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# IRIS Recognition Using High Level Features

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***Abstract*: This paper demonstrates that personal identity authentication through comparison of high level features of iris is very effective. The success of a biometric recognition system depends heavily on its feature representation model for biometric patterns. Accomplishing sensitivity to inter-class differences and at the same time robustness against intra-class variations is very difficult. Many biometric representation schemes have been reported but the above issue remains to be resolved. This paper introduces iris recognition using high level features in an attempt to resolve this issue. Huge feature space can be derived with different parameter settings such as distance, location, scale, orientation and number. Feature selection aimed at accurate and sparse representation of ordinal measures. This paper provides separation between inter classes and intra class robustness. High level features of iris provide simple and fast recognition through small feature set using ordinal feature representation.**

**Keywords – Iris, High level features, ordinal measures, feature selection.**

## I. INTRODUCTION

This paper shows high level features give effective acknowledgment utilizing ordinal representation. On the other hand, ordinal measures are a general idea of image examination and various variations with distinctive parameter settings, for example, area, scale, introduction, etc, can be inferred to build a huge feature space. This paper proposes advancement formulation for ordinal feature selection with successful applications to iris recognition. The objective function of the proposed feature selection method has two parts, i.e., reducing misclassification error of intra and interclass matching samples and weighted sparsity of ordinal feature descriptors. Therefore, the feature selection aims to accomplish an accurate and sparse representation of ordinal measures. And, the optimization subjects to a number of linear inequality constraints, which require that all intra and interclass matching pairs are well isolated with a large margin.

It is desirable to develop a feature analysis model which is perfect both discriminating and robust for iris biometrics. On one hand, the biometric features should have enough segregation power to distinguish interclass samples. Intra-class variations of biometric patterns in uncontrolled conditions such as, deformation, illumination changes, occlusions, pose/view changes, etc. should be minimized via strong feature analysis. Therefore it is a testing problem to achieve a good balance between intra-class robustness and inter-class isolation. Feature analysis consists of feature representation and feature selection. Feature representations aimed at computationally characterize the visual features of biometric images. Texture biometrics feature representation achieved using Gabor filters, Local Binary Patterns and ordinal measures.

However, redundant feature pool generated by variations of tunable parameters in image filters (e.g. location, scale, orientation, and inter-component distance). Therefore, during feature selection, it is necessary to make feature set compact and effective for efficient identity authentication. Information discovered during feature selection can be related to pattern recognition problem of texture biometrics. Ordinal measures of high level features provide a good feature representation for iris recognition. Ordinal measures are defined as the comparative 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 differentiate the qualitative image structures of texture-like biometric patterns. For ordinal measuring image filtering easy compared to low level feature comparison. In ordinal comparison complex Gabor filters are not used.

Texture-like visual biometric patterns provide sharp and frequent intensity variations between image regions provide abundant ordinal measures for robust and discriminating description for individual features sets. Frequent intensity variations between image regions provide separation between image regions.

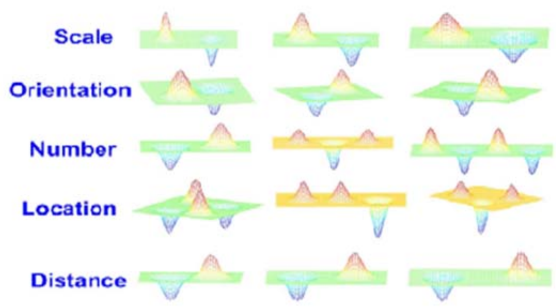


Fig. 1. Filters for feature representation

Robustness, distinctiveness, compactness and efficiency can be implemented in feature representation. Good balance should be achieved between features sparsity and accuracy. Redundant feature sets are ignored for ordinal measuring. High level feature such as brightness/darkness provides easy ordinal coding.

