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Iris Image Classification: A Survey

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Abstract: ***Iris recognition is one of the consistent accurate, fast and secure biometric techniques for human identification. Iris recognition systems capture an image from an individual's eye. The iris in the image is then segmented and normalized for feature extraction process. The performance of iris recognition systems highly depends on segmentation. In this paper survey of iris recognition and classification methods and challenges related to iris recognition and classification are discussed.***

Keywords: race classification, vector quantization, support vector machine, iris liveness detection

1. Introduction

Biometric systems have been developed based on fingerprints, facial features, voice and hand geometry. It has emerged as one of the most influential and exact identification techniques in the current world. Iris is the protected part of eye that lies within the pupil and sclera and is unique for each individual.

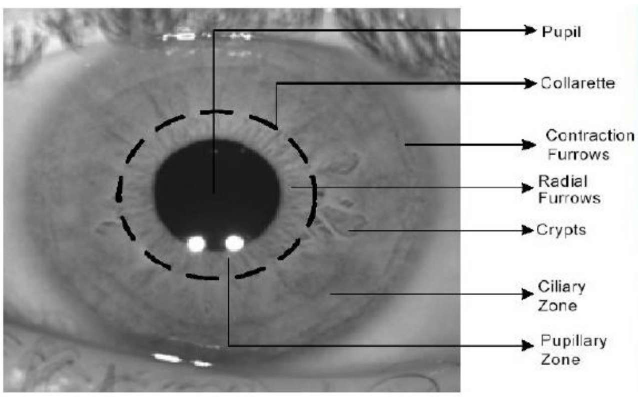

Figure 1: Eye image [1]

Iris has sole characteristics like steadiness of iris patterns during one's life era and is not surgically changeable. Iris recognition consist of diverse tasks like 1) Iris image acquisition; 2) Iris segmentation and normalization; 3) Feature extraction The iris recognition process is essentially separated into four steps:

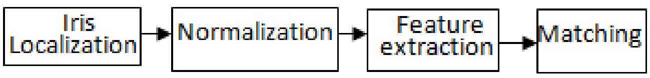

Figure 2: Iris Recognition Steps

Localization: Inner and outer boundaries of the iris are extracted.

Normalization: Iris of different people may be of distinct size. The same person may have the varying size because of variations in illumination and additional factors. So normalization is performed to acquire all the images in a usual form appropriate for processing.

Feature extraction: Iris serves ample of texture information, a feature vector is created which consists of the structured sequence of features extracted from a variety of representations of the iris images.

Matching: Feature vectors are classified over different threshold techniques like weight vector and winner selection, Hamming Distance, dissimilarity function, etc.

Once the localization is done then Eyelids and eyelashes that may cover iris are removed. The live-wire is one of the techniques which have been utilized to localize eyelid boundaries based on the intersection points between the eyelid and outer iris boundary. Then iris normalization converts iris image from Cartesian coordinates to Polar coordinators. An alternative method of feature extraction is to apply histogram equalization and binarization to the unwrapped iris image and use a self-organizing map neural network to divide the binary image into nodes, integro-differential operator, Hough transform, active counter method etc.

To speed up iris matching techniques used such as support vector machine-recursive feature elimination (SVM-RFE), contribution-selection algorithm used to reduce the feature vector dimension [2]. what would happen in a biometric-enabled application when a person's biometric template is stolen that shows the importance of security. The application requests some approach to shield each individual's biometric template such as watermarking the iris image, using encryption to protect the biometric, using the iris code to generate a key for encryption, using AES encryption of an enrolled iris code etc. Some of the techniques to detect and classify irises as spoofed or live i.e. iris are divided into subregion and analyze texture using local binary patterns(LBP), wavelet packet decomposition etc.

This paper is organized as follows. Section II describes the previous work in detail and different techniques proposed,for iris recognition. Section III describes the database may be used during iris recognition and section IV conclude the paper.

2. Previous Work

A. Iris image Capture

Iris images are captured using digital cameras such as iCAM TD 100, iCAM 4000, LG 4000, I Scan 2 etc. I Scan 2 ia a durable and compact dual iris capture scanner and it is an integral part of any comprehensive identity management program. Iris ID has been producing commercial iris recognition systems since 1997. There are iris devices such as LG2200, LG4000 etc. used to collect ND-CrossSensor-Iris-2013 Dataset.

S. Sondhi et al., have described[3] an iris recognition system is collection of iris image acquisition, preprocessing, neural network training process and pattern matching. They utilized a digitally captured iris image and then preprocessed. This is desired to take away the redundant parts that are usually captured along the iris image and to avoid effects due to a alter in camera-to-face distance and also due to non-uniform illumination. The image obtained is trained by means of self organizing map.

B. Iris Segmentation

Vaious iris image database has been used for the analysis of different segmentation algorithms. A good segmentation algorithm involves two procedures iris localization and noise reduction.

W. L. Lye et al., have proposed [4] a system consisting of two parts: Iris Localizaton and Iris Pattern Recognition. They used digital camera for capturing image. Iris is extracted. Only the portion of selected iris then reconstructed into rectangle format, from which Iris pattern is recognized.

