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FEATURE EXTRACTION TECHNIQUES FOR RECOGNITION OF IRIS IMAGES: A REVIEW

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Abstract: In this paper, an overview of the latest research works in the feature extraction stage of an iris recognition system is presented. Among many other biometric systems, iris based biometric system, is one of the stable and reliable system. Iris image segmentation, normalization, feature extraction and matching are the various stages involved in an iris based biometric system. Of all these stages feature extraction algorithms, plays a major role in improving the overall system performance in terms of accuracy and reliability. This paper presents a review of various feature extraction techniques available for iris based biometric system in literature along with a comparative study.

Keywords : Iris Feature Extraction, Phase based methods, Zeros-crossing Representations, Keypoint descriptors, Intensity variation Analysis.

1. INTRODUCTION

In today's world personal identification is required in many application areas like banking, unique citizen id cards (like Voters ID, Aadhar card), driving licenses. Biometrics provide a more trustworthy and reliable solution over many traditional approaches. Among various types of biometrics like, iris, face, finger print, ear, palm print, etc., iris has gained more attention due to the presence of unique and highly stable feature. Iris biometrics is one of the high confidence biometric systems, since its development from the past two decades [1].

An iris based biometric system, consists of two phases, (i) enrolment phase and (ii) identification phase. In enrolment phase, eye images are acquired and segmented to get iris region of interest (ROI), features are extracted and stored as feature vectors in databases. In identification phase, a query image to be identified is segmented to get Iris ROI, followed by feature vector creation. A matching phase is included to match this identified feature vector against those stored to identify the individual. Fig. 1 shows the iris based biometric system and its two phases.

2. REVIEW OF LITERATURE OF IRIS FEATURE EXTRACTION

Iris has a unique textural pattern present in it, which could be extracted using wide varieties of feature extraction techniques and could be stored as a biometric template in a database for further processing. Features identified give either local or global or both local and global information about an iris. Features help in quantifying significant textural characteristics of an iris. In general feature extraction techniques could be grouped under any one of the following methods; (i) Signal or Image processing methods or (ii) Statistical processing methods [2]. Both the spatial domain and frequency domain methods are included in the first method, where as second method works on the spatial inter dependencies of the intensity information. To group down this further, in an iris based biometrics, feature extraction can be performed by using any one of the following methods:

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1. Phase and Texture Based methods
2. Zero-crossing Representation
3. Keypoint Descriptors
4. Intensity Variation Analysis

Phase and Texture Based Methods: First commercial iris recognition system was developed by Daugman [1, 3, 4] using phase features. In this system, from the iris ROI pattern in the normalized polar coordinates (r,theta), 2D-gabor filters were used to extract the feature vector (iris code) of size 256 byte. Though able to achieve good recognition rate, computation complexity in terms of time increased as Gabor increases. In [5,6,7] Wildes, derived isotropic band pass decomposition using LOG filters, which yielded a compact iris representation of size 256 bits, but computational complexity was increased. In [8] Lim et al., used 4 levels of 2-d Haar Wavelet to get a compact iris representation of size 87 bits, but the middle frequency components of iris were lost in this method. Ma et al., in [9] used key local sharp variations using dyadic Wavelet Transform to normalized iris. In this method, iris textures were considered as a set of signals with varied intensities and used the local sharp variations in the vector to distinguish the iris. This method produced result with good speed and accuracy, but the feature vector had a variable length. Miyazawa et al. [10] unwrapped only the lower half of segmented iris images as input pattern and proposed a iris feature extraction system using the phase components of 2-D Discrete Fourier Transform (DFT). A Phase- only Correlation function was used to perform phase based image matching.

Sun and Tan in [11] proposed a Multi-lobe Differential Filter, which extracted ordinal measure features (non- local measures) resulting in better performance. This method was to implement and the computational complexity in terms of time was very low. Ordinal code size and recognition performance were based on the separation of lobes and kernel size. Chou et al., [12] used edge type maps to extract iris feature descriptor, using the Laplacian of Gaussian (LOG) and Derivative of Gaussian (DOG) filters. This non- orthogonal view system resulted in a 48 dimension feature vector. Equal Error Rate (EER) of LOG and DOG filters were less when compared with Gabor filters. In [13] Ali Alheeti proposed an iris recognition system using 2d DWT with wavelet masks like Haar and Db2 WT masks, followed by edge detection operators like canny, Prewitt, Roberts and Sobel to recognize features. This hybrid technology helped to identify the power of edge detection operators used in generating the minimum features needed in identifying an iris.

