A Novel Human Identification System Using Iris Pattern Recognition

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Abstract

With the development of information technology and a possibility of access to database through internet from anywhere, the need for personal data security has gained a widespread importance in recent years. In this regard the intelligent personal identification systems based on biometric features are preferred to other authentication systems. In the identification systems using various biometric parameters, "IRIS RECOGNITION" has been accepted as one of the reliable authentication method. In this paper a hybrid approach of subjecting the edge detected images to e-DWT to finally extract the parameters such as separability and distance of one image with respect to other image is suggested. The systems can also has the option of using any of the standard edge detection methods. The results of this system indicate the significance of only approximate coefficient (A) of e-DWT to extract the separability and distance. This leads to speedier identification system as compared to the existing ones. The details of this system and results thereof are presented in this paper.

1. INTRODUCTION

Recent advancements in sensor and matching algorithms have led to the deployment of biometric authentication in a large number of civilian applications. Iris is unique biometric feature of each individual. The human iris is rich in features, which can be used to quantitatively and successfully distinguish one eye from another. The necessity for high performance and highly reliable system for personal identification systems puts a thrust on the development of automated personal iris identification system.[1] The system shall be dynamic in the sense that the features extracted from iris are stored dynamically in the current database. In this paper we propose a system that can capture any format of iris and also perform on line matching of two iris images. A typical system developed to meet these requirements is as shown in Fig. 1.

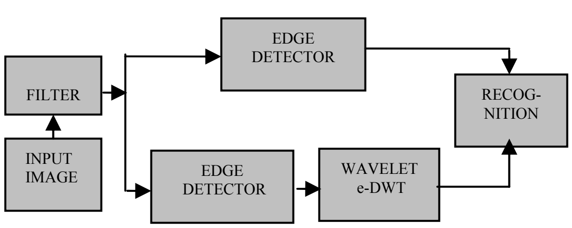

Fig: 1

2. IMAGE PROCESSING

The steps involved in image processing constitute image acquisition, feature extraction and identification. These steps for the system proposed and developed by us are described below.

2.1 Iris Image Acquisition

One of the major challenges of an automated Iris Recognition System is to be able to capture high quality images for iris identification. For this it is important to acquire images with sufficient resolution and sharpness with good contrast in the interior of the iris region. Additionally images must be well framed. The camera and camera system must take care of these points. For the system presented in this paper, the captured images of iris from CASIA database are used.

2.2 Iris Feature Extraction

The feature extraction part is crucial for the whole recognition process. The type of classifier and its parameters in terms of speed and complexity are dependent on this stage. If feature extraction method is good, then powerful feature vector classifier can be simple and fast. This is important for global identification system especially with a large database. Additionally, if extraction is very efficient then the images captured in low resolution with economical camera systems can also be identified fairly accurately. The variation in the directional properties of brightness (i.e. the first derivative) and the derivative of gray level giving the idea about the concavity as determined from the zero crossing of the second derivative are generally used to extract the features. In the method proposed by us, the features such as edge count extracted from any of the edge detection methods and coefficients of e-DWT are used either in isolation or in combination for the iris identification purpose.

2.2.1 Edge Detection

The number of edges present in the iris region, is one of the features that can be extracted and used directly or indirectly (in the encoded form) for database storage and subsequent comparison for identification purpose. If an image consists of objects of interests, displayed on a contrasting background, then an edge is identified from the abrupt transition from background to object or vice-a-versa. The total change in intensity from back ground to foreground is called as the strength of an edge.[2]

The rate of change in gray level with respect horizontal distance in continuous image is equal to the partial derivative.

$$\frac{\partial g(x,y)}{\partial x} = \lim_{\Delta x \longrightarrow o} \frac{g(x+\Delta x, y) - g(x,y)}{\Delta x} \quad (1)$$

