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Iris Recognition Using Rapid Haar Wavelet Decomposition

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Abstract—**In this paper, we propose an iris recognition system using a basic and fast Haar wavelet decomposition method to analyze the pattern of a human iris. This system has two main modules, which are the feature encoding and iris code matching modules. Among all feature extraction methods, Haar wavelet decomposition is chosen for its computational simplicity and speed in filtering the iris pattern. In the feature extraction module, unrolled iris images are filtered using high pass filter and low pass filter for four times to produce the corresponding coefficients. Subsequently in the second module, Hamming distance between iris codes is calculated to measure the difference between the query iris image and the iris images in the database. Iris recognition is then performed by matching the iris pair with the minimum Hamming distance. This system is tested with 450X60 pixels iris images from the CASIA iris database (CASIA-IrisV3-Interval), and a recognition rate of 98.45% is achieved.**

Keywords-iris recognition; Haar wavelet

I. INTRODUCTION

Iris recognition has been a popular area of research in the past decade. It plays a major role in identifying and recognizing an individual given a huge database. There are a few challenges faced while developing an iris recognition system. Among them are the dynamic sized iris region that causes a direct match to be infeasible, and the invariant moment of the eye that caused by the angle of the head while the eye image is taken. Despite all these challenges, there are many automated iris recognition systems which have been commercialized over these years using different approaches.

Iris identity recognition systems are mostly used in real time to authenticate an individual. For instance, iris identity recognition system can be used in ATM in banking environment. Therefore, a rather quick processing speed is needed in order to fulfill the real time requirement.

There are various ways presented in the past to perform iris recognition, which include John Daugman's renowned IrisCode [2]. However, in this paper, we proposed to use Haar decomposition [3] to extract the iris features and convert them into 348-bits iris code to effectively recognize an individual. Besides its advantage in computational simplicity and speed, Haar wavelet decomposition is also less likely to be affected by environment factors as compared to Gabor wavelet [3].

II. RELATED WORKS

Extensive researches have been carried out in the field of iris recognition where various approaches have been presented, such as [1]-[4]. Feature extraction using Gabor filter [2], [3] has proven a significantly high accuracy but sacrifices processing speed. This method has been tested on several millions of real human iris images, and as reported in [2], researchers have successfully obtained a optimal threshold value of 0.32 to be used as the maximum dissimilarity for the hamming distance between two iris codes.

Another method in [5] is using the wavelet transform and (Wavelet Transform) zero crossings to extract iris features for recognition. This technique is translation, rotation and scale invariant, thus it offers freedom in capturing eye images. This method is relatively better compared to Daugman's prototype system [5] for iris recognition, due to its ability to tolerate illumination variation. Unfortunately, zero crossings technique has a high equal error rate and is sensitive towards the resolution level, whereby resolving iris images in wrong resolution will result in losing important iris features.

In [1], the system recognition accuracy achieved is only up to 93% and it has a relatively small iris database. While [4] uses a similar approach that is using Haar wavelet acquires an accuracy of 98.4% using a complex neutral network matching method. In [4], a lower number of bits used but a complex matching method is used to compensate the lesser number of bits.

Due to the computational simplicity and high speed in matching binary strings, Haar wavelet decomposition and Hamming distance are adopted to perform iris feature extraction and iris code matching in our proposed system. To fasten the matching speed, a lower number of bits (348 bits) is used in composing the iris code, as compared to 2048 bits in [2], [3] and 702 bits in [1].

III. METHODOLOGY

Our approach in this paper is using Haar wavelet decomposition to extract the iris features, and Hamming distance to measure the dissimilarity between the binary iris codes. Figure 1 shows the general structure of the iris recognition system.

