Iris Recognition using Four Level HAAR Wavelet Transform: A Literature review

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Abstract –
There is considerable rise in the research of iris recognition system over a period of time. Most of the researchers has been focused on the development of new iris pre-processing and recognition algorithms for good quail iris images. In this paper, iris recognition system using Haar wavelet packet is presented. 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. And then matching of this iris code with the stored one is performed using hamming distance . Our proposed work significantly decreases FAR and FRR values as compared to previous work. Experimental results are demonstrating significant improvements in iris verification process.

Keywords — *Biometrics, Iris recognition, Iris segmentation, Iris normalization, Wavelet packet.*

I. INTRODUCTION

For the last decade, biometric-based personal verification and identification methods have gained much interest with an increasing emphasis on security. Iris recognition is a fast, accurate and secure biometric technique that can operate in both verification and identification modes since the iris texture pattern has no links with the genetic structure of an individual and since it is generated by chaotic processes [1]. Consequently, a variety of iris recognition approaches were proposed that can be broadly classified in three categories depending on the method used to extract features from the texture. These categories are: (1) texture-based, (2) appearance-based and (3) featurebased extraction. Texture-based techniques [2-9] make use of filters for image processing and extract iris features from the filtered images. Daugman [2] used Gabor wavelets to extract texture phase structure information of the iris to compute a 256-byte binary iriscode. The Hamming distance measure was used to compare the difference between a pair of iris representations. In Wildes' approach [4], the Laplacian pyramid constructed with four different resolution levels is used as iris features. Then, the normalized correlation is used to compare both the input and the template iris images. Wang et al [7,8] have proposed recognition techniques using multichannel Gabor filtering. Hence, they have used 8- directional Gabor filters with multiple frequencies to capture both global and local details in an iris image.

The mean and variance of these Gabor filtered images are used as features for the matching process. Other approaches that exploit other wavelet categories such as the 2D Haar wavelet and zero-crossing representation of 1D wavelet Transform, were proposed in [9] to characterize an iris texture. Appearance-based approaches [10,11], such as Independent Component Analysis (ICA), direct Linear Discriminant Analysis (LDA) and Principal Component Analysis (PCA), attempt to use classical statistical approaches to extract iris features. The PCA is superior in image construction, because it can control construction errors by selecting the cumulative variance. Euclidean-distance and Nearest-Neighborhood (NN) classifier are adopted in these approaches.

Feature-based extraction techniques [7,11,12] use local variations, which are characterized by the appearance and disappearance of an important image structure. A bank of spatial filters is constructed for efficient feature extraction and for matching process. However, if the original iris images are of poor quality, the wavelet-packet approaches are more efficient for iriscode generation comparatively to the classical wavelet approaches without a greater risk of iris recognition errors. For this reason, some authors have proposed the iris recognition based on wavelet packet [13].

In this paper, we present a method for iris recognition based on a wavelet packet decomposition of iris images. Each iris image is described by a subset of band-filtered images (subimages) containing wavelet coefficients. From these coefficients, which characterize the iris texture, we compute a compact iris feature code using the appropriate energies of these sub images to generate binary iris codes according to an adapted threshold. Thereafter, we show how an efficient and reliable Hamming distance can be used in order to classify iris codes. Results are presented that demonstrate significant improvements in iris recognition accuracy.

