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An Iris Feature Extraction Using 2D-Dual Tree Complex Wavelet Transform

Ajita Singh, Jayesh Gangrade

Abstract— ***This paper presents an iris recognition system consists of an automatic segmentation system that is based on the 2D-Dual tree complex wavelet transform(2D-CWT), and is able to localize the circular iris and pupil region, occluding eyelids and eyelashes, and reflections. The extracted iris region was then normalized into a rectangular block with constant dimensions to account for imaging inconsistencies. Finally, the data was extracted and quantized to four levels to encode the unique pattern of the iris into a bit-wise biometric template. The K-nearest neighbor technique was employed for classification of iris templates. The obtained experimental results showed that the proposed approach enhanced the classification accuracy. Iris verification is shown to be a reliable and accurate biometric technology.***

Index Terms— ***iris recognition; Dual-Tree Complex Wavelet Transform ; biometrics.***

I. INTRODUCTION

A biometric system provides automatic identification of an individual based on a unique feature or characteristic possessed by the individual. Iris recognition is regarded as the most reliable and accurate biometric identification system available. Most commercial iris recognition systems use patented algorithms developed by Daugman, and these algorithms are able to produce perfect recognition rates. The emphasis will be only on the software for performing recognition, and not hardware for capturing an eye image.
Every biometric system has mainly two modules, one is "verification" and the other is "recognition". The verification part is involved in matching the test/real-time input with current database while recognition involves presenting the output from the database to which the test/real-time input. Biometrics-based personal authentication systems have recently gained intensive research interest due to the unreliability and inconvenience of traditional authentication systems. Biometrics recently became a vital component of any effective person identification solutions as biometric traits cannot be shared, stolen or even forgotten [1]. While looking for a proper biometric to be used in a particular identity authentication application, the distinguishing traits should possess the following properties: uniqueness, stability, collectability, performance, acceptability and forge resistance [2]. Among biometric technologies, iris-based authentication systems bear more advantages than other biometric technologies do. Iris offers an excellent recognition performance when used as a biometric. Iris patterns are believed to be unique due to the complexity of the underlying the environmental and genetic processes that influence the generation of iris pattern. These factors result in textural patterns that are unique to each eye of an individual and even distinct between twins [3]. The iris is a delicate circular diaphragm, which lies between the cornea and the lens of the human eye. The pattern of the human iris varies from person to person, even between monocular twins. The iris is considered to be one of the most stable biometric, as it is believed to not alter significantly during a person's lifetime. Iris recognition is the most precise personal identification biometric. Compared with other biometrics, such as fingerprints and face, iris has a fairly short history of use. The idea of an automated iris recognition system was conceptualized and patented in 1987 by Flom and Safir [4]. Most of the common approaches reported in the literature are based on iris code and integral-differential operators suggested by Daugman [5,6,7].

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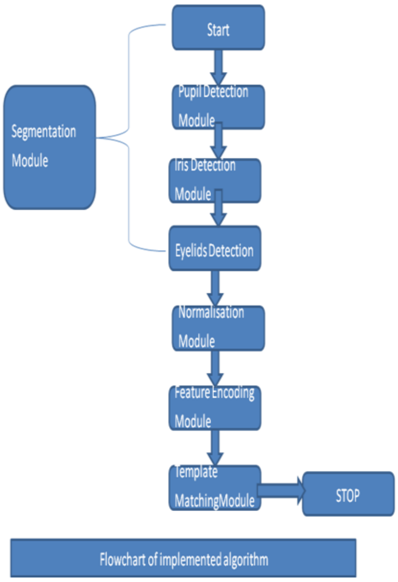
II. RELATED WORK

