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Iris Feature Extraction for Personal Identification using Lifting Wavelet Transform

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ABSTRACT
With an increasing emphasis on security, automated personal identification based on biometrics has been receiving extensive attention over the past decade. Iris recognition, as an emerging biometric recognition approach and has become a popular research and practical applications in recent years due to its reliability and nearly perfect recognition rates. In this paper, we present a novel approach to iris recognition. Our goal is to develop a Lifting (integer) wavelet-based algorithm that enhances iris images, reduces noise to the maximum extent possible, and extracts the important features from the image. Then the similarity between two iris images is estimated using Euclidean distance and comparison of threshold. The proposed technique is computationally effective with recognition rate of 99.97 % on iris database. This approach will be simple and effective.

Keywords
Iris recognition, biometrics, identification, Lifting wavelets, and security.

INTRODUCTION
Most traditional methods of security require a person to possess some type of physical possession, such as a key, or to know certain information, such as a password. These techniques are not as secure as organizations may desire. In recent years, the increasing capabilities of computers have allowed more sophisticated and intelligent personal identification methods. Biometric techniques [1] [2], which use uniquely identifiable physical or behavioral characteristics to identify individuals, are one such method. Commonly used biometric features are the face, fingerprints, voice, DNA, retina, and the iris. Iris recognition is thought to be one of the most reliable methods of biometric identification. It involves using photographs of a person's eye(s) to determine the identity of the individual. The iris contains unique features, such as stripes, freckles, coronas, etc. [4], collectively referred to as the texture of the iris. This texture is analyzed and compared to a database of images to obtain a match. The probability of a false match is close to zero, which makes iris recognition a very reliable method of personal identification. This paper discusses a lifting wavelet based algorithm for iris image enhancement, noise reduction, feature extraction, and matching. Following this introduction, we briefly review related works. In section 3, we discuss our proposed methodology for iris recognition. Section 6 & 7 is our result and conclusion.

Related Work
In this section, we discuss techniques that have been used in iris recognition. Though the theory behind iris recognition was studied as early as the 19th century, most research has been done in the last few decades [5], [6], [7]. Daugman [8] used a multiscale quadrature method and used Hamming distance for matching. Boles and Boashash [9] used a zero-crossing method, with dissimilarity functions for matching. Wildes et al. [10] used a Laplacian pyramid for analysis of the iris image. Lim et al. [11] used a 2D Haar transform to extract iris data. Ma et al. [12] used multichannel Gabor filtering to extract important data. Tisse et al. [13] used a Hilbert transform for extraction. In later research, Ma et al.[4] used a different spatial filter to extract features. The iris has a complex texture. Using infrared light, many of the unique properties of the iris can be seen. Because the properties used are based on texture, eye color is unimportant, and images can be grey-scale. Typically, a CCD camera is used to obtain iris images. The camera should have a resolution of 512 dpi [3].
The iris is not believed to change drastically over time, and so a database of images should be reliable for a long time [4]. The technique described in Daugman's [5] paper uses wavelets for demodulation of the iris image to extract two-dimensional modulations which are turned into what is referred to as an IrisCode. The extracted IrisCode is compared to an IrisCode in a database, and if it is similar enough, it is considered a match. Most iris recognition used today is based on this method [5]. Ma et al. use a technique which first converts the round image of the iris into a rectangular pattern, essentially by "unwrapping" the circular image. Filters are then used to obtain the frequency distribution of the image. This data is used to make a match in the iris database. According to the research of Ma et al., this technique is inferior only to Daugman's method [4].
In C.M.Patil and S. Patilkulkarni [14], we proposed to detect the inner and outer boundary of an iris using wavelet approximations..
In C.M.Patil and S. Patilkulkarni [15], we proposed to extract the features of an iris using wavelet approximations.

I. Proposed Methodology
In this section, we discuss our proposed methodology for iris image recognition. Figure 1 shows the process that will be used. The process involves seven modules and a database.

