Identification of Human Iris using Discrete Haar Wavelet Transform

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Abstract

Image recognition is one of the fields of Artificial Intelligence. Nowadays, Image recognition is affecting not only corporations using it within an economic interest but also the average user who uses a digital camera. This process can be done with a variety of tools but most of the time these are too complicated for the inexperienced user to handle. We applied the Haar Wavelet in order to extract the deterministic patterns in a person's iris in the form of a feature vector for personal identification. These are three basic steps in our system such as image preprocessing, feature extraction and recognition. By comparing the quantized vectors using the Hamming Distance operator, we determine finally whether two irises are similar. Our results show that our system is quite effective.. Our system intent to help for security to identify the person based on human's iris.

1. Introduction

Biometric system is essentially a pattern recognition system which makes a personal identification by determining the authenticity of the specific biometric identifier possesses by the user. Today, there are many biometric devices based on characteristics that are unique for everyone. Some of these characteristics include iris, fingerprints, hand geometry and voice but are not limited.

Human iris is a kind of physiological biometric feature, contain unique texture pattern and is highly complex enough to be used as a biometric signature. This characteristic shows that the probability of finding two persons with identical iris pattern is almost zero. Several studies have shown that normal variation in coloring and structure of the tissues of the iris is so much that there are not ever two irises alike, not even for identical twin.

Even for a single person his two irises are also different. So, iris feature is a very good physiological trait for personal identification due to its inherent of high uniqueness and high performance. Among the biometric technologies iris recognition is more popular than other recognition system because of the many advantages.

We implemented 'Iris Recognition' using Matlab for its ease in image manipulation and wavelet applications. The first step of our project consists of images acquisition. Then, the pictures' size and type are manipulated in order to be able subsequently to process them. Once the preprocessing step is achieved, it is necessary to localize the iris and unwrap it. At this stage, we can extract the texture of the iris using Haar Wavelets. Finally, we compare the coded image with the already coded iris in order to find a match or detect an imposter.

2. Related Work

Biometrics systems offer great benefits with respect to other authentication techniques. In particular, they are often more user friendly and can guarantee the physical presence of the user[1-2]. Iris recognition is one of the most reliable biometric technologies in terms of identification and verification performance. The first use of iris recognition can trace back to the Paris prison in eighteenth century, where police discriminated criminal by inspecting their irises color.

In recent years, Daugman [3][4] developed the feature extraction method based on 2D Gabor filter which used multi-scale quadrature wavelets to extract texture phase structure information of the iris to generate a 256 bytes iris code and compared the iris code by computing their Hamming distance. Wildes [5] decomposed the iris region by application of Laplacian of Gaussian filters. The normalized correlation method is used for classification. Boles and Boashash [6] extracted the features of the iris pattern by using the zero-crossings of 1D wavelet transform of the concentric circles on the iris. Iris matching was based on two dissimilarity functions. Sanchez-Avila and Sanchez- Reillo [7] further developed the method of Boles and Boashash by using different distance measures for matching. Lim et al. [8] used 2D Haar wavelet transform to process the iris image and quantized the fourth-level high frequency information to form iris code. E. Krichen et al. [9] used wavelet packets to produce an iris code at each level of resolution. R.Zewail et al. [10] used a bank of Log-Gabor filters to extract iris feature. The matching was done by using Euclidean distance. Ma et al. [11] used a bank of spatial filters to capture local characteristics of the iris so as to produce discriminating texture features. Monro et at.[12] presents a novel iris coding method based on differences of DCT coefficients of overlapped angular patches. Thornton et al.[13] describes a general probabilistic framework for matching patterns that experience in-plane nonlinear deformations.

3. Background Theory

The iris recognition system consists of an automatic segmentation system and is able to localize the circular iris and pupil region. Firstly, we use Laplacian of Gaussian Method (LOG) for edge detection. This express as

$$G(x,y)=(\frac{1}{\sqrt{2\prod}\delta})(e^{-(x^2+y^2)/2\delta^2})(\frac{x^2+y^2}{\delta^4}-\frac{2}{\delta^2}) \qquad (1)$$

where,

G(x,y)=smoothing function of scale

(x,y)=image position

And then, we use median filter to remove the garbage around pupil to gain clear pupil to determine perfect center.Get the center of the pupil by counting the number of black pixels (zero value) of each column and row. Then get each row and column that has the maximum number of these black pixels. Then determine the center by simple calculation according to the image coordinate to set it correct on the image, consequently we can determine the radius of the pupil. Thus we can find the papillary boundary(inner) and outer boundary.