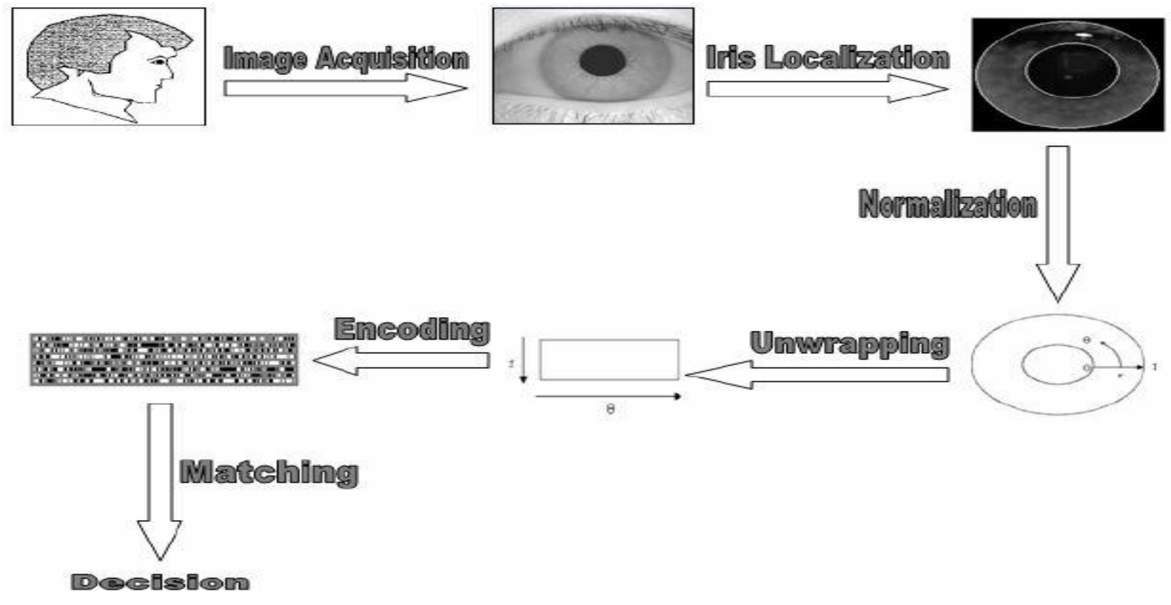


Figure 1.Iris Recognition Process

II. IRIS RECOGNITION METHOD

Figure 1 summarizes the steps to be followed when doing iris recognition.

Step 1: Image acquisition, the first phase, is one of the major challenges of automated iris recognition since we need to capture a high-quality image of the iris while remaining non-invasive to the human operator.
Step 2: Iris localization takes place to detect the edge of the iris as well as that of the pupil; thus extracting the iris region.
Step 3: Normalization is used to be able to transform the iris region to have fixed dimensions, and hence removing the dimensional inconsistencies between eye images due to the stretching of the iris caused by the pupil dilation from varying levels of illumination.
Step 4: The normalized iris region is unwrapped into a rectangular region.
Step 5: Finally, it is time to extract the most discriminating feature in the iris pattern so
that a comparison between templates can be done. Therefore, the obtained iris region is encoded using wavelets to construct the iris code.
As a result, a decision can be made in the matching step.

III.PROPOSED METHODOLOGY

Figure.2 shows the flow of the proposed method. It consists of various stages like segmentation ,normalization, feature extraction and matching.

A. Iris Image Pre-Processing

1) Iris Image Localisation

The iris is an annular part between the pupil (inner boundary) and the sclera (outer boundary). Different iris localization approaches have been reported in the literature: Integro-Differential, Circular Hough, Hough Transform and edge and contour detection. In our approach, this task is performed by hough transform. The Hough transform is a standard computer vision algorithm that can be used to determine the parameters of simple geometric objects, such as lines and circles, present in an image. The circular Hough transform can be employed to deduce the radius and centre coordinates of the pupil and Firstly, an edge map is generated by calculating the first derivatives of intensity values in an eye image and then thresholding the result .

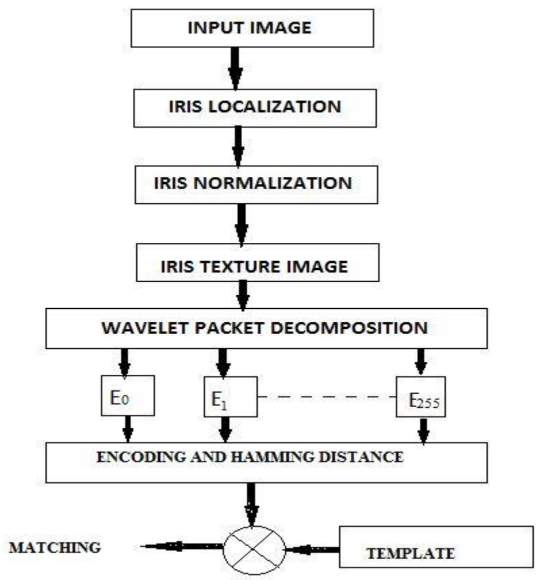
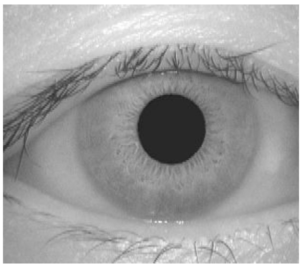