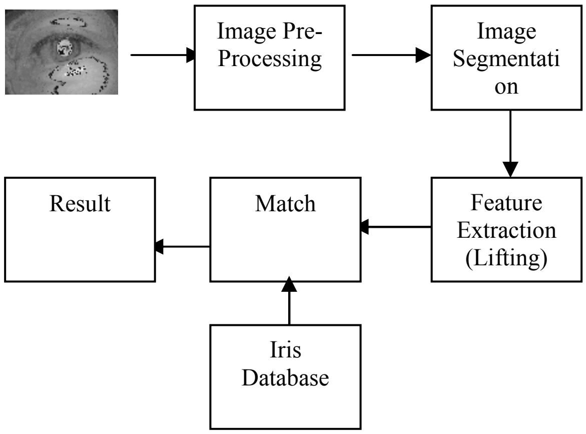


Figure 1: Flowchart of our Methodology

A. Data Collection

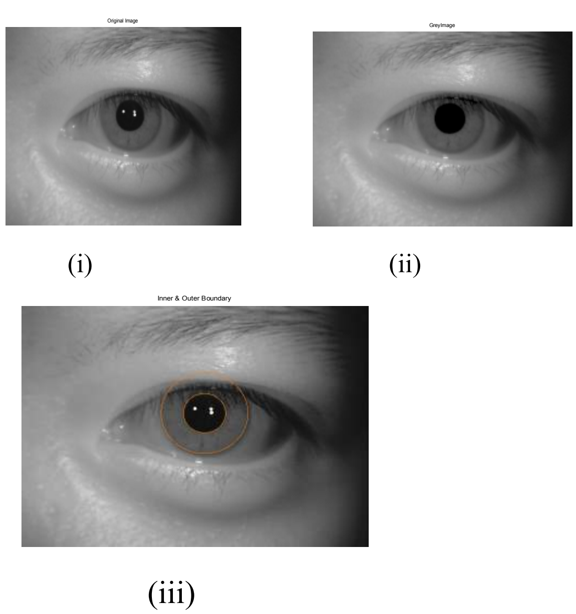
The first phase of our method is to collect a large database consisting of several iris images from various individuals, and we selected CASIA version II database for the implementation which has more noise, specular reflections and eyelids occlusions.

B. Image Pre-Processing

The image is pre-processed to reduce the noise and secular reflections as much as possible to improve the quality of the image shown in Figure 2.

- Must reduce the papillary area to pure black, in order to properly recognize the inner papillary boundary.

- Must be capable of removing bright flashes present in the image.



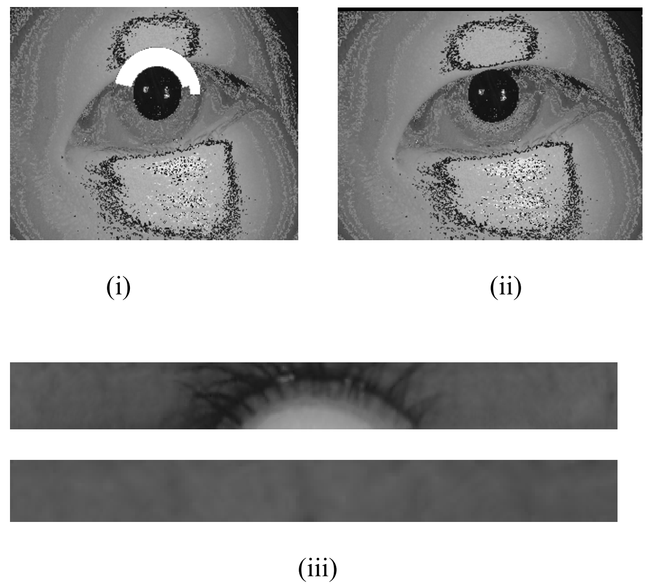
(i) (ii)

(iii)

Figure 2: (i) Original Image, (ii) Removal of bright flashes (iii) Inner and Outer Boundary

C. Image segmentation

In this phase the irises is extracted from the eye image i.e. disturbing features like eyelids & eyelashes are eliminated to the maximum possible extent and then process of normalize is carried out. Figure 3 shows the removal of eyelashes, extracted regions and normalization of image.



(i) (ii)

(iii)

Figure 3 : (i) Removal of eyelashes, (ii) Extracted regions (iii) Crop & Normalization

D. Feature extraction

Feature extraction is a key process where the two dimensional image is converted to a set of mathematical parameters. The iris contains important unique features, such as stripes, freckles, coronas, etc. These features are collectively refereed to as the texture of the iris. These features are extracted using various algorithms. In our approach we will focus on Lifting wavelet based algorithms.