Several researchers have contributed to the maturation of iris biometric technology. Daugman [3,6,7] applied Gabor wavelets filtering to encode the iris regions and extract the phase information of iris textures to create a 2048 bit (256 bytes) of iris template. The Hamming distance is used to compare the stored iris template with the claimed iris. Wildes et al. [8] represented another iris recognition system that decomposed the distinctive spatial characteristics of the iris into four levels Laplacian pyramid and used a normalized correlation for matching. Boles and Boashash [9] detected zero crossings of one-dimensional dyadic wavelet transform with various resolution levels over concentric circles on the iris. Both the position and magnitude information of zero crossing representations were used to measure the similarity between the recognition and enrollment images. Ma et al. [10] proposed an iris texture analysis method based on using multi-channel Gabor filtering to capture both global and local details in the iris. Ma et al. considered the characteristics of the iris as a sort of transient signals and identified the local sharp variation points as iris features. Lim et al. [11] used 2D Haar wavelet transform to decompose the iris image into four levels and quantized the fourth-level high-frequency information to form an 87-bit code. The researchers improved the efficiency and accuracy of the proposed system by using a modified competitive learning neural network (LVQ). Sun and Tan [12] proposal is based on using ordinal measures for iris feature representation with the objective of characterizing qualitative relationships between iris regions rather than precise measurements of iris image structures. They demonstrated that ordinal measures are intrinsic features of iris patterns and largely illumination changes. The aim of this paper is to illustrate the DT-CWT and K-nn in iris classification.

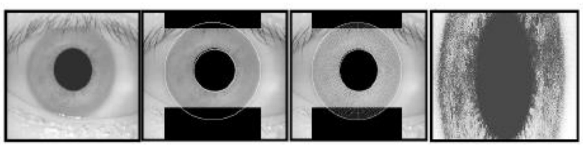
The remainder of this paper is organized as follows. The next the proposed approach and Section 4 experimental results. Finally, Section 5 presents and suggestions for future work.submission.

III. PROPOSED APPROACH



A. Iris preprocessing

The primarily step in iris segmentation is the detection of pupil and iris boundaries from the input eye image. Researchers have proposed different algorithms for iris detection [5,6,7,8]. Processing iris images is a challenging task since the iris region can be occluded by eyelids or eyelashes. This will cause a significant difference between the intra- and inter-class comparisons. Therefore, we decided to isolate the effect of the eyelids and eyelashes by using only the left and right parts of the iris area for the iris recognition . Most of the methods extract the complete iris image, but we plan to extract parts of the iris image for recognition. This is done by trimming the iris area above the upper boundary of the pupil and the area below the lower boundary of the pupil. Afterward, we apply histogram equalization to enhance the contrast of images by transforming its intensity values [17]. Example of this process is shown in Figure 2



(a) (b) (c) (d)

Figure 2. Example of localized iris where the upper and lower parts is occluded and the segmentation result. (a) original image (b)(c) localized iris and the normalization region used for recognition (d) enhanced and normalized iris image.

Basically the iris recognition technology have four basic technological modules which are implemented in sequence are :

1. Segmentation
2. Normalisation
3. Feature Encoding
4. Matching Algorithms

1. Segmentation

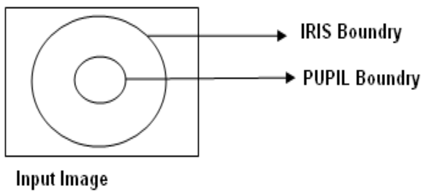
The very first module of iris recognition is to separate or segment the actual iris region in a digital eye image. The iris region, can be approximated by two circles, one for the iris/sclera boundary and another, interior to the first, for the iris/pupil boundary. The eyelids and eyelashes normally occlude the upper and lower parts of the iris region. A highly efficient technique is required to isolate and exclude these artifacts as well as locating the circular iris region An automatic segmentation algorithm based on the circular Hough transform is employed 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 iris regions. Firstly, an edge map is generated by calculating the first derivatives of intensity values in an eye image and then thresholding the result. From the edge map, votes are cast in Hough space for the parameters of circles passing through each edge point. These parameters are the centre coordinates x and y, and the radius r, which are able to define any circle according to the equation

$$x^2 + y^2 - r^2 = 0$$

The motivation for this is that the eyelids are usually horizontally aligned, and also the eyelid edge map will corrupt the circular iris boundary edge map if using all gradient data. Taking only the vertical gradients for locating the iris boundary will reduce influence of the eyelids when performing circular Hough transform, and not all of the edge pixels defining the circle are required for successful localization. Not only does this make circle localization more accurate, it also makes it more efficient, since there are less edge points to cast votes in the Hough space .