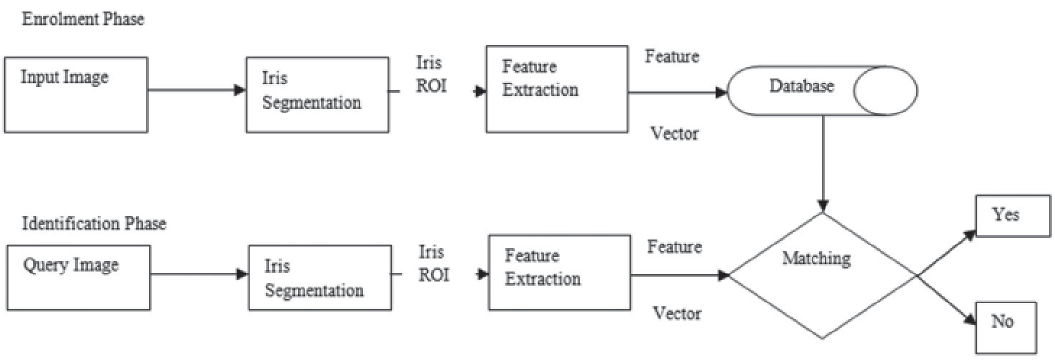

Figure 1. Iris Based Biometric System

Najafi and Ghofrani [14] proposed a system to handle the 2-d singularities of the edges in an image efficiently, using the directionality and anisotropy properties of Ridgelet and Curvelet transforms. 11 different wavelets ware applied on these two techniques and Curvelet transforms were found to provide better results.

Local Binary Patterns and histogram properties were used to extract features in [15] by Rashan et al., were powerful tools to describe the textural characteristics of an iris images. LBP is a statistical pattern approach which extracts the most important feature affecting the computational cost of a classifier found to provide better recognition rate.

A framework based on based Gabor filter to extract the global and local features was proposed and received 2nd rank in NICE II competition by Qi Wang et al., [16]. Selected best 4 features from normalized iris patches and classified them using Adaboost.

Radu et al., [17] proposed a framework using the 6 orientations of 2-d gabor filter. This technique was proposed to optimize multiple sets of 2D Gabor filter parameters to gradually enhance the accuracy of an iris recognition system.

Tan and Ajay [18] proposed Log-Gabor filters and Geo key encoding system to extracts iris features from localized and global normalized iris image regions. This joint strategy was adopted to simultaneously extract and combine both the global and localized iris features and found to provide better accuracy results when compared with several state- of-the-art iris encoding techniques.

Zero-Crossing Representation: Sharp variations in an image are one among the most meaningful features to characterize it. The zero-crossing approach provides the locations of sharp variation points at different scales in an image and marks them as edge points. Boles et al. [19] proposed a framework for iris recognition system based on the zero-crossings of the Wavelet transform and the resultant 1-D signals were used for comparison with the model features. This approach is both rotational and translational invariant.

Sanchez-Avila and Sanchez-Reillo in [20] extracted zero-crossings of the dyadic wavelet transform from two different iris signatures based on: (i) single iris virtual circle and (ii) an annular region. The performance when done in an annular region is found to be better when compared to the other iris signature.

Monro et al., 2007 [21] used zero-crossings of 1-d Discrete Cosine Transform (DCT) for faster feature extraction. Feature vector is formed from the normalized iris using the DCT series obtained from the averaged overlapping angular patches.

Ahamed and Bhuiyan in [22] proposed a framework based on zero-crossings of Curvelet transforms using approximation of sub bands as features, with low computational complexity. In the several zero-crossings based approaches it is observed that DCT based approach provides a very low computational complexity iris recognition system and high accuracy compared to other approaches.