E Lifting wavelet Transform

The lifting scheme is an algorithm to calculate wavelet transform in an efficient way [16]. It is also a generic method to create so- called second generation wavelets.

- *Predict and Update***:** The lifting scheme is an efficient implementation of the filtering operations. At the j^{th} level, input data set is transformed into two other sets: the low-resolution part λ_j and the high resolution part γ_j. This is obtained first by just splitting the data set into two separate data subsets (usually called the *lazy wavelet transform).* The next step is to recombine these two sets in several subsequent lifting steps which decorrelate the two signals.

- A *dual lifting* step can be seen as a prediction: the data γj are "predicted" from the data λj. When the signals are still highly correlated, then such a prediction will usually be very good, and we can store only the part of γ_j that differs from its prediction (the prediction error). Thus γ_j is replaced by $\gamma_j - P(\lambda_j)$, where P represents the prediction operator.

- However, the new representation has lost certain basic properties, like for example the mean value of the signal. To restore this property, one needs a *primal lifting* step, whereby the set λ_j is updated with data computed from the (new) subset γ_j. Thus λ_j is replaced by $\lambda_j + U(\gamma_j)$, with U some updating operator.

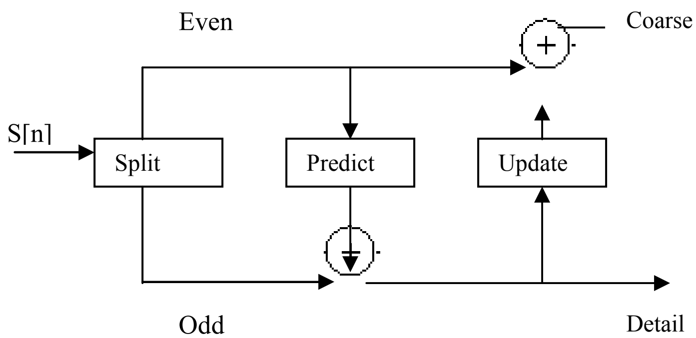


Figure 4: Block diagram of predict and update lifting Steps.

Thus, lifting scheme contains three [17] steps to decompose signal, that is, Split, Predict and Update, as shown in Figure 4.
The original signal is $s[n]$. It is transformed into approached signal in low frequency $c[n]$ and detail signal $d[n]$.

(1) Split: In this step, the original signal $s[n]$ is split into two subsets which do not overlap with each other: $s_e[n]$ (even sequence) and $s_o[n]$ (odd sequence), that is

$$s_e[n] = s[2n]$$
$$s_o[n] = s[2n+1] \quad \textbf{(1)}$$

(2) Predict: If the original signal is locally coherent, the subsets $se[n]$ and $so[n]$ are also coherent, so one subset can be predicted by another. Commonly we use even sequence to predict odd sequence,

$$d[n] = so[n] - P(se)[n] \quad \textbf{(2)}$$

Where P is the predict operator and reflects the degree of correlation of data. $P(se)[n]$ implies that the value of $d[n]$ can be predicted by the value of $se[n]$.

(3) Update: $c[n]$ in Figure 4 is the approach signal which has been decomposed. One of the important features is that its average value should be equal to the average value of original signal $s[n]$.So we can use detail subset $d[n]$ to update the signal $se[n]$, expressed by $c[n]$:

$$c[n] = se[n] + U(d)[n] \quad \textbf{(3)}$$

The decomposition of wavelet can be written as

$$\begin{pmatrix} \lambda(z) \\ \gamma(z) \end{pmatrix} = M(z) \begin{pmatrix} s_e(z) \\ Z^{-1}s_o(z) \end{pmatrix} \quad \textbf{(4)}$$

Where M(z) is polyphase matrix

$$M(z) = \begin{pmatrix} 1 & -1/4+1/4\,Z^{-1} \\ 0 & 1 \end{pmatrix} \begin{pmatrix} h_e(z) & h_o(z) \\ g_e(z) & g_o(z) \end{pmatrix} \quad \textbf{(5)}$$

Where he (z) and $g_e(z)$ are the FIR filters for Haar wavelet i.e he $(z)=1/2$, $h_o(z)=½$ and $g_e(z) = -1, g_o(z) = 1$

If there are 2^n data elements, the first step of the forward transform [18] will produce 2^{n-1} averages and 2^{n-1} differences (between the prediction and the actual odd element value). These differences are referred to as wavelet coefficients
The split phase that starts each forward transform step moves the odd elements to the second half of the array, leaving the even elements in the lower half. At the end of the transform step the odd elements are replaced by the differences and the even elements are replaced by the averages.