If we replace Δx by 1 i.e. the smallest possible non zero value of Δx in a sampled image then (1) becomes

$$g'_x(x,y) = g(x+1,y) - g(x,y) \quad (2)$$

Where g'_x represents the first difference in g with respect to x similarly $\frac{\partial g(x,y)}{\partial y}$ can be approximated by

$$g'_y(x,y) = g(x,y+1) - g(x,y) \quad (3)$$

This finite difference represents the change in the grey level from one pixel to the next and can be used to detect abrupt changes in grey level in the image. Since the edges of objects in an image often produce such changes, these operators are often called as edge detectors. A positive value of edge detector operator indicates a transition from low grey level to high gray level while a negative value shows a transition from high to low when moving towards the right hand side pixel. The basic idea behind edge detection is to find places in an image where the intensity changes rapidly.

For detection of edges present in image, various detection operators are used. They range from the simple edge detectors, such as Roberts, Sobel or Prewitt using first derivative to the more complicated ones, such as Laplacian using second derivative based on zero crossing. These are applied either with convolution masks or are based on differential operations. Differentials for edge detection are used to define changes in the color or brightness of pixels and their direction. If there is an abrupt change in the brightness of the image in a short interval then an edge can be identified in that interval. Edge detection operators are used as primary step to define the potential edges of the complex object. During this process direction of each possible edge is also defined. In the second step, using both brightness and dimension information the potential edges are joined to obtain the final edges of the image. It is advisable to filter the images before presenting them to edge detector operators.[3]

In the proposed system, the edge count obtained from the edge detection method can be used directly for iris identification purpose or alternatively, an edge detected image can be subjected to e-discrete wavelet transform to extract the coefficients for identification purpose. The details of feature extraction using a suitable wavelet transform are given below.

2.2.2 Wavelet Transform

Mathematical transformations are applied to signals to obtain further information from that signal that is not readily available in the raw signal. Wavelet transform is a mathematical tool for efficient local analysis of non-stationary and fast transient signals. It is a mapping of the signal to the time-scale joint representation. The Wavelet transform function is given by,

$$W_s(s,\tau) = \int f(t) h^*_{s,\tau}(t) dt \quad (4)$$

Where, * denotes the complex conjugate. The wavelets are generated from single basis function h (t) by translation and scaling.

$$h_{s,\tau}(t) = (1/\mathrm{sqrt}(s)) * h\{(t-\tau)/s\} \quad (5)$$

Where, s is the scale factor and τ is the translation factor.

Discrete Stationary Wavelet Transform (SWT)

SWT2 of MATLAB performs a multilevel 2-D stationary wavelet analysis using a specific orthogonal wavelet decomposition filter.[5] The function of SWC is given by equation (6) which computes the stationary wavelet decomposition of the matrix X at level N, using the database stored in file 'wname'. N must be a strictly positive integer and 2^N must divide size(X,1) and size(X,2).

SWC = SWT2 (X,N,'wname') (6)

The wavelet coefficients of SWT viz, A, V, H, D≤ are 3-D arrays which contain the coefficients: for $1 \le i \le N$, A(:,:,i) contains the coefficients of approximation of level i. H (:,:,i), V(:,:,i) and D(:,:,i) contain the coefficients of details of level i, (Horizontal., Vertical., Diagonal.).

SWC = [H (:,:,1:N) ; V(:,:,1:N); D(:,:,1:N);A(:,:,N)] (7)

SWC = [A,H,V,D] = SWT2(X, N, Lo_D ,Hi_D) (8)

Where Lo_D is the decomposition low-pass filter and Hi_D is the decomposition high-pass filter. Lo_D and Hi_D must be the same length.