The localized iris part from the image should be transformed into polar coordinates system Locating iris in the image delineates the circular iris zone of analysis by its own inner and outer boundaries. Thus the following equations implement:

$$I\left(x(r,\theta),y(r,\theta)\right)=I(r,\theta) \qquad (2)$$

$$X(r,\ \theta)=(1\text{-}r)\ x_p(\theta)+rx_i(\theta) \qquad (3)$$

$$Y(r,\ \theta)=(1\text{-}r)y_p(\theta)+ry_i(\theta) \qquad (4)$$

where $I\ (x,\ y)$ is the Iris image, $(x,\ y)$ are the original Cartesian coordinates, $(r,\theta\ )$ are the corresponding normalized polar coordinates, and are the coordinates of the pupil and iris boundaries along the θ direction.

In this paper, a wavelet transform is used to extract features from iris images. Among the mother wavelets, we use Haar Wavelet. The wavelet transform breaks an image down into four sub-sampled, or images. The result consists of one image that has been high pass in the horizontal and vertical directions, one that has been low passed in the vertical and high passed in the horizontal, and one that has been low pass filtered in both directions. The conceptual model for the three levels Integer Wavelet decomposition for feature extraction is shown in Figure 1.

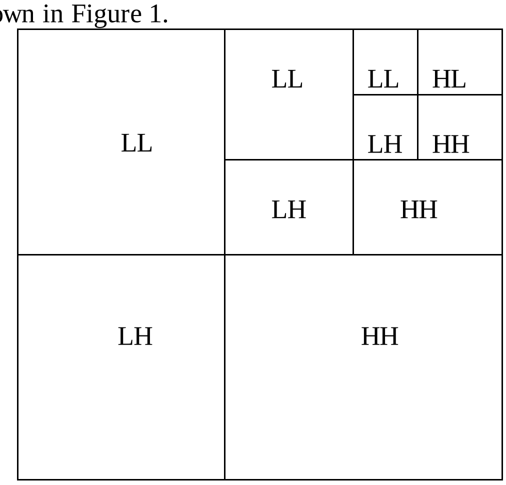


Figure 1. Conceptual diagram for 3 levels 2D Integer Wavelet Decomposition .

4. Proposed System

Our proposed system consists of two separate parts: the first one is to store the registered human iris data into the database and the second part is to identify these iris data when users enter into the system. Our proposed system architecture is shown in figure(2). To store or recognize the human iris data, it contains three basic steps:

1. Preprocessing
2. Feature extraction
3. Matching process.

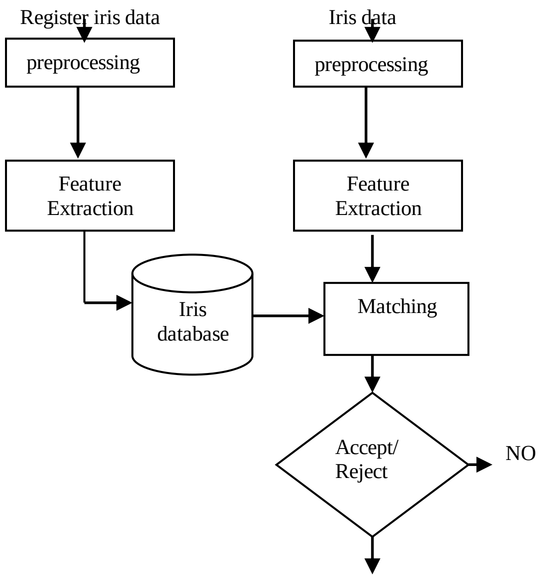
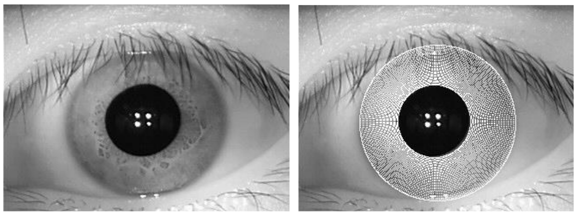


Figure 2. System architecture

4.1. Preprocessing

The iris is an annular part between the pupil (inner boundary) and the sclera (outer boundary), which can approximately be taken as circles. Iris segmentation is implemented referring to the method ,LOG. For the purpose of achieving shift and scale invariant, the annular iris region is further normalized to a fixed size by anti-clockwise unwrapping the iris ring. Then filter is used to enhance normalized iris image in order to compensate for the effects of image contrast and illumination. Figure 3 shows the iris preprocessing results.