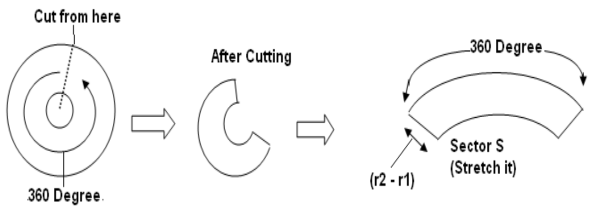
2. Normalization

The next step once the iris region is successfully segmented from an eye image, is to transform the iris region so that it has fixed dimensions in order to allow comparisons.



- First decide the (inner) radius of pupil.
- Then decide the radius of IRIS

This is necessary because we need to convert IRIS image (which is circular basically) to its rectangular form, following example would illustrate this.



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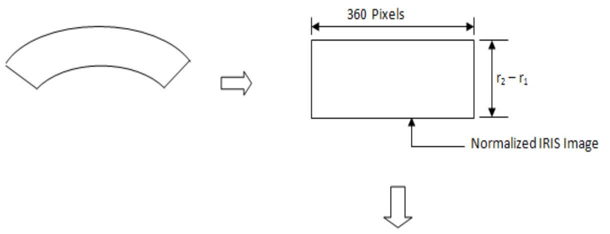
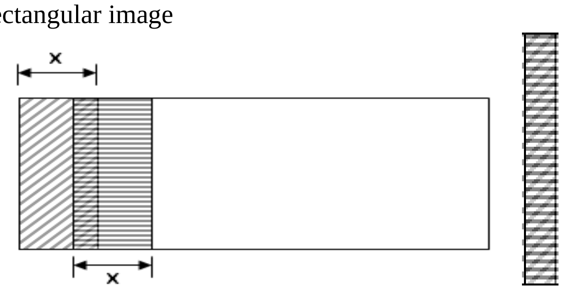
Now obviously after stretching width of that foil would be (r2 – r1) and angle covered would be 3600[or 2 π radians] and area of sector S would be lesser than the rectangular form in which sector S need to be converted into. So this is the final conversion need to be brought;



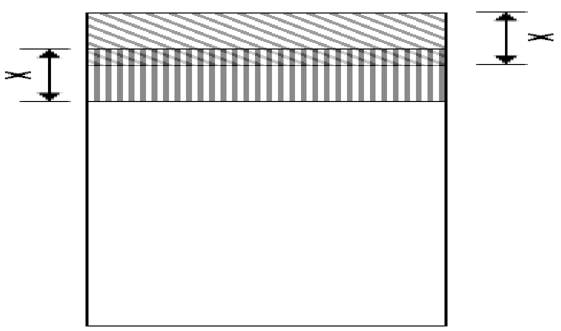
This is the sector or image which had to be processed for feature extraction and it is referred as normalized IRIS image. To remove the illumination effects it is histogram equalized and enhanced before preprocessing

3. Feature Encoding

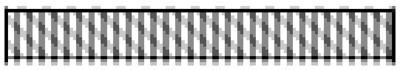
In order to provide accurate recognition of individuals, the most discriminating information present in an iris pattern must be extracted. Only the significant features of the iris must be encoded so that comparisons between templates can be made. Most iris recognition systems make use of a band pass decomposition of the iris image to create a biometric template. Second important thing is as this is the feature extraction process (and features are very much necessary to distinguish one from other. For instance we are distinguishing two boys one is very tall and other is very short or dwarf. So strong feature here is height. If both are of same height there is no point in distinguishing them based on height) here Features are zero crossing of DCT coefficients. To preserve the features as any processing activity may lose features. For this reason the normalized IRIS image is horizontally and vertically over lapped by certain pixels. This results into increase in the height and width of the normalized rectangular image



This part is repeated in above figure.(i.e. in every X). This results into increase in width.