Classical DWT suffers from a drawback that it is not a time-invariant transform. However in the iris identification system fast time varying samples need to be processed. For this e-decimated DWT is the recommended wavelet transform.

e-Decimated DWT

There exist a lot of slightly different ways to handle the discrete wavelet transform. Let us recall that the DWT basic computational step is a convolution followed by decimation. The decimation retains even indexed elements. But choosing odd indexed elements instead of even indexed elements could carry out the decimation. This choice concerns every step of the decomposition process, so at every level we chose odd or even. If we perform all the different possible decompositions of the original signal, we have 2*J* different decompositions, for a given maximum level *J*. Let us denote by e*j* = 1 or 0 the choice of odd or even indexed elements at step *j*. Every decomposition is labeled by a sequence of 0's and 1's: e = e1,…,e*J*. This transform is called the e-decimated DWT. You can obtain the basis vectors of the e-decimated DWT from those of the standard DWT by applying a shift and corresponds to a special choice of the origin of the basis functions.

It is possible to calculate all the e- decimated DWT for a given signal of length N, by computing the approximation and detail coefficients for every possible Sequence e. Do this using iteratively, a lightly modified version of the basic step of the DWT of the form

[A, D] = dwt (X, wname,'mode','per','shift', e)

The last two arguments specify the way to perform the decimation step. This is the classical one for e = 0, but for e = 1 the odd indexed elements are retained by the decimation. Of course, this is not a good way to calculate all the e- decimated DWT, because many computations are performed many times. We shall now describe another way, which is the stationary wavelet transform (SWT). The SWT algorithm is very simple and is close to the DWT one. More precisely, for level 1, all the e- decimated DWT (only two at this level) for a given signal can be obtained by convolving the signal with the appropriate filters as in the DWT case but without down sampling.

Then the approximation and detail coefficients at level 1 are both of size *N*, which is the signal length. This can be visualized in the following figure2.

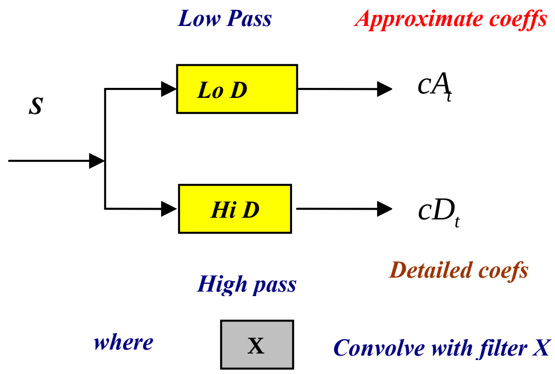

Fig: 2

By applying 'swt2' function for input grayscale image, where 'swt2' decomposition returns array values which are; appropriate cfs level (**A**), horizontal detection (**H**), vertical detection (**V**) and diagonal detection (**D**). Then the mean value of these wavelet coefficients (**I**) is calculated according to the equation :

$$I = \text{mean (mean (mean (A/H/V/D)))} \quad (9)$$

We got different wavelet coefficient values (mean values) for different edge operators as shown in table 1.

Distance Calculation

The distance of image I_2 from image I_1 is calculated using the following equation.

$$Distance = \frac{\sigma_1 - \sigma_2}{\sqrt{\frac{\zeta_1^2 + \zeta_2^2}{2}}} \quad (10)$$

Where, σ_1 and σ_2 are the mean feature approximate coefficient (A) and ζ_1 and ζ_2 are the standard deviations for images I_1 and I_2 respectively. Using the system developed by us, the distance values for ten number of iris images obtained from CASIA ,are normalized with respect to the maximum distance of that image.[6] The graphical representation of distance and separability is shown in fig 3 and fig 4.