Multi-lobe Ordinal Filter (MOF) with a number of tunable parameters is proposed to analyze the ordinal measures of biometric images. MOF has a number of positive and negative lobes which are specifically designed in terms of orientation, scale, number, location and distance 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. Variations of the parameters in multi-lobe ordinal filter seen in Fig 1.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. So there are totally 10 variables in a di-lobe and 15 tunable parameters in a tri-lobe ordinal filter. Supposing that each variable has ten possible values, the number of all possible di-lobe and tri-lobe ordinal measures in a biometric image is at least in the order of $10^{10}$ and $10^{15}$ respectively. There exist huge differences between various ordinal features in terms of uniqueness and robustness although in general ordinal measures are good descriptors for biometric feature representation. Variation of primitive image structures across different biometric modalities in terms of shape, scale, orientation, etc., highlight the fact that there does not exists a generic feature set of ordinal measures which can provide the best recognition performance for all biometric modalities. Difference in visual texture pattern determines the fact that the optimal ordinal features may vary from person to person even for the same biometric modality. High accuracy in iris biometrics can be achieved by reducing redundancy among different ordinal features. Because of the redundancy in the over-complete set of ordinal feature representation it is absolutely unnecessary to extract all ordinal features. A compact biometric representation is one with smaller subset of ordinal measures from the original feature space for the purpose of efficient biometric identification into which the characteristics of visual biometric patterns should be incorporated.
Of course, ordinal measures are not limited in one pixel's intensity. The values used for ordinal comparison may be the results of image transformation or the weighted intensity of a group of pixels. Multi-lobe Ordinal Filter (MOF) with a number of tunable parameters is used to examine the ordinal measures of biometric images. 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.
However, there are a large number of stable ordinal measures in iris images how to choose the most effective feature set of ordinal measures for reliable iris recognition is demanding. The parameter settings of these di and tri ordinal filters are hand-crafted and they are performed on all iris image regions. It is a better solution to employ a region specific ordinal filter for iris feature analysis since the texture characteristics such as scale, distance, number, orientation and salient texture primitives of iris patterns vary from region to region.

## II. RELATED WORK

Stevens recommended four levels of measurements from coarse to fine: nominal, ordinal, interval and ratio measures. Ordinal measures come from a simple and clear-cut concept that we often use. For example, easily grade or order the weights or heights of two persons, but it is hard to answer their precise differences. This kind of qualitative measurement, which is related to the comparative ordering of several quantities, is defined as ordinal measures (or OM for short). The total 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 solidity with such changes and reflect the basic natures of the object.

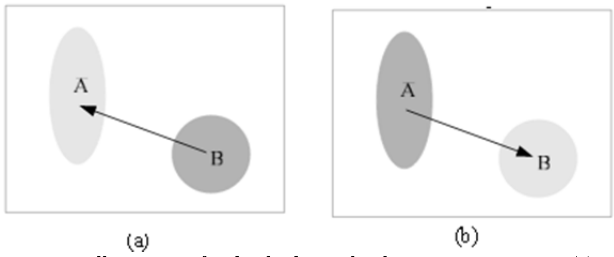


Fig.2. – Illustration of ordinal relationship between two regions. (a) Region A is brighter than B, i.e. A $\succ$ B (b) Region A is darker than B, i.e. A$\prec$ B.

A general picture of ordinal measures is shown in Fig 2. above where the symbols "$\prec$" or "$\succ$" 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$\prec$ B".

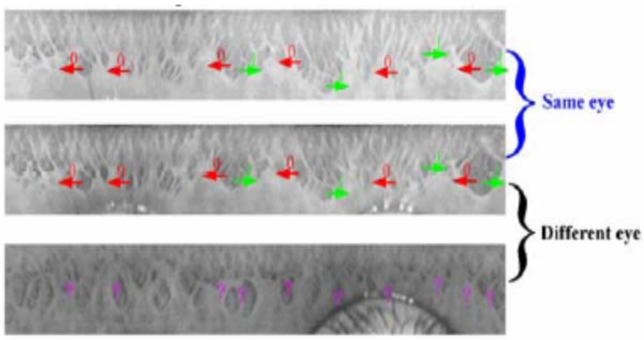


Fig 2.1 – Stable ordinal measures in intra-class iris images

For example, sufficient stable ordinal relations could be found in iris images Fig. 2.1. For inter-class biometric patterns, the possibility of matching two ordinal relations in corresponding region is only 50%, but for intra-class samples, most of ordinal measures should be matched except Some weak relations affected by noise. So ordinal representation is sensitive to inter-class variations and robust to intraclass variations, which is desirable property for biometric recognition.