Keypoint Descriptors: Keypoint descriptors are obtained from the selected interest points in an image and when applied on an image provides scale and rotational invariance. These descriptors are highly robust to illumination and minor viewpoint changes and even to noise factors. In an iris based biometric system, keypoint descriptors can be applied directly on segmented iris ROI. They do not require a polar transformation as by default they provide a scale and rotational invariance [23]. Scale Invariant Feature Transform (SIFT) is one of the well known keypoint descriptors developed by Lowe for object recognition [24]. SIFT is applied to regions of iris which does not require polar transformation [38]. Mehrotra et al. [25] proposed an iris recognition system using interest point pairing which is capable of providing good results for iris textures.

In [26] Mehrotra et al., proposed a Speeded Up Robust Features (SURF) based iris recognition system. SURF was directly applied on the segmented iris ROI and found to perform well because of its capability to distinguish significant texture features from the background. Gabor Wavelets were combined with SIFT to generate phase and magnitude features of Gabor by Du et al. in [27]. For non-cooperative iris images, Gabor feature descriptor provide scale, rotational, deformational, illumination and contrast invariance and work well with frontal and off-axis images.

Zhang et al. [28] proposed a keypoint descriptor framework using deformable DAISY features for robust iris feature matching. In this method, DAISY features are extracted from the normalized (polar transformed) iris images to get a low computational cost.

Mehrotra et al., [29] proposed a Fourier-SIFT method. In this method, interest points are detected using traditional SIFT followed by describing local features around the points using Fourier spectrum and found to perform better when compared to traditional SIFT on iris images taken in non-cooperative scenarios.

Sun et al. [30] proposed a recognition system using bovine iris images captured from non-cooperative audiences. SIFT method is applied to detect the key points in the iris image, and points located in pupil region are removed. Then, feature vocabulary, called bag-of-features is constructed, and histogram representation for each iris image is generated. Results proved the efficiency of the system. SIFT is used to develop a time consuming system. Future work is proposed to use SURF descriptors to focus rotational invariance.

Ibrahim et al., [31] proposed a SIFT based iris recognition system with few sub segments alone. In this method, sub segments are cropped from left of the iris, below the pupil, 2 sides of iris, 3 sides of iris and core iris. When applied SIFT descriptors on these sub segments, found to provide 100% accuracy with low computation complexity in terms of time for the sub segment taken from 2 sides of iris.

Intensity variation Analysis: Intensity variation analysis methods are based on local features of an image and used to efficiently provide an iris image’s shape information [32]. These methods are mainly used to reduce the dimensions of the feature vectors. Huang et al., [33] proposed an intensity variation based feature extraction technique using Independent Component Analysis (ICA) on non- cooperative iris images. ICA is found to work well for blurred and noisy iris images captured under varied illumination settings. The performance of this model could be improved if the ICA coefficients are selected in an efficient manner.

Dorairaj et al., [34] developed a system based on Principal Component Analysis (PCA) followed by global ICA for image encoding to process off axis iris images. This method uses both the local and global iris features.

Schuckers et al., [35] proposed a framework using global ICA and bi-orthogonal Directional Filter Banks (DFB) on off-axis iris images and found to provide a comparatively good recognition rate. One of the major drawback of this method is that, the training phase is semi automated.

Chandra Murty et al., [36] developed an algorithm using 1-d LOG Gabor filters followed by PCA. Performance of this system is nearly 100% when the resolution of the iris images is more than 256.

Hussain [37] proposed a technique to extract features from the rectangular iris codes in the Eigen space domain. Different numbers of Eigen iris vectors, like 10, 7 and 4 were considered to evaluate the performance of the system for both iris codes with and without noise. System is found to provide an accurate recognition when used with 10 and 7 number of Eigen iris vectors, even for partial iris (120X200).

3. CONCLUSION

Based on this review on different iris feature extraction techniques, it is observed that a system when developed with local feature based approaches have shown to improve the iris recognition performance. Of all the techniques identified, keypoint descriptors method has an advantage of eliminating the iris normalization stage. Even if the iris is not accurately segmented, experimental results show that keypoint descriptors are capable of providing better results. The survey of the techniques provides a platform for the development of the new novel feature extraction technique in the iris biometrics area as future work.

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