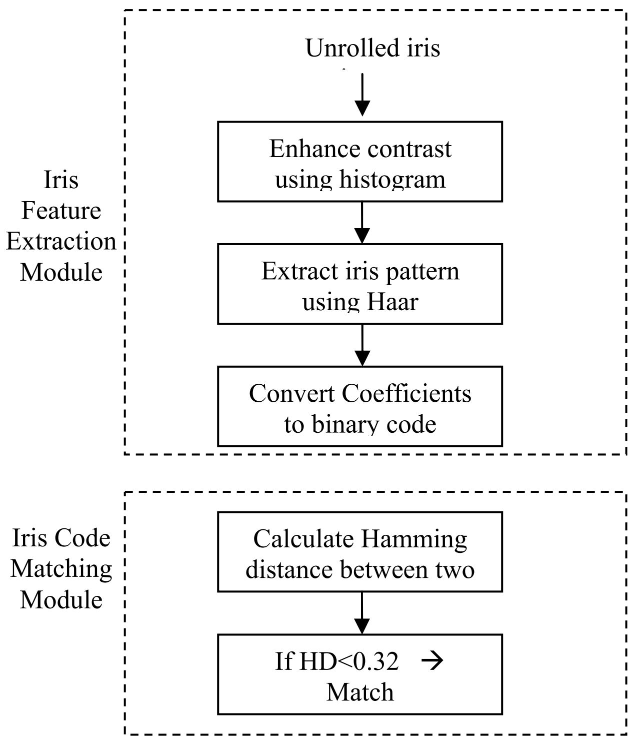

Figure 1. General structure of iris recognition

A. Iris Feature Extraction

In the first module, an unrolled iris image contrast is enhanced using histogram to enable a better extraction of pattern by transforming the values in an intensity image, or the values in the colormap of an indexed image, so that the histogram of the output image approximately matches a specified histogram. Figure 2 shows the effect of performing histogram equalization on an iris image.

Histogram equalized iris region is then decomposed using Haar decomposition up to four levels of decomposition (Figure 3). Since decomposing the iris region of 450 X 60 pixels will produce a very large number of coefficients, in our method, we only choose to take the fourth level of Haar decomposition to reduce the code length. Taking only the fourth level decomposition will produce 348 coefficients. These numbers are then converted to binary iris code simply by converting positive coefficients to 1 and negative coefficients to 0.

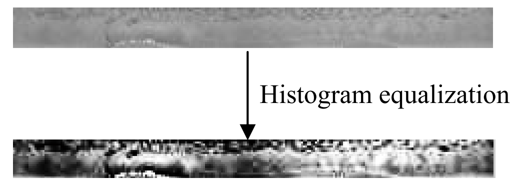

Figure 2. Unrolled iris image before contrast equalized and after equalized

B. Iris Code Matching

The iris codes in the database are used to find out which iris codes come from the same eye. Hamming distance is chosen because of its speed in calculating dissimilarity between binary codes. The formula is shown in Equation 1, where *HD* is the Hamming distance between j^{th} X and Y binary codes, and N is 348 in this case.

$$HD = \frac{1}{N}\sum_{j=1}^{N}\left(X_j \oplus Y_j\right) \tag{1}$$

IV. RESULTS

We implemented our system on 344 preprocessed iris images using Matlab 2009a version, using a Pentium Core 2 Duo 2.4 Ghz processor. These test data are obtained from CASIA iris database (CASIA-IrisV3-Interval) [6], and are of a resolution of 450 x 60 pixels. Each of the iris images is matched against all other test data, which consist of images of the same iris and also different irises. The results are summarized in Table 1 with high true positive and true negative observed.