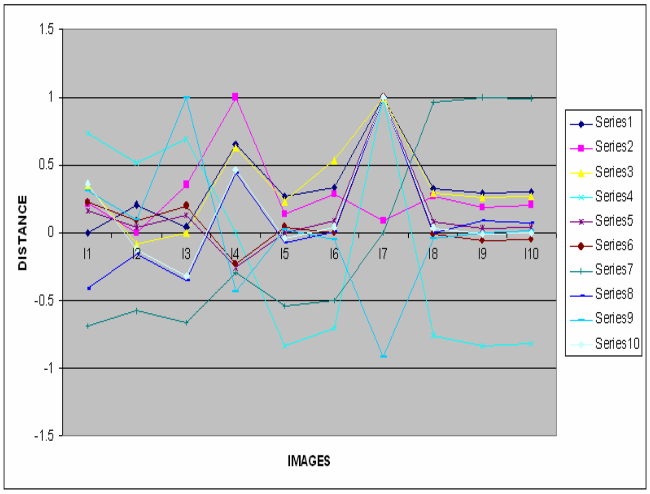

Fig: 3

Separability Calculation

The separability of image I_2 from image I_1 is calculated using the following equation.

$$Separability\,[s1] = \left| \frac{\sigma_1 - \sigma_2}{\zeta_1 + \zeta_2} \right| \quad (11)$$

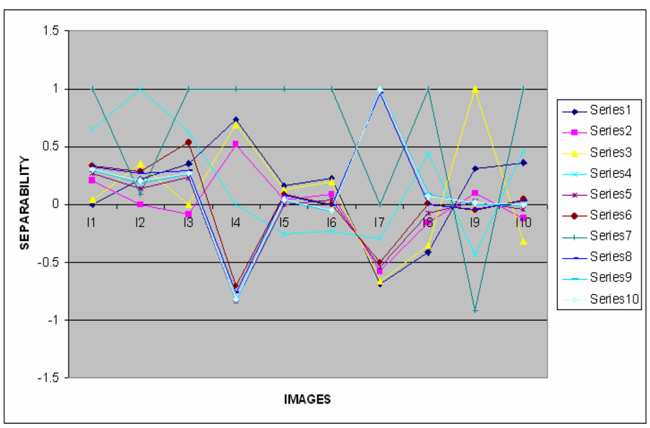

Fig: 4

Matching Percentage

$$\text{Matching Percentage} = \frac{\text{Total Edges Matched With Database Image}}{\text{Edge Count Of Image To Be Matched}} \times 100\ \% \quad (12)$$

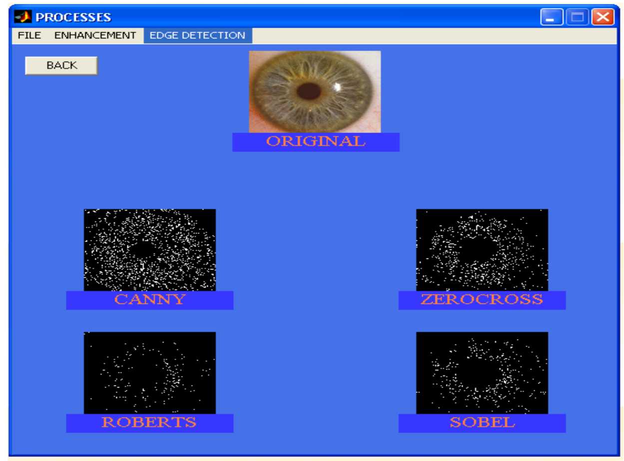

Fig: 5(a)

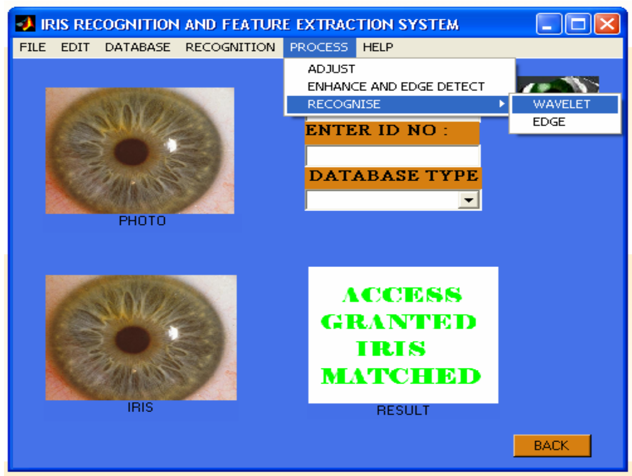

Fig: 5(b)