Similarly horizontal overlapping is done by certain number of pixels

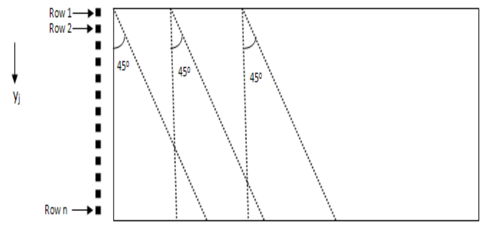


Horizontal overlapping causes increase in height of normalized IRIS image.

Next step in algorithm is rotation of an image by 450(any rotation between 00to 900 is OK), but 450 seems to give better results. There are two possibilities while rotating the image by 450;

- Rotating the normalized image by 45^0 and keeping the view straight (or our view)
- Rotating the view by 45^0 and keeping the image straight.

We apply the first strategy



For every row i.e. for every y_j find out the equivalent column co-ordinate in 45^0 direction. We map, for every row, equivalent column co-ordinate for 45^0 direction, and store into different array [image here] in program {apply patchgivendegrees.m} files does this task. Next step is to apply hanning window to rotated image 3rd step. Hanning window is applied in both horizontal and vertical direction. that "a weighted average under ¼ hanning window is formed". The weighted average is slightly different from normal average. Consider for hanning window of length 4, four coefficients are generated, by function hanning.

i.e. coeff = hanning (4);

let coeff = [C1 C2 C3 C4]

& let a = [a11 a12 a13 a14 a15 a16 a17 a18 a19 a20 a21 a22]

Be the array of image pixels in particular row(row 1) and out be the output array by processing the a array for normalized weighted average hanning window.

OUT1 = (C1*a11 + C2*a12 + C3*a13 + C4*a14) / 4

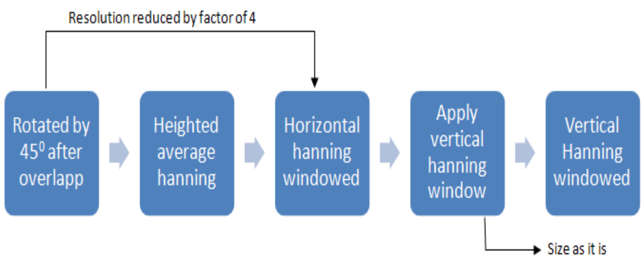
OUT2 = (C1*a15 + C2*a16 + C3*a17 + C4*a18) / 4

OUT3 = (C1*a19 + C2*a20 + C3*a21 + C4*a22) / 4

Therefore out array consist of

OUT = [OUT1 OUT2 OUT3] Coefficients

As a result of applying horizontal weighted average hanning window resolution of normalized image is reduced by factor of 4. i.e. if 360 is the width of normalized image after rotation, then after applying weighted average horizontal average , width would be 360/4 = 90. Same thing is done in vertical direction, but it is not a weighted average, it is simple multiplication of hanning window to the one which is obtained by weighted average hanning window.



