Fingerprint Recognition using Ordinal Measures

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***Abstract*— the proposed work is to present new fingerprint recognition method using ordinal features. The objective function of the proposed feature selection method has two parts, i.e., misclassification error of intra and interclass matching samples and weighted sparsity of ordinal feature descriptors. Therefore, the feature selection aims to achieve an accurate and sparse representation of ordinal measures. The proposed method is subjected to a number of linear inequality constraints, which require that all intra and interclass matching pairs are well separated with a large margin. Ordinal feature selection is formulated as a linear programming (LP) problem so that a solution can be efficiently obtained even on a large-scale feature pool and training database.**

***Keywords*— Ordinal features; linear programming; multi-lobe ordinal filter; hamming distance**

I. INTRODUCTION

The fingerprint feature is usually categorized into three levels. The first level is macro feature of the fingerprint such as ridge flow and pattern type. The second feature level is known as Galton feature (minutiae) such as ridge bifurcations and endings. The third feature level or shape includes all attributes of ridges such as ridge path deviation, width, shape, breaks, scars and other permanent details [2]. The performance enhancement of the fingerprint recognition is investigated in [2] where second and third feature levels are used. It is found that there is an improvement around20% in terms of EER if both of the features are employed. The work in [3] proposes a combination of texture features and minutiae for fingerprint matching. It is argued that features (descriptors) instead of the minutiae itself are required to increase the matching rate of a fingerprint system. The correspondent between two individual features is established by an alignment-based greedy matching algorithm. The features are implied in order to carry out the deficiency of minutiae in the orientation matching.

Ordinal measures have been demonstrated as an effective feature representation model for fingerprint recognition. However, ordinal measures are a general concept of image analysis and numerous variants with different parameter settings, such as location, scale, orientation, and so on, can be derived to construct a huge feature space.

The success of a texture biometric recognition system heavily depends on its feature analysis model, against which biometric images are encoded, compared and recognized by a computer. It is desirable to develop a feature analysis method which is ideally both discriminating and robust for fingerprint biometrics.

The biometric features should have enough discriminating power to distinguish interclass samples. The intra-class variations of biometric patterns in uncontrolled conditions such as illumination changes, deformation, occlusions, pose/view changes, etc should be minimized via robust feature analysis. Therefore it is a challenging problem to achieve a good balance between inter-class distinctiveness and intra-class robustness.

Generally the problem of feature analysis can be divided into two sub-problems, i.e. feature representation and feature selection. Feature representation aims to computationally characterize the visual features of biometric images. Local image descriptors such as Gabor filters, Local Binary Patterns and ordinal measures are popular methods for feature representation of texture biometrics [1]. However, variations of the tunable parameters in local image filters (e.g. location, scale, orientation, and inter-component distance) can generate a large and over-complete feature pool. Therefore feature selection is usually necessary to learn a compact and effective feature set for efficient identity authentication. Ordinal measures are defined as the relative ordering of a number of regional image features (e.g. average intensity, Gabor wavelet coefficients, etc.) in the context of visual image analysis. The basic idea of OM is to characterize the qualitative image structures of texture-like biometric patterns.

Ordinal measures are defined as the relative ordering of a number of regional image features (e.g. average intensity, Gabor wavelet coefficients, etc.) in the context of visual image analysis. The basic idea of OM is to characterize the qualitative image structures of texture-like biometric patterns. The success of ordinal representation comes from the texture-like visual biometric patterns where sharp and frequent intensity variations between image regions provide abundant ordinal measures for robust and discriminating description of individual features. Detailed information on ordinal measures in the context of biometrics, including its definition and properties of invariance, robustness, distinctiveness, compactness and efficiency can be found in [2]–[5].

II. LITERATURE SURVEY

A. *A brief introduction to ordinal measures*

Stevens suggested four levels of measurements from coarse to fine: nominal, ordinal, interval and ratio measures. Ordinal measures come from a simple and straightforward concept that we often use. For example, we could easily rank or order the heights or weights of two persons, but it is hard to answer their precise differences. This kind of qualitative measurement, which is related to the relative ordering of several quantities, is defined as ordinal measures (or OM for short). For computer vision, the absolute intensity information associated with an object can vary because it can change under various illumination settings. However, ordinal relationships among neighboring image pixels or regions present some stability with such changes and reflect the intrinsic natures of the object.

(a) Region A is darker than B, i.e. A ≺ B.
(b) Region A is brighter than B, i.e. A ≻ B.