## III. HIGH LEVEL FEATURE SELECTION FOR IRIS RECOGNITION

The prior mask information of eyelids, eyelashes, specular reflections not been considered in the process of ordinal feature selection. This paper proposes two kinds of strategies to deal with occlusion problem in iris recognition. The first is to segment and exclude occlusion regions in iris images and label the regions using mask in iris matching. But it needs accurate and efficient iris segmentation. In addition, the size of iris template becomes double. More importantly, the computational cost of both iris image preprocessing and iris matching is significantly increased because of the iris mask strategy. So it is more reasonable to identify and exclude the heavily occluded iris images in quality assessment stage. The remained iris images used for feature extraction and matching are less occluded by eyelids and eyelashes. So that it is beneficial to both accuracy and efficiency of iris recognition. This paper aims to learn a common ordinal feature set applicable to less occluded iris images of all subjects. The process of the feature selection is independent on any individual or image specific prior information such as iris segmentation mask. We believe the commonly selected feature set should be exact enough to recognize almost all subjects because the individual or sample specific variations have already been taken into consideration in feature selection.

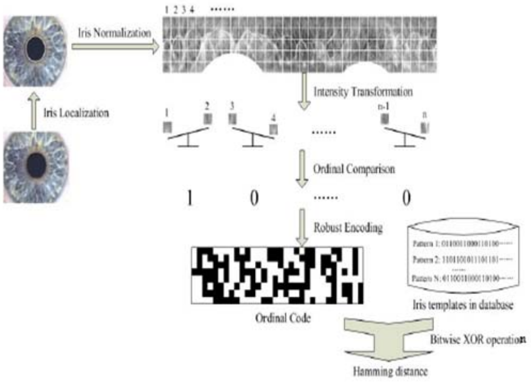


Fig. 3.Architecture of Iris recognition system

This paper aims to provide a general ordinal feature set applicable to less occluded iris images of all subjects. The process of the feature selection is independent on any individual or image specific prior information such as iris segmentation mask. The commonly selected feature set should be accurate enough to recognize almost all subjects because the individual or sample specific variations have already been taken into consideration in feature selection. We have also tried to integrate the occlusion mask into feature selection and feature matching but no improvement of accuracy on state-of- the-art iris image databases which have usually excluded heavily occluded iris images. The common ordinal features discovered in this paper are valuable for practical iris recognition systems. This paper mainly focuses on feature analysis and the details of iris image preprocessing can be found. Iris texture varies from region to region in terms of scale, orientation, shape of texture primitives, etc. So it is needed to use region specific ordinal filters to achieve the best results. Therefore iris images are divided into multiple blocks and different types of ordinal filters with different parameter settings are applied on each image block. So that feature selection methods can be used to find the most effective set of image blocks with the most appropriate setting of parameters. In this paper, the preprocessed and normalized iris image is divided into multiple regions and a number of di-lobe and tri-lobe ordinal filters with variable orientation, scale and inter-lobe distance are performed on each region to generate regional ordinal feature units. Each feature unit, which is jointly determined by the spatial location of iris region and the corresponding ordinal filter, is constituted by 256 ordinal measures or 32 Bytes in feature encoding. The objective of feature selection is to select a limited number of OM feature units from the candidate feature set.

The probability that adjacent iris regions are highly similar with each other is more than with distant regions so long distance ordinal comparison is made reducing the redundant comparisons.

**IRIS Localization**: Regarding that illumination intensity is very different in pupillary inner and outer parts, and pupil is darker compared with iris, the use of Canny edge detection in pre-processing stage results in determining points in iris pupil boundary. The results of performing Canny edge detection on an eye image as pre-processing output. As it could be observed, pupillary boundary is almost completely detected. After determining edge points, by the use of circular Hough Transform, the center and radius of iris circle are obtained. In this method, after pre-processing stage, circular Hough transform was utilized for localizing circular area of iris inner and outer boundaries. Also, through applying linear Hough transform localization of boundaries between upper and lower eyelids occluding iris has been performed.

The most important stage of segmentation is detecting the boundary of iris and sclera. Firstly, there are other edge points in eye image in which illumination intensity distinction is much more than that of the boundary of iris and sclera. Secondly, because there is usually no specific boundary in this area and illumination intensity distinction between iris and sclera is very low at the border. As a result, edge detection algorithms which are able to detect outer iris edges identify those points as edge. Therefore, in order to detect iris outer boundary, these points have to be identified and eliminated. In this paper, available boundaries are initially enhanced and then extra edge points are identified and eliminated. At the end, through circular Hough transform, outer iris boundary is obtained. In order to enhance iris outer boundary edges, edge detection is performed on eye image in preprocessing stage. By performing such edge detection, a matrix is obtained with the same dimensions as of the image itself which its elements are high in areas where there is a definite boundary and the elements are low in areas where there is no perfectly definite boundary, such as iris outer boundary.

