map and period map which is shown in Fig.No.2, 3 and 4. These two maps are needed to the feature vector and then the Naive Bayes classifier is applied to perform the classification task.

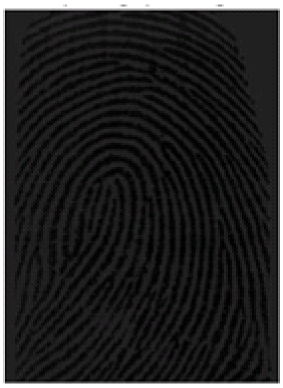

Fig.No.2: Input Fingerprint

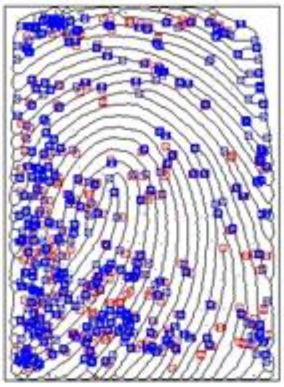

Fig.No.3: Orientation Map

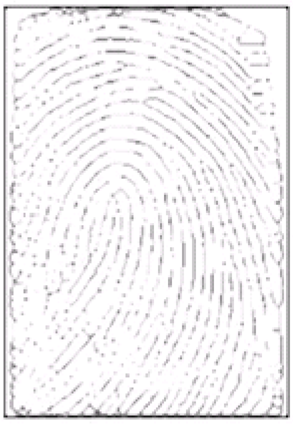

Fig.No.4: Period Map of the Fingerprint

The registered image after the classification stage is applied to estimate the field of the distorted fingerprints. The geometric transformation of the distorted fingerprints is shown in the Fig.No.5.

Fig.No.5: Geometric Transformation of the Distorted Field

6. CONCLUSIONS

The fingerprint distortion detection and rectification is most important to find the false non-match fingerprints. The Naive bayes classifier is used to perform the classification task and KNN (K-Nearest Neighbour) algorithm is applied to estimate the distortion field. The experimental results show the efficiency of the fingerprint distortion detection.

REFERENCES

[1]. G.S. Sodhi, Jasjeet Kaur, "physical developer method foe detection of latent fingerprints: a review", Egyptian Journal of Forensic Sciences, 6, 44- 47, may 2015.

[2]. Aadithya Balaji, Varun. H. S, Sikha O.K, "multimodal fingerprint spoof detection using white light" international conference on information security & privacy (ICISP2015), 330-335, dec 2015.

[3]. Kumar Abhishek, Ashok Yogi, "A Minutiae Count Based Method for Fake Fingerprint Detection ",Second International Symposium on Computer Vision and the Internet (VisionNet'15), 447- 452, 2015.

[4]. Soweon Yoon, Jianjiang Feng and Anil K. Jain, "Altered Fingerprints: Analysis and Detection", IEEE TRANSACTIONS ON PATTERN ANALYSIS AND MACHINE INTELLIGENCE, vol. 34, may 2011.

[5]. Reshma K V, Anitha T Nair, Tina Babu, Mehbooba P Shareef, Nimisha Abraham, "Identity of User Thrashing and Privacy Protection of Fingerprints", International Conference on Information and Communication Technologies (ICICT 2014), 652-659, 2015.

[6] R. M. Bolle, R. S. Germain, R. L. Garwin, J. L.Levine, S. U. Pankanti, N. K. Ratha, and M. A. Schappert, "System and method for distortion control in live-scan inkless fingerprint images," U.S. Patent No. 6 064 753, May 16, 2000.

[7] N. Ratha and R. Bolle, "Effect of controlled image acquisition on fingerprint matching," in Int. Conf. Pattern Recognit., 1998, vol. 2, pp. 1659–1661.

[8] Y. Fujii, "Detection of fingerprint distortion by deformation of elastic film or displacement of transparent board," U.S. Patent No. 7 660 447, Feb. 9, 2010.

[9] C. Dorai, N. K. Ratha, and R. M. Bolle, "Dynamic behavior analysis in compressed fingerprint videos," IEEE Trans. Circuits Syst. Video Technol., vol. 14, no. 1, pp. 58–73, Jan. 2004.

[10] N. K. Ratha, K. Karu, S. Chen, and A. K. Jain, "A real-time matching system for large fingerprint databases," IEEE Trans. Pattern Anal. Mach. Intell., vol. 18, no. 8, pp. 799–813, Aug. 1996.

[11] X. Chen, J. Tian, and X. Yang, "A new algorithm for distorted fingerprints matching based on normalized fuzzy similarity measure," IEEE Trans. Image Process., vol. 15, no. 3, pp. 767–776, Mar. 2006.

[12] A. M. Bazen, and S. H. Gerez, "Fingerprint matching by thin-plate spline modelling of elastic deformations," Pattern Recognit., vol. 36, no. 8, pp. 1859–1867, Aug. 2003.

[13] L. R. Thebaud, "Systems and methods with identity verification by comparison and interpretation of skin patterns such as fingerprints," U.S. Patent No. 5 909 501, Jun. 1, 1999.

[14] Z. M. Kov_acs-Vajna, "A fingerprint verification system based on triangular matching and dynamic time warping," IEEE Trans. Pattern Anal. Mach. Intell., vol. 22, no. 11, pp. 1266–1276, Nov. 2000.

[15] J. Feng, Z. Ouyang, and A. Cai, "Fingerprint matching using ridges," Pattern Recognit., vol. 39, no. 11, pp. 2131–2140, 2006.

[16] A. Ross, S. C. Dass, and A. K. Jain, "A deformable model for fingerprint matching," Pattern Recognit., vol. 38, no. 1, pp. 95–103, 2005.

[17] A. Ross, S. C. Dass, and A. K. Jain, "Fingerprint warping using ridge curve correspondences," IEEE Trans. Pattern Anal. Mach. Intell., vol. 28, no. 1, pp. 19–30, Jan. 2006.

[18] A. Senior, and R. Bolle, "Improved fingerprint matching by distortion removal," IEICE Trans. Inf. Syst., vol. 84, no. 7, pp. 825–831, Jul. 2001.

[19] D. Wan, and J. Zhou, "Fingerprint recognition using model-based density map," IEEE Trans. Image Process., vol. 15, no. 6, pp. 1690– 1696, Jun. 2006.

[20] J. Feng, "Combining minutiae descriptors for fingerprint matching," Pattern Recognit., vol. 41, no. 1, pp. 342–352, 2008.

[21] X. Si, J. Feng, and J. Zhou, "Detecting fingerprint distortion from a single image," in Proc. IEEE Int. Workshop Inf. Forensics Security, 2012, pp. 1–6.