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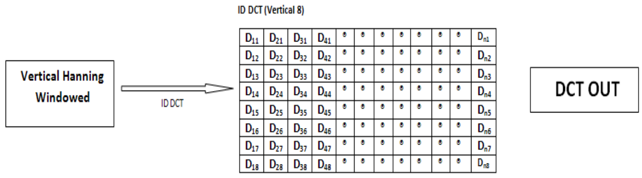
Now main goal of the applying the hanning window is to reduce the spectral leakage. As this paper is DTCWT based IRIS recognition, discrete cosine transform is the major tool which is used in feature extraction process. The output which is generated previously (Vertical hanning windowed) is used to apply DTCWT in vertical direction. Lets arrange this it in below way;



[This is the ID DTCWT output shown in the paper] Next thing is across horizontal of DTCWT array substraction is carried out in following way

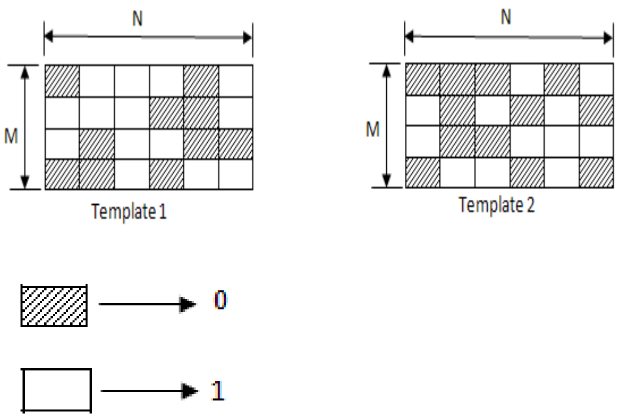
$D_{21}-D_{11}$	$D_{31}-D_{21}$	•	•	•	•	$D_{n1}-D_{(n-1)1}$
$D_{22}-D_{12}$	$D_{32}-D_{22}$	•	•	•	•	$D_{n2}-D_{(n-1)2}$
$D_{23}-D_{13}$	$D_{33}-D_{23}$	•	•	•	•	$D_{n3}-D_{(n-1)3}$
$D_{24}-D_{14}$	$D_{34}-D_{24}$	•	•	•	•	$D_{n4}-D_{(n-1)4}$
$D_{25}-D_{15}$	$D_{35}-D_{25}$	•	•	•	•	$D_{n5}-D_{(n-1)5}$
$D_{26}-D_{16}$	$D_{36}-D_{26}$	•	•	•	•	$D_{n6}-D_{(n-1)6}$
$D_{27}-D_{17}$	$D_{37}-D_{27}$	•	•	•	•	$D_{n7}-D_{(n-1)7}$
$D_{28}-D_{18}$	$D_{38}-D_{28}$	•	•	•	•	$D_{n8}-D_{(n-1)8}$

This is a difference of ID DTCWT coefficients across horizontal. Then where this crossing is zero I.e. zero crossing. Such points are marked as ones in the binary code array. Where zero crossing is absent such points are marked as zeros. So our binary code consists of either ones or zeros, depending on zero crossing. This binary code forms the basis of our recognition.

4. Matching Algorithms

Matching Algorithms are used for verification as well as Identification functions. The binary codes are stored as features in our input database. Then query IRIS image (input image for recognition), for the same query image, binary code is generated for matching nearest neighbor approach is used. Following is the empirical formula for hamming distance as an cost function used for matching;

$$HD = \left(\prod_{i=1}^{M}\left\{\frac{\sum_{j=1}^{N}\left(subfeature1_{(i,j)} \oplus subfeature2_{(i,j)}\right)}{N}\right\}\right)^{1/M}$$



Formula will result into something like this

Row1cost = [(1 ⊕ 0) + (0 ⊕ 1) + (1 ⊕ 1) +.........+ (0 ⊕ 0)] / N

Similarly we find out row2cost, row3cost. We calculate rowMcost.

$$(row1cost * row2cost * row3cost * rowmcost)^{1/M}$$

As we can see for nearest neighbor match, if every bit of template1 matches to template2, then X-Oring would always result in zero.

$$[\textstyle\prod_{i=1}^{M}(0)/N]^{1/M}$$

And if template1 is exactly cross template2 then X-Oring will always be 1.