S. Eric et al., have proposed[6] a method for complexity computation based on maximum Shannon entropy of wavelet packet rebuilding to enumerate the iris information. Real-time eye-comer tracking, iris segmentation and feature extraction algorithms are implemented. An regular camera with a zoom lens captures video images of the iris. Several useful findings were reached from a small database. The iris codes are found to contain almost all the discriminating information. Correlation approach coupled with nearest neighbor's classification outperforms the conventional thresholding method for iris recognition with degraded images.

Well-known methods such as Integro-differential, Hough transform and active contour models have been successful techniques in detecting the boundaries.

In 1993, J. Daugman [7] have introduced an integro-differential operator which acts as a circular edge detector, is employed for determining the inner and outer boundaries of the iris as well as the upper and lower eyelids. They have used a texture-based process to predetermine iris. Multi scale 2D Gabor Wavelet transform has worn to create a 256-byte iris code. Hamming distance is next used as a measurement to establish the proximity of two iris codes.

Wildes [8] has used Laplacian of a Gaussian filter to take out features as of the iris image. A Hough transform-based method has used for segmentation. Also, the upper and lower of the eyelids are approximated by parabolic curves.

Masek and Kovesi [9] employed weighted gradients using a combination of Kovesi's modified canny edge detector and the circular Hough transform to segment the iris.

J. Koh et al., have proposed[10] robust iris localization that uses an active contour model and a circular Hough transform. The segmentation is supposed to be accurately mine the iris region regardless of the presence of noises such as varying pupil sizes, shadows, specular reflections and highlights. Taking into account these obstacles, a number of attempts have been prepared in robust iris localization and segmentation.

R. Abduljalil et al., have proposed[11] live-wire technique which has been applied to localize eyelid boundaries based on the intersection points among the eyelid and outer iris boundary. The eyelid detection algorithm enhanced the iris segmentation accuracy. The saturation color features of the sclera region of the HSI color space of the iris image are exploited to choose the two intersection points between every eyelid and the outer iris boundary. The strongly connected edges between these two points are detected using the live wire technique that is probable to be the eyelid boundary.

G. Guodong et al., have proposed[12] a method to get better iris localization performance that optimally utilizes both the intensity gradient and texture difference. To formulate the iris boundary further accurate, they offered a new issue called model selection and projected a method to select among ellipse/circle and circle/circle models.

R. B. Dubey et al., have proposed[13] an automatic segmentation system that is based on the diverse algorithms and is able to localise the circular iris and pupil region, occluding eyelids and eyelashes and reflections. The approach addresses the subject of processing iris images where pupil and iris boundaries are not essentially perfectly circular by considering diverse operations such as, binary image creation, finding all connected component, removal of small connected component, selecting pupil component and finding pupil component for pupil boundary detection and intensity level transformation, dilation and image thresholding.

B. Z. Vargahan et al., [14] have segmented iris image using by Hough transform and canny edge detector. Then they normalized image to improve quality using Contourlet transform and used Symlet4 wavelet transform for feature extraction.

M. Vatsa et al., have proposed[15] a iris verification algorithm which uses textural and topological features of the iris image. They proposed 1D log Gabor wavelet which is used to extract the textural information and Euler numbers which is used to extract the topological information from the iris image. Hamming distance is used.

C. Feature Encoding

Huang et al. [16] coarsely segment the iris by means of edge detection filters and Hough transform before normalizing it. The noise due to eyelids is then localized by the edge information based on the phase congruency.

N. Singh et al., have[17] proposed a fusion mechanism that amalgamates both, a Canny Edge Detection and a Circular Hough Transform, to detect the iris boundaries in the eye's digital image. They applied the Haar wavelet in order to take out the deterministic patterns in a person's iris in the form of a feature vector.

S. M. Rajbhoj et al., have proposed[18] a method for iris recognition based on Haar wavelet approach of Iris texture extraction. The feature extraction algorithm extracts haar wavelet packet energies of the normalized iris image (local features) to generate a unique code by quantizing these energies into one bit according to an adapted threshold. Hamming distance measure is used in favor to get similarity involved in the iris images.

S. Lokhande et al., have proposed[19], iris recognition system using Haar wavelet packet. Wavelet Packet Transform (WPT) which is extension of discrete wavelet transform has multi-resolution approach. In this iris information is encoded based on energy of wavelet packets.

S. Zhenan et al., have proposed [20] a method to conquer the restrictions of local feature based classifiers (LFC). In order to know different iris images efficiently a novel cascading scheme is proposed to merge the LFC and an iris blob matcher. Then the iris blob matcher is resorted to choose the input iris uniqueness because it is capable of recognizing noisy images.

D. Matching

The aim of matching is to evaluate the similarity of two iris representations. The created templates are compared using the Hamming distance or Euclidean distance. The normalized Hamming distance used by Daugman measures the fraction of bits for which two iris codes disagree[21]. A low normalized Hamming distance implies strong similarity of the iris codes.