Figure.2. Proposed Method of Iris Recognition

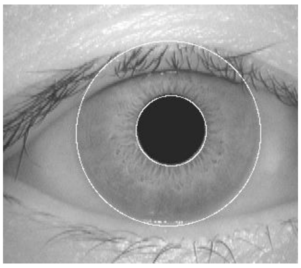
2) Iris Image Normalization

Once the iris region is segmented, the next stage is to normalize this part, to enable generation of the iris code and their comparisons. Since variations in the eye, like optical size of the iris, position of pupil in the iris, and the iris orientation change person to person, it is required to normalize the iris image, so that the representation is common to all, with similar dimensions.

Normalization process involves unwrapping the iris and converting it into its polar equivalent. It is done using Daugman's Rubber sheet model. The centre of the pupil is considered as the reference point and a Remapping formula is used to convert the points on the Cartesian scale to the polar scale.
The radial resolution was set to 20 and the angular resolution to 240 pixels.



(a)Original Image



(b)Iris Localisation

(c)normalization
Figure. 3. Iris Image Segmentation

B. Feature Extraction and Encoding

The majority of researchers have proposed wavelets approaches in order to capture local iris features at different scales.

After the iris image segmentation process is completed, the iris code is performed using Haar wavelet packets as well as the energy of the packets sub-images to extract texture phase structure information of the iris and to compute the iris 256-bits codes.

The Iris code generation process can be summarized
in the following steps:

1) Wavelet Packets Decomposition:

We have used the Haar wavelet in a 4-level wavelet packet decomposition to extract the texture features of the unwrapped images . This generates 256 wavelet packets (output iris subimages), numbered 0 to 255.

In the Haar wavelet transformation method, low-pass filtering is conducted by averaging two adjacent pixel values, whereas the difference between two adjacent pixel values is figured out for high-pass filtering.

The Haar wavelet applies a pair of low-pass and high-pass filters to image decomposition first in image columns and then in image rows independently. As a result, it produces four sub-bands as the output of the first level Haar wavelet. The four sub-bands are LL1, HL1, LH1, and HH1. Upto four levels of decomposition are done to get the detail image [14].

The WT separates an image into a lower resolution approximation image (LL) as well as horizontal (HL), vertical (LH) and diagonal (HH) detail components. The process can then be repeated to compute multiple scale wavelet decomposition, as in the four scales WT is shown in fig.4.

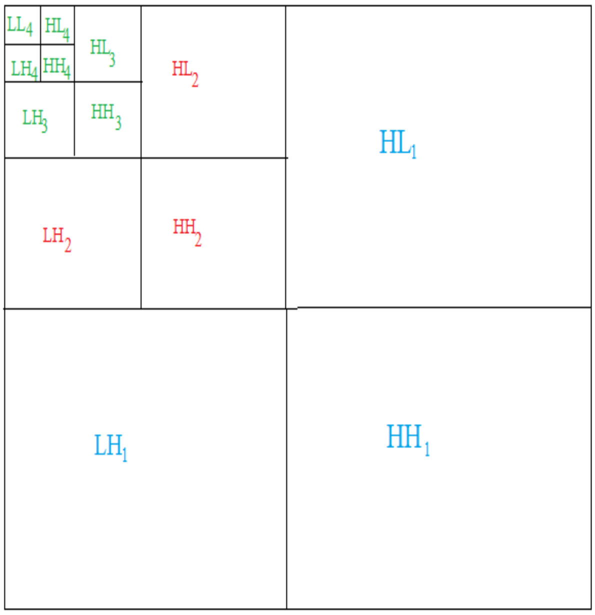


Figure.4 .Four Level Wavelet Decomposition

*2) **Wavelet Packets Energy Computation***:

In order to obtain the most texture information in packet subimages, we have used an energy measure. The mean energy distribution allows evaluating which packets are used to compute the normalized adapted threshold for our iriscode generation. The energy measure E_i for a wavelet packet subimage W_i can be computed as follows :

$$E_i = \sum_{j,k} W_i(j,k)^2 \qquad (1)$$

We use the appropriate wavelet packet energies of each iris image to compute the adapted threshold to encode the 256 subimages Let $E_1 \ldots E_\lambda$ be the appropriate wavelet packet energies of the packets 1…λ respectively. We define the normalized adapted threshold S as follows:

$$S = Coeff \cdot \frac{\mu(E_1,\cdots,E_\lambda)}{Max(E_1,\cdots,E_\lambda)} \qquad (2)$$

where $\mu(E_i,\cdots,E_\lambda)$ represents the mean wavelet peak energy value, *Coeff* as a constant and λ is the number of the appropriate energies.

*3) **Iris Feature Coding:***

After determination the appropriate wavelet packets energies and the normalized adapted threshold, we can carry out the coding of the 256 wavelet packets energies to generate a compact iriscode by quantizing these energies into one bit according to each appropriate energy. Let E_λ be the appropriate energy of the peak λ. Then the iriscode C_λ computed according to E_λ we define by the following:

$$C_\lambda(j) = \begin{cases} 1 & if \quad \dfrac{E_j}{E_\lambda} > S \\ 0 & otherwise \end{cases} \qquad (3)$$

Where j=0..............255.

In our approach, we have used significant wavelet coefficients of the iris subimage. Each used appropriate energy resulting in a total of 256 bits which correspond to the 256 subimages of the iris wavelet decomposition. Therefore, we obtain one iriscode according to each energy.

C. Iris Code Matching

The iris codes matching task is performed by pairing the iriscodes extracted from the input and the template iris images. The most common comparison method of iris signatures is the Hamming Distance (*HD*) [12]. This comparison is to be made with the user's iris template, which will be calculated depending on the binary matching algorithm which is implemented by the Boolean exclusive-OR operator (⊕) applied to the 256 bit vectors that encode any two iriscodes.

Let $T = \{C_i(j) \quad j = 0 \cdots N\}$ and $I = \{C_k(j) \quad j = 0 \cdots N\}$

be the iris binary codes extracted from the template and input iris images. The binary Hamming distance *HD* i,k, between these iris binary codes is measured according to the following

$$HD_{i,k} = \frac{1}{N}\sum_{j=0}^{j=N} C_i(j) \oplus C_k(j) \qquad (4)$$

The preceding distance is computed according to the appropriate energy (maximal value) between two iris signatures in order to decide if both come from images of the same iris (authentic distance) or from Images of different iris (impostor distance). Therefore, the combination of two or several packets is likely to hold more discriminating information than what each of them does separately as mentioned in. So, the preceding distance can be extended for two appropriate energies of each iris image as follow [14]:

$$HD_{i,k} = \frac{1}{2*N}\sum_{j=0}^{j=N} \left\| C_i(j) \oplus C_k(j) \right\| \cdot \left\| C_{i'}(j) \oplus C_{k'}(j) \right\| \qquad (5)$$

where C_i and $C_{i'}$ are the iris codes computed according to the two appropriate energies of the template iris image and C_i and $C_{i'}$ of the input one.

IV. CONCLUSION

A proposal algorithm for iris recognition has been presented. Hough transform is useful for segmentation of the iris because of efficient localization. The Haar wavelet transform has a number of Advantages , it is conceptually simple, fast, memory efficient and reversible when compared with other wavelets. A fixed length feature vector is obtained. Experimental results show that proposal algorithm can effectively distinguish different persons by identifying their irises. It is also computationally efficient and insensitive to illumination and noise. Our future work will focus on more robust iris features as well as iris recognition from image sequences.

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