So

$$[\textstyle\prod_{i=1}^{M}(1+1+1+1+1)N\ times/N]^{1/M}$$

$$= [\textstyle\prod_{i=1}^{M} 1]^{1/M} = [1]^{1/M} = [1]^{1/M}$$

So for best H.D [hamming distance] = 0

For worst match H.D. = 1.

Thus our recognized IRIS is the one with lowest H.D.

B. Feature extraction

There have been many techniques suggested in the literature for extracting unique and invariant features from the iris image [5]. These techniques can employ either texture- or appearance-based features wavelet techniques are successfully applied to a wide range of problems in signal processing, classification, data compression and denoising. Researchers have used a range of wavelets to analyze the iris texture. Some techniques used the output of the wavelet transform to create a binary feature vector, while others considered using the output as a real -valued feature vector. But it is well known that the ordinary discrete wavelet transform is not shift-invariant because of the decimation operation during the transform Therefore, any minor shift in the input signal can cause very different output Therefore,ki [13] introduced the dual-tree complex wavelet transform (DT-CWT) to overcome some of the shortcomings of the ordinary discrete wavelet transform (DWT). DT-CWT has improved directionality and reduced shift sensitivity and it is approximately orientation invariant [14]. The DT-CWT employs two real wavelet transforms in parallel where the wavelets of one branch are the hilbert transforms of the wavelets in the other. In this manner any input image can be decomposed into its 6 directional sub bands. At each scale, the DT-CWT generates 6 directional sub bands with complex coefficients, oriented at ±15°,±45° and ±75°. The real (Ri) and imaginary (Ci) parts of complex wavelets in the 6 directional sub bands are illustrated in fig 3

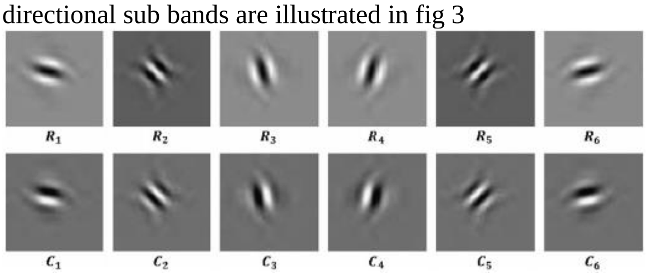


Figure 3. The real (R) and imaginary (C) parts of the impuse responses of the 2D DT-CWT filters under six directional sub bands

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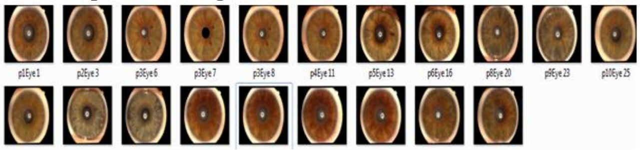
IV. EXPERIMENTAL RESULT

In this section, experiment is performed in order to evaluate the performance of the proposed scheme.

A. Iris database

We conducted all the experiments on the eye image data base which is avalable on bellow given link
http://phoenix.inf.upol.cz/iris/download
The database contains 3 x 128 iris images (i.e. 3 x 64 left and 3 x 64 right).
The images are: 24 bit - RGB, 576 x 768 pixels, file format:PNG. The irises were scanned by TOPCON TRC50IA optical device connected with SONY DXC-950P 3CCD camera. If the database or images are used for evaluation and if published it should be stated in references: Michal Dobe� and Libor Machala, Iris Database, http://www.inf.upol.cz/iris/

Sample Iris Images



B. Recognition result and conclusion

This work proposes a modified iris segmentation technique based on minimizing the effect of the eyelids and eyelashes by trimming the iris area above the upper and the area below the lower boundaries of the pupil.
The 2D DTCWT is extracted from the iris images and used k-nn classifier to train the iris pattern
Experimental results also indicate that the performance of the of k-NN classifiers is computationally effective as well as reliable in term of recognition rate of 82.867%.
The combination of dual-tree complex wavelet with k-NN is promising**.**

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