TABLE I. RESULT SUMMARY

True Positive	2178
True Negative	114322
False Positive	1358
False Negative	478

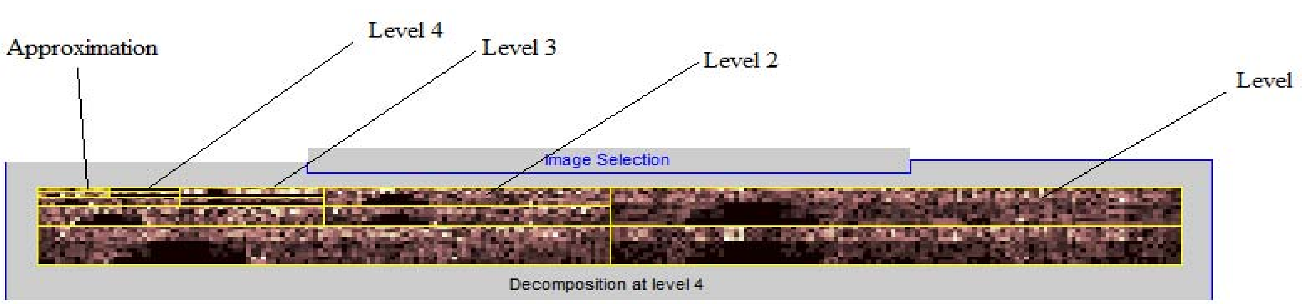

Figure 3. Four levels Haar decomposition

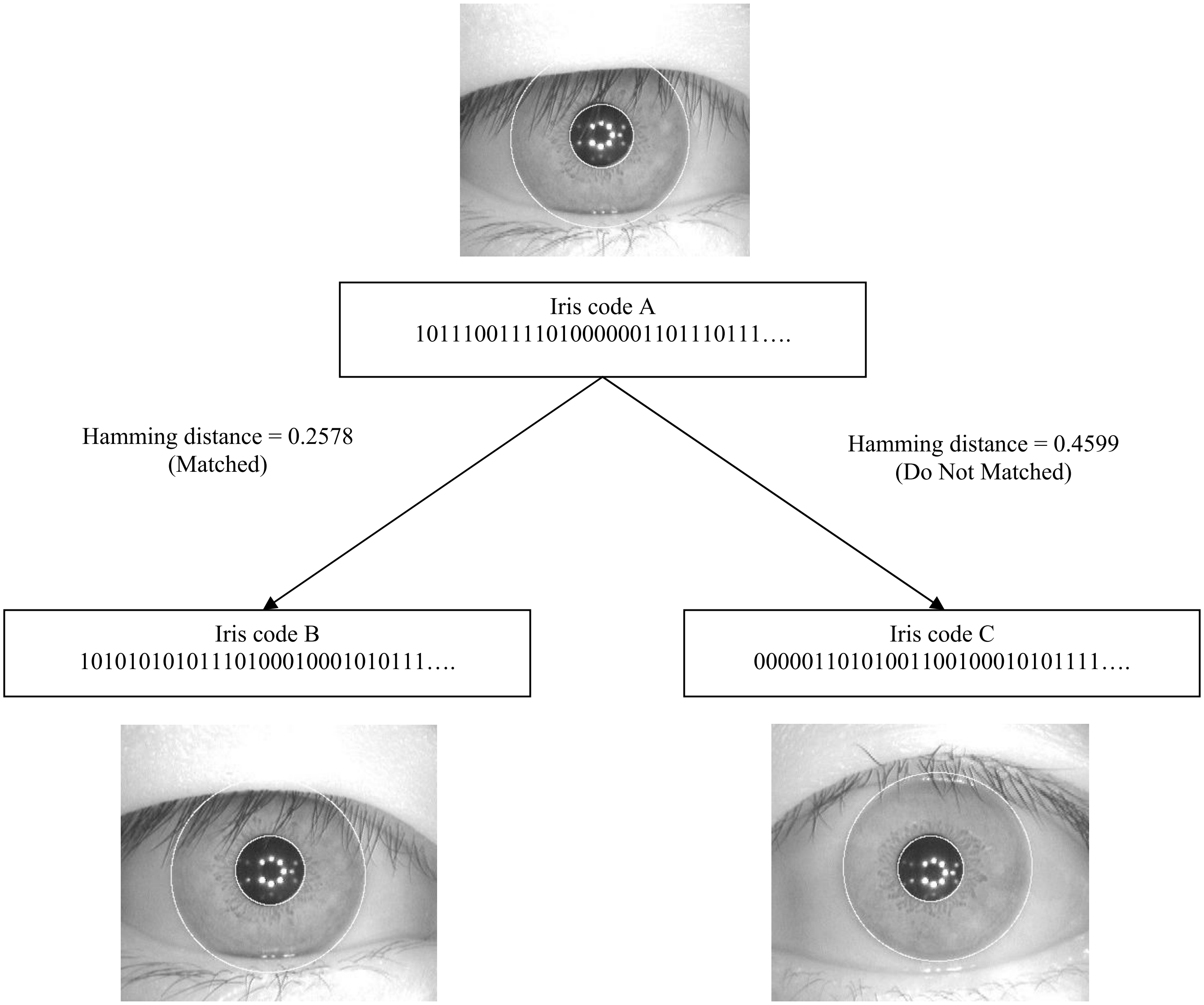

Figure 4. Iris code matching process

An overall accuracy of 98.45% is yielded. Figure 5 shows an example of iris code matching process. An iris pair with Hamming distance above a threshold of 0.32 is matched against each other, whereas the rest are rejected. The main reason a perfect accuracy cannot be obtained is due to the quality of the test data and the iris regions are not segmented accurately due to noises like eye lashes and lighting effect.

V. CONCLUSION

In this paper, Haar decomposition is used to extract the feature of the human iris. Coefficients obtained from the decomposition of are then converted to binary codes to be used on calculation of Hamming distance for matching purpose. Haar decomposition is rather simple compare to Gabor wavelet, because of its computational simplicity and lesser parameters are involved in determining the accuracy of the method. Despite the simplicity of Haar decomposition, this approach has achieved a high recognition rate up to 98.45%.

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