(a) (b)

Figure 3. Preprocessing. (a) Source image. (b)Localized iris and the normalization region used for recognition.

4.2. Feature Extraction

Feature extraction is the most important step in Iris Verification. We use Haar Integer Wavelet Transformation to extract the features from the normalized Iris image. The normalized Iris image of size 60*250 is subjected to Integer Wavelet Transformation to get Approximation band, Horizontal band, Vertical band and Diagonal band. The Horizontal Detail band obtained after the first level Integer Wavelet Transformation is further subjected to two levels of decomposition. The approximation band obtained after the third level decomposition consists of the prominent features. The horizontal band is selected at the first two stages of decomposition, because the normalized Iris image shows more details in the horizontal direction i e., angular dimensions of the actual Iris image compared to the vertical direction i e., the radial dimension of the actual Iris image. The two dimensional approximation band containing the prominent features is converted into a one dimensional array and it is binarized. To binarize, we equate all the positive features to 1 and the negative features to 0. This finally results in a feature vector of size 256 bits.

4.3. Matching

Matching between the two Iris feature vectors is done using Hamming Distance. It is a measure of how many bits are the same between two bit patterns. Using the Hamming Distance of two bit patterns, a decision is made as to whether the two patterns were generated from different Irises or from the same one. In comparing the bit patterns *X* and *Y*, the Hamming Distance *HD*, is defined as the sum of disagreeing bits over *N*, the total number of bits in the feature vectors and is given by the Equation 5.

$$HD = \frac{1}{N}\sum_{j=1}^{N} A_j \oplus B_j \qquad (5)$$

Since an individual Iris region contains features with high degrees of freedom, each Iris region produces a bit pattern which is independent to that produced by another Iris. On the other hand, two Iris codes produced from the same Iris will be highly correlated. In ideal case, if two bits patterns are completely independent, such as Iris templates generated from different Irises, the Hamming Distance between the two patterns is high. This occurs because independence implies the two bit patterns will be totally different. If two patterns are derived from the same Iris, the Hamming Distance between them is close to zero, since they are highly correlated and the bits should agree between the two Iris codes. However, because of the presence of noise due to Eyelid and Eyelashes occlusion, the Hamming Distance may vary up to 0.4 even for the same Iris images captured at different instances. To increase the efficiency, we compare the Iris image under test with all the 7 images of each group and the mean value of the 7 Hamming Distances is used to decide whether the Iris image under test belongs to the same group or not. If the average Hamming Distance obtained is greater than 0.39 then the subject is rejected and if the average Hamming Distance is lesser than 0.39 then the subject is accepted as genuine.

5. Experimental Results

We tested our project on 95 pictures, using a Pentium IV processor, and we obtained an average of correct recognition of 97.112%, with an average computing time of 31s. The main reason of the failures we encountered is due to the quality of the pictures. Some of these problems are bad lighting, occlusion by eyelids, noises or inappropriate eye positioning.

In our implementation, we divide the 240 samples of irises data into equal size folders, such that a single folder is used for testing the model that has been developed from the remaining nineteen sets For wavelet transform the best results were obtained for the high pass(H) in scales 3 and 4 in vertical direction. Maximal statistical measure value was 2.54 what means that it is quite good and accurate resultby calculating Equation 6. Acceptance Rate (FAR) and False Rejection Rate(FRR) are the two critical measurements of system effectiveness. This system is scored a perfect 0.001% FAR and 0.55% FRR. Table(1) shows the classification rate compared with the well known two methods; Wilde's and Daugman's. Now, we are working on more precisely representing the variation of texture of the iris in local region and reducing the dimensionality of the feature vector. Thus, we expect to further improve the performance of the current method.

$$MR = \frac{N_z * 100}{T_n} \quad (6)$$

Table 1. Classification Rate

Method	Rate (%)
Wilde's	99.2%
Daugman's	100%
Haar Wavelet	97.112%

6. Conclusion

We have successfully developed a new Iris Recognition system capable of comparing two digital eye-images. This identification system is quite simple requiring few components and is effective enough to be integrated within security systems that require an identity check. The errors that occurred can be easily overcome by the use of stable equipment. Judging by the clear distinctiveness of the iris patterns we can expect iris authorization systems to become the leading more secure technology in identity verification.

7. References

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