A simple illustration of ordinal measures is shown in Fig above where the symbols "≺" or "≻" denote the inequality between the average intensities of two image regions. The inequality represents an ordinal relationship between two regions and this yields a symbolic representation of the relations. For digital encoding of the ordinal relationship, only a single bit is enough, e.g. "1" denotes "A≺B" and "0" denotes "A≻B", and the equality case (a low possibility event) can be assigned to either.

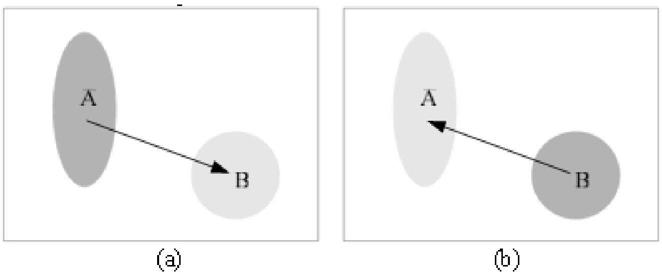

Fig. 1. Ordinal measure of relationship between two regions. An arrow points from the darker region to the brighter one.

Ordinal representation is sensitive to inter-class variations and robust to intraclass variations, which is desirable property for biometric recognition.

Multi-lobe Ordinal Filter (MOF) with a number of tunable parameters is proposed to analyze the ordinal measures of biometric images (Fig. 2) [3]. MOF has a number of positive and negative lobes which are specially designed in terms of distance, scale, orientation, number, and location so that the filtering result of MOF with the biometric images can measure the ordinal relationship between image regions covered by the positive and negative lobes.

From fig.2 below, we can see that variations of the parameters in multi-lobe ordinal filter can lead to an extremely huge feature set of ordinal measures. For example, each basic Gaussian lobe in MOF has five parameters, i.e., x-location, y-location, x-scale, y-scale and orientation.

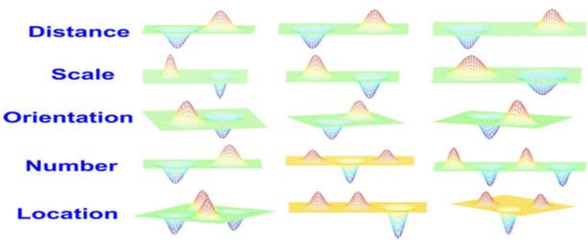

Fig.2 Basic parameters in multi-lobe filter

B. *Motivation*

Although in general ordinal measures are good descriptors for biometric feature representation, there are significant differences between various ordinal features in terms of distinctiveness and robustness. Since the primitive image structures vary greatly across different biometric modalities in terms of shape, orientation, scale, etc., there does not exist a generic feature set of ordinal measures which can achieve the optimal recognition performance for all biometric modalities. Even for the same biometric modality, the existing individual difference in visual texture pattern determines that the optimal ordinal features may vary from person to person. Moreover the redundancy among different ordinal features should be reduced and it has been proven that it is possible to only use a small number of ordinal features to achieve high accuracy.

C. *Existing Systems*

Feature selection is a key problem in pattern recognition and has been extensively studied. However, finding feature subset is usually intractable and in most cases there are only solutions to suboptimal feature selection [6].Most research works on feature selection mainly focus on generic pattern classification applications rather than specific applications in biometrics. This paper mainly addresses the efficient feature selection methods applicable to biometric authentication. Boosting [8] and Lasso [9] have been proved as the well performed feature selection methods in face recognition.

Boosting [8] has become a popular approach used for both feature selection and classifier design in biometrics. Boosting algorithm aims to select a complementary ensemble of weak classifiers in a greedy manner. A reweighting strategy is applied for training samples to make sure that every selected weak classifier should have a good performance on the "hard" samples which cannot be well classified by the previously selected classifiers. Boosting has achieved good performance in visual biometrics, including both face detection [8] and face recognition [10].

Destrero et al. proposed a regularized machine learning method enforcing sparsity for feature selection of face biometrics based on Lasso regression [9], [11].

The L1 regularized sparse representation was evaluated to be better than Boosting for face detection and authentication in small size training dataset [9], [11]. The squared sum of regression errors defined in the objective function makes the feature selection sensitive to outliers.

