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Iris feature extraction through wavelet mel-frequency cepstrum coefficients

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ABSTRACT

In this paper, a novel technique based on wavelet cepstrum feature is discussed for iris recognition system. The proposed method is based on the wavelet derived from the popular biorthogonal Cohen-Daubechies-Feauveau 9/7 filter bank. Moreover, being biorthogonal in nature it has superior frequency selectivity, symmetric, and better time-frequency localization. The suggested scheme deals with computing the two level detail coefficients from the normalized iris template. Then these detailed coefficients are then divided into non-uniform bins in a logarithmic manner. This helps in reducing the dimension of the wavelet coefficients followed by assigning non-uniform weights to the different frequency components. Then the discrete cosine transform of the same is computed, from which the energy feature is extracted. The proposed technique is experimentally validated with publicly available databases: CASIAv3, UBIRISv1, and IITD. The performance of the proposed approach is found be superior to that of the state-of-the-art methods.

1. Introduction

Biometrics is the science that deals with recognition of an individual by considering its different traits. These traits can be either behavioral or physical. In *cybernetics*, authentication is a fundamental and important activity. Biometrics has found its place ranging from modest to expansive applications. Since automation of many day-to-day activities in public places are achieved through softwares, biometrics based person identification has provided a platform for ensuring security in airports, making financial transactions in banks, and surveillance [1]. The level of difficulty in identity verification increases manifold, when it is designed with high accuracy. Person authorization and authentication since the last two decades has been predominantly carried out by: (i) *token-based system* (e.g., passport, smart card, etc.); (ii) *knowledge-based system*(e.g., PIN, password, etc.); and (iii) *biometric based system* (e.g., face, signature, etc.). To deal with spoofing effectively, a combination of two or more of these, referred to as *multifactor authentication*, has become the preferred way of authenticating users in recent years.

Password/PIN is the frequently used authentication/authorization technique, whose usage is widely found in personal computers, automated teller machines (ATM) for making financial transactions. The need to physically possess the token/piece of information makes the biggest disadvantage of the token/knowledge based authentication system. Hence, both are prone to spoofing attack. On the contrary, biometrics has a unique advantage, where the user authenticates himself by using his/her own physical traits. These unique biometric traits include fingerprint, iris, face, palmprint, etc. The fingerprint/palmprint is prone to changes due to external injury or change in pattern due to rough work.

Abbreviations: AUC, Area Under Curve; CDF, Cohen-Daubechies-Feauveau; CHT, Circular Hough Transform; DCT, Discrete Cosine Transformation; DFT, Discrete Fourier Transformation; DWT, Discrete Wavelet Transform; EER, Equal Error Rate; FAR, False Acceptance Rate; FFT, Fast Fourier Transformation; FPC, Fourier Phase Code; FRR, False Rejection Rate; FV, Feature Vector; GAR, Genuine Acceptance Rate; HOG, Histograms of Oriented Gradients; IDFT, Inverse Discrete Fourier Transformation; IDO, Integro-Differential Operator; JPEG, Joint Photographic Expert Group; LBP, Local Binary Patterns; LoG, Laplacian of Gaussian; MFC, Mel-Frequency Cepstrum; MFCC, Mel-Frequency Cepstrum Coefficients; MLDF, Multi-lob Differential Filters; MT, Mel Transformation; NIR, Near Infra Red; POC, Phase-Only Correlation; PILP, Phase Intensive Local Pattern; ROC, Receiver Operating Characteristic; SIFT, Scale Invariant Feature Transform; THFB, Triplet Half-band Filter Babk; VS, Visual Spectrum; WCF, Wavelet Cepstrum Feature; WT, Wavelet Transformation.

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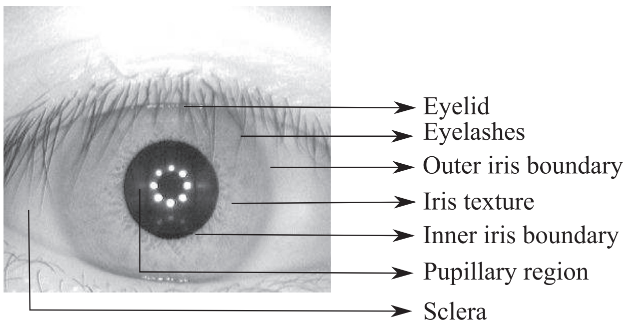

Fig. 1. Different traits of an iris image.

Similarly, face feature is not stable as it changes over time. On the contrary, the iris pattern is not exposed to the outside environment. It is covered by a very transparent material called cornea leaving the iris protected (see Fig. 1). Apart from that the iris pattern remain stable over the years. Also it is not affected by cataract surgery or any other disease. Hence, iris is known to be highly reliable due to the above said reasons among all these biometric features. A block diagram representation of iris recognition system is shown in Fig. 2.