Iris Image Classification

Both iris image classification and iris recognition can be globally regarded as the same problem of pattern recognition. It mean classification of iris images into some pre-defined categories. The class labels in the traditional iris recognition is the individual identity and iris images taken from a human eye are defined as the same class so that the dissimilarity between iris images of different subjects should be identified. The main difference between both is the class labels at macro or micro scale. In classification, the class label corresponds to a group of subjects with similar properties of iris images. Therefore the solution of iris image classification is considerably different to iris recognition. Since each subject has unique pattern for every subject and individually specific features to distinguish different subjects helps to classify the iris images.Local binary patterns(LBP), weighted-LBP, gray level co-occurrence matrix etc. are few of the texture feature useful for liveness detection.

Iris image classification is separated into four steps as shown in figure 2.

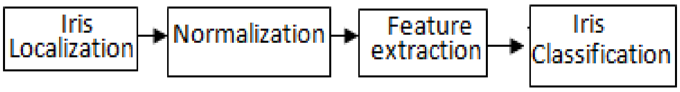

Figure 2: Iris classification steps

H.B. Kekre et al., have described[22], that K-means is an optimization algorithm but the algorithm takes very long time to converge. The adoption of codebook to facilitate the convergence time for K-means is condensed significantly. The codebooks are obtained by using Linde Buzo and Gray (LBG) and Kekre's Fast Codebook Generation (KFCG) algorithms.

S. Zhenan et al., have proposed[23] a method which classifies the iris image for three kinds of application i.e. iris liveness detection, race classification and coarse-to-fine iris identification. A texture pattern based method called Hierarchical Visual Codebook is proposed to encode texture primitive of iris images.

A. I. Desoky et al., have proposed[24] an iris recognition algorithm in which a set of iris images of a specified eye are merged to create a final template by means of the most consistent feature data. Features consistency weight matrix is resolute according to the noise level offered in the considered images.

Table 1: Few iris segmentation and matching technique proposed above

Author	*Segmentation Technique*	*Encoding Technique*	*Matching Technique*
Daugman[7]	Integro-differential operator	Multiscale 2-D Gabor Wavelet coefficients	Hamming distance
Wildes[8]	Edge detection and Hough transform	LOG filter	Normalized correlation
Masek and Kovesi[9]	Edge detection and Hough transform	1D Log-Gabor filter	Hamming distance
Dorairaj et al.[5]	Integro-differential operator	PCA and ICA	Euclidean distance
Huang et al.[16]	Phase congruency and Hough transform	Multiscale 2-D Gabor Wavlet	Hamming distance
Singh et al.[17]	Canny edge detection and Circular hough	2-D Haar wavlet transform	Hamming distance

3. Database

In order to find out the performance of the developed iris segmentation approach, publicly available databases which comprise of the images. Brief description of each database is provided below.

CASIA DATABASE[25]

It have been approved by the Chinese Academy of Science. It contains 756 iris images from 108 eyes composed over two sessions. All the images captured is nearly faultless and free from noise and rough image conditions.

CASIA version 3 is acquired in an enclosed environment. Nearly all of the images have been captured in two sessions among an interval of at least one month. The database comprises 249 subjects with total of 2655 images from left and right eyes.

CASIAV3 is a superset of CASIAV1. The pupil regions of all iris images in CASIAV1 were automatically detected and replaced with a circular region of constant intensity to mask out the specular reflections.

CASIA-Iris-Fake

The database is developed for iris liveness detection. It contains four subsets, namely Print, Contacts, Synth and Plastic. The IG-H100 iris device is used to capture a huge amount of fake iris images. There are 6000 fake iris image in the genuine dataset, 2950 synthesized iris image in the Synth dataset, 400 images in the Plastic dataset and 640 images in the Print dataset.

CASIA-Iris-Thousand

CASIA-Iris-Thousand contains 20,000 iris images from 1,000 subjects, which were collected using IKEMB-100 camera.

UBIRIS DATABASE[26]

It contains 1877 images from 241 persons composed over in two sessions. The image captured in the first session was noise free or low-noise image. In contrast, image captured in second session were captured in different conditions such as: under natural light, reflections, different contrast levels etc. Such type of images capable to provide the realistic situations and environment with nominal relationship from the subjects.

UPOL Database[27] includes images from internal parts of the eye which focus on the localization part of iris. In the next section, we will discuss a new approach for the iris recognition system which includes eye liveness checking to avoid fake sources entering from the database. This algorithm provides the real time security applications

NOTREDAME DATABASE[28]

ND Cosmetic Contact Lenses 2013 Dataset. This dataset contains iris images of subjects without contact lenses, with soft contact lenses, and with cosmetic contact lenses, acquired using an LG 4000 and an IrisGuard AD100 iris sensor. The dataset contains 4,200 TIFF files from the LG4000 sensor, 900 TIFF images form the AD100 sensor, and four metadata files describing the images.

4. Conclusion

The paper discussed different methods for iris recognition. Each method is having some advantages and limitations. The methods for existing system discussed require more computation time is for shifting process and it could not perfectly identify the fake contact lens. For iris images from a same category, the iris feature should be clustered closely even though iris images are captured from different subjects. For iris images from different categories, the iris feature should be separated at a distance. This can be achieved by iris classification. Iris image classification helps to speed up large-scale identification.

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