Margin analysis is important to the generalization ability of machine learning algorithms and the most powerful machine learning methods, e.g. Support Vector Machine and Boosting are motivated by margins. In addition, the features of training samples should be normalized to match the class label, therefore additional computational cost is needed. The L1 regularization is a popular technique for feature selection. For example, Guo et al. proposed a linear programming formulation of feature selection with application to facial expression recognition [7]. The objective function aims to minimize misclassification error and the L1 norm of feature weight.

D. *Disadvantages of Existing Systems*

- The class label can only take the value either +1 or −1, therefore the model could not generate a maximal margin.
- The features of training samples should be normalized to match the class label, therefore additional computational cost is needed

III. PROPOSED SYSTEM

A. *The Proposed System*

Initial step in this research was the preparation of fingerprint image database, followed by designing the identification algorithm. Finally, the algorithm was implemented and evaluated using fingerprint images saved in the database.

The normalized images were tiled into blocks with size 8 x 8 so that the total block was 256. Then, each block was transformed using discrete cosine transform (DCT) so that each block had its DCT coefficients. Finally, the absolute value of the AC component of DCT coefficient of each block was sorted in order to obtain the ordinal measure. All of these ordinal measures were stored in the database for subsequent matching process. In this case, ordinal measure of DCT coefficient is the feature of the proposed algorithm.

B. *Methodology*

The proposed matching algorithm is divided into two stages and illustrated in block diagrams as shown in Fig. 1 below.

The input images were normalized, tiled, and transformed to DCT in order to obtain the ordinal measure. Furthermore; the distance of ordinal measure of the input image and all of ordinal measure in the database were calculated using Hamming distance based on Eq. 1.

$$HD = \frac{1}{N}\sum_{j-1}^{N} Xj(XOR)Yj \qquad \ldots\ldots. (1)$$

where Xj and Yj were ordinal measure of the input image and the database image respectively , and N was the total AC components from each 8x8-pixel block, which were 63 coefficients. In the matching process, ideal condition was achieved if the Hamming distances between the images in a particular class were very small or approaching zero.

C. *Block Diagram*

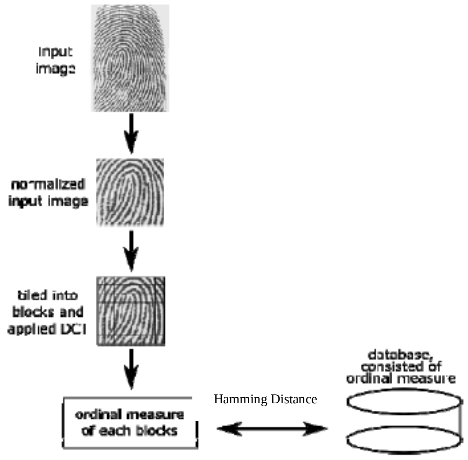

Fig. 1. Proposed flow diagram for fingerprint recognition using ordinal measures

IV. RESULTS

A. Fig.3 shows the comparison of performance measures for fingerprint recognition using both the Daugman's and Ordinal code.

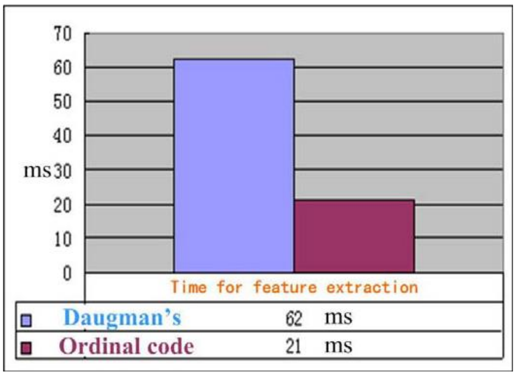

Fig.3. Comparison of performance measures for fingerprint feature extraction using Daugmans's and Ordinal code.

B. TABLE 1. Comparison of Ordinal code with other algorithms

Algorithm	Feature Template Size	Feature Extraction time	Equal Error Rate	Discriminating index
Palm code	256 Bytes	63ms	1.72%	4.29
Fusion code	256 Bytes	293ms	0.51%	5.07
Competitive code	384 Bytes	233ms	0.30%	5.20
Ordinal code	384 Bytes	120ms	0.22%	6.30

C. *Advantages*

- Accurate and sparse representation of ordinal measures is achieved.
- All intra and interclass matching pairs are well separated with a large margin.

D. *Scope*

The implementation of ordinal features in fingerprint recognition can be used in the field of Security systems, Authentication systems and Forensics.

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