The rest of the paper is organized as follows: Section 2 describes about some notable contributions towards iris recognition followed by Section 3, which discusses about the proposed technique. Section 4 deals with the application of wavelet cepstrum feature extraction from iris images. Result and discussion is given in Section 5 followed by concluding remark in Section 6.

2. Related work

Numerous contributions on iris segmentation have been reported in the last decade. Iris localization carried out by employing integrodifferential operator is a widely adopted method, which is invented by Daugman [2]. This technique globally searches for the circle center and radius. The time complexity of this technique amounts to cubic order. Subsequently Wildes has developed another landmark method by using primitive edge detection followed by Circular Hough Transform (CHT) [3] for achieving localization with reduced time complexity. Huang et al. [4] have proposed a coarse to fine search strategy to improve localization time. Their technique finds out the limbic iris boundary in the re-scaled image in the coarse stage. After this stage using integrodifferential operator, the pupillary boundary is found with the obtained information. Many refinements have been brought to Hough transform to bring improvement over traditional one. In [5], Liu et al. have reported the application of Canny edge detector to improve localization speed along with Hough transform. For finding center and pupillary boundary normal line algorithm is used by means of Canny edges. Then the outer edge is found using homocentric circle algorithm. The application of bisection method is studied by Sung et al. [6] to find the inner iris boundary. Further, the collarette boundary is computed by using histogram equalization and statistical information. Another work reported by Liu et al. [7], describes about bringing improvement over Hough transform by restricting votes for locating center based on direction of edges for circle detection. Feng et al. [8] have proposed an algorithm to deal with bottleneck of traditional iris segmentation approaches which are badly affected by time complexity; also yields degraded performance in presence of non-cooperative factors like eyelid occlusion, presence of lens, gaze tilt, etc.

Fig. 3 represents some real world challenging scenarios that are encountered in the acquisition process. Fig. 3(a) depicts a case of occlusion, where capture of iris region is hindered by camera due to presence of eyelashes and eyelids since it has covered almost 50% of the iris. Fig. 3(b) shows another instance of a subject where the iris region is covered by contact lens. In such case, the integrodifferential operator performs well to detect pupil boundary. However, the highest change of illumination happens to be along the lens boundary; hence results in segmentation failure along the limbic boundary. Fig. 3(c), shows the problem posed by gazing. In such case, the standard algorithms for iris segmentation fail as the non-

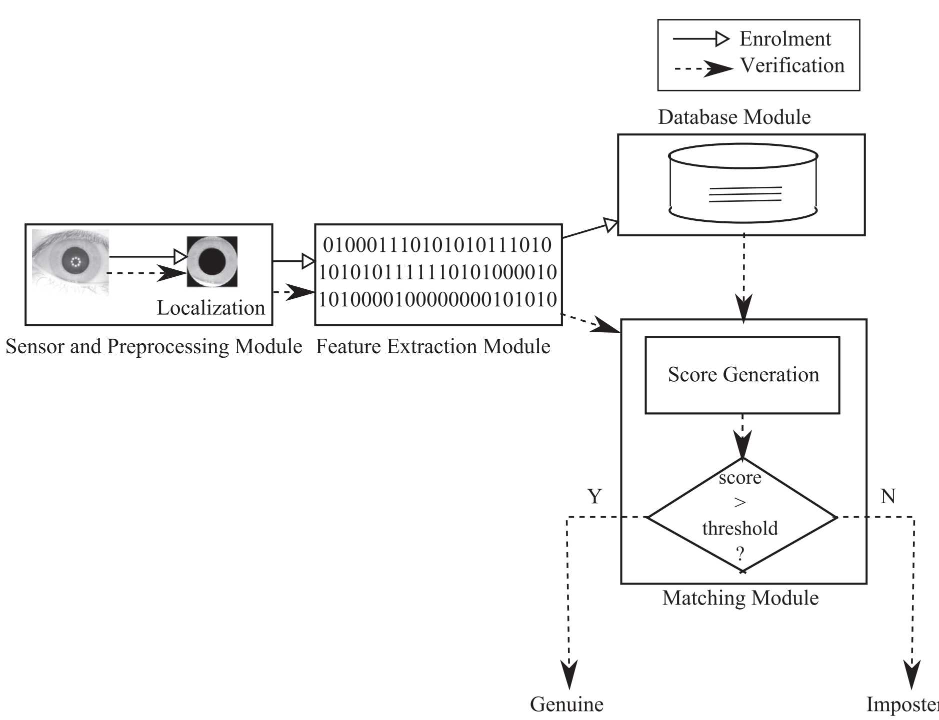

Fig. 2. Generalized block diagram of iris recognition system.

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