The even elements become the input for the next step, which again starts with the split phase. The first element in the array contains the data average. The differences (coefficients) are ordered by increasing frequency. In our approach the original masked image is resized to [256, 256] shown in Figure 5 and then obtaining 6th level co-efficient by increasing the frequency. At K^{th} level coarse approximation component will get reduced to $(N/2)^k \times (M/2)^k$. After few levels image size can become too small to be useful.

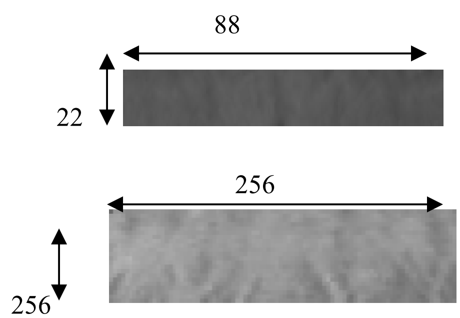


Figure 5: Normalize image and its resized image

II. Matching

Once the features are extracted using lifting wavelet transforms, an iris image is transformed into a unique representation within the feature space. In order to make the decision of acceptance or refusal, a distance is calculated to measure the closeness of match. the extracted features of the iris are compared with the iris images in the database.

Euclidean Distance: The Euclidean distance is one way of defining the closeness of match between two iris feature templates. It is calculated by measuring the norm between two vectors.

$$D = \mathrm{Sqrt}\{ (X2-X1)^2 + (Y2-Y1)^2 \} \quad \textbf{(4)}$$

Distance Measure: The Square of the difference between the maximum value of input (Max_1) and database image (Max_2) is then compared with absolute value of the difference value.

$$DM = \{Max\ (Max\_1 - Max\_2)\}/2 \quad \textbf{(5)}$$

Distance Threshold: The difference between the threshold maximum value of input (Max_1) and database image (Max_2) of the 6th level decomposition.

$$DT = \{Max\ (Max\_1 - Max\_2)\}^{\wedge}2 \quad \textbf{(6)}$$

III. Result

To evaluate the performance of the proposed system, extensive experiments were performed. Iris images are obtained from CASIA V2.0 iris image database [20]. The experiments are done in MATLAB. The run-time results for the iris recognition are given in table I which confirm that the proposed method performs faster than Daugman and Wildes. We tested our algorithm on 750 images, and we obtained an average correct recognition rate 97.91% and 99.78% for Euclidean Distance and Distance Threshold (refer Table II) 95.69% and 98.56% and Distance measure 96.66% and 98.91%.The proposed method achieved up to 99.78% compared with wavelet transforms

TABLE I**.** Runtime results for iris recognition

Algorithm	**Localization (Sec)**	**Feature Extraction (msec)**	**Comp - arision (msec)**	**Total Time (sec)**
Daugman	8.7	682.5	54	9.436
Wildes	8.3	210	401	8.911
Proposed	1.42	3762	42	5.224

TABLE II**.** Comparison Successful rate

Approximation Level	**Images**	**Successful rate**		
		DM	**DT**	**Euclidean**
I	750	96.66%	95.69%	97.91%
VII	750	98.91%	98.56	99.78%

With Lifting wavelet transform

With wavelet transform

Approximation Level	**Images**	**Successful rate**		
		DM	**DT**	**Euclidean**
I	750	95.95%	94.79%	96.39%
VII	750	97.19%	97.96	98.78%

CONCLUSION

In this paper, the performance of Iris recognition system by using higher level lifting wavelet approximations for detecting singularities to extract features and capable of comparing two eye images. The proposed approach considerably reduces the computation time and improves the accuracy. Furthermore, this identification system is quite simple requiring few components and is effective enough to be integrated within security systems that require an identity check. Lifting wavelet –based system can be used for various security related purposes. The experimental results are encouraging and the comparison with some algorithms indicates our method is comparable to them, and the outputs of this paper are satisfactory.

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