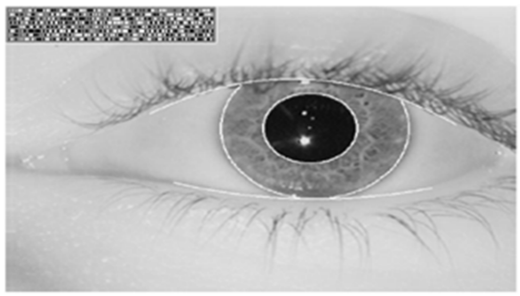

Fig.3.1. (a) Iris Segmentation

Through multiplying of 2.76 in the matrix of pixel values of iris image and intensifying light in eye image, the edges are enhanced. Applying Canny edge detection and multiplying that to the constant value of 2.76 results in better revelation of iris outer boundary edge points.
The operations performed are:

- IRIS Segmentation
- IRIS Normalization
- Intensity Transformation
- Ordinal comparison
- Robust Encoding
- Hamming distance based Classification

**IRIS Segmentation**: As shown in Fig. 3.1(a) Restructuring of iris by localization of iris inner and outer boundaries and localization of boundary between iris and eyelids.
In computer vision, segmentation refers to the process of separating a digital image into multiple regions (sets of pixels). The goal of segmentation is to simplify and/or change the representation of an image into something that is more clear, meaningful and easier to examine. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. The result of image segmentation is a set of regions that collectively cover the entire image, or a set of contours extracted from the image. Each of the pixels in a region is similar with respect to some Color or texture. Adjacent regions are significantly different with property or computed property, such as color, intensity.

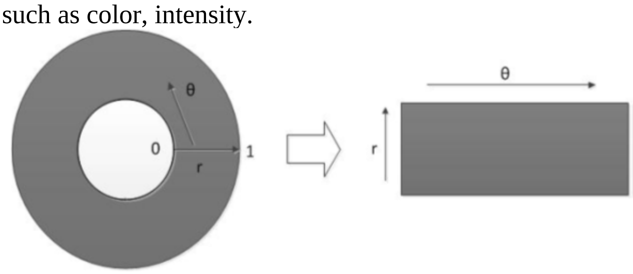


Fig.3.1. (b) Iris Normalization

**IRIS Normalization**: As shown in Fig 3.1(b) normalization involves transformation from degrees to Cartesian coordinates and normalization of iris image. In order to transform iris area from degrees to Cartesian coordinates, 128 pupils-centered perfect circles are chosen starting from iris-pupil boundary and then the pixels located on these circles are mapped into a rectangle. As a result, iris area which looks like a circular strip is converted into a rectangular strip. Theta becomes the length of the rectangle and radius become breadth of the rectangle so it is better to divide the iris into multiple regions.
Since with changes in surrounding illumination level, the size of pupil is adjusted by iris to control the amount of light entering into eyes and it is also possible that individual's distance with a camera could be different, iris is not of the same size in different images. Therefore, choosing these 128 perfect circles normalizes iris in terms of size as well. Then we adjust illumination intensity in segmented iris tissue, i.e. we applied image contrast to bring more clarity into iris tissue. In initial stage, localization of iris circular inner and outer boundaries, then that of eyelids; later choosing 128 circles on iris area, and eventually transforming polar to Cartesian coordinates has been performed. In order to extract features, Gabor Filters are utilized. Through performing Gabor Filters to the image from different orientations, ultimate feature vector is obtained.
**Intensity Transformation**: Involving brighter regions becomes brighter and a darker region becomes darker.
**Ordinal comparison**: Adjacent Iris regions compared for brightness or darkness.
**Robust encoding**: According to ordinal comparison bit 0 or 1 is assigned for iris regions.
**Hamming distance based classification**: XOR operation is performed between query image and reference image and sum of differences is calculated. According to some fixed threshold IRIS is classified as matched or not matched.

## IV CONCLUSIONS

This paper proposed an effective feature selection method to for iris recognition. The experimental results shown that the ordinal code of high level features is superior in comparison with iris code and shape code. So high level features only need simple low pass filtering and qualitative comparison. So ordinal code of high level features need two times less cost compared to shape code and three time less cost compared to iris code feature extraction

- Sparse ordinal feature set can be described as a linear objective function.
- Model only needs a small number of training
- Based on Qualitative measurement of quantities.
- Time complexity of algorithm is less.
- Personal identification is more easy and effective.

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