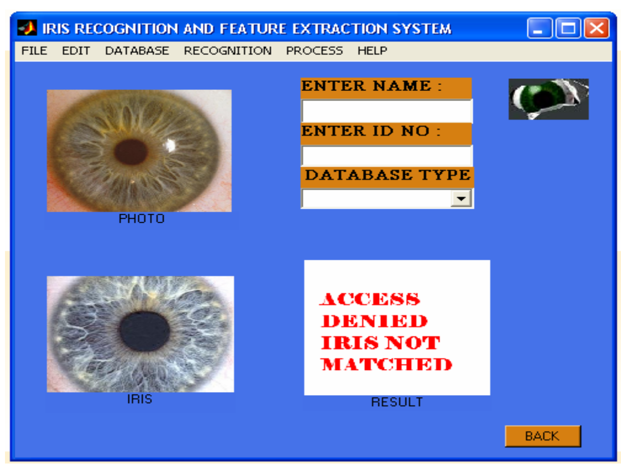

Fig: 5(c)

3 EXPERIMENTAL RESULTS

We have tested our system for different iris images and calculated coefficients of e-DWT i.e. approximate coefficient (A), horizontal (H), vertical (V) and diagonal (D) by using different edge detectors such as Roberts, Sobel, Zerocross and Canny as shown in table 1. The graph of distance and separability are also shown in fig 3 and fig 4 respectively. The Graphical User Interface (GUI) for the same system is shown in fig 5(a), 5(b), 5(c), which is related to different images passed through the edge detectors. The GUI also shows how the person identification is done in our system.

4. CONCLUSION AND FUTURE WORK

From the experimentation performed to validate the system, it was observed that the system accepts and identifies the authentic images while rejects the invalid images (Refer Fig.5(b) and Fig 5(c)). This indicates that the system developed is accurate for iris identification. The graphical user interface provided to the system enables the user either to use any one of the edge detectors or a combination of the desired edge detectors in a sequence as per the application. e-DWT method in the system is to extract the wavelet coefficients of the images which indicates the significance of only approximate coefficient (A) while the total insignificance of vertical (V), horizontal (H) and diagonal (D) coefficients of the wavelet transform. The implementation of only one coefficient out of four DWT coefficients for iris identification purpose resulted in a much speedier identification system. This is one of the striking results out of the experimentation performed.

The graphical user interface of the system also offers a choice between "Only Edge Detection" and "Edge Detect Followed by Wavelet Transform" for identification purpose. The later option is a unique feature of the system developed by us. The system can be enhanced by adding the facility to trace the distance and separability graphs for real time display of matching with already stored and displayed database graphs. Secondly, in the present system, image capturing stage was not necessary due to availability of CASIA database.

However, for the development of a stand-alone system it is necessary to interface it with iris acquisition camera. Further for a large database and to increase the speed of the system, it would be advisable to use a neural network approach for iris recognition. All these aspects can be future scope for the system.

5. ACKNOWLEDGEMENT

This research paper uses the CASIA Iris image database collected by Institute of Automation, Chinese Academy of Sciences.

6. REFERENCES

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[7] CASIA iris image database ver 1.0
http://www.sinobiometric.com

TABLE 1: COEFFICIENTS OF DISCRETE WAVELET TRANSFORM FOR VARIOUS EDGE DETECTORS.

IMAGE	ROBERTS				SOBEL			
	A	H	V	D	A	H	V	D
I1	0.16169	-5.9993e-019	1.2468e-019	2.8189e-020	0.17172	-7.1702e-019	8.5291e-019	-1.9877e-020
I2	0.14656	-5.0307e-019	-3.2887e-019	-2.2045e-020	0.14492	-6.0318e-019	-3.9754e-019	-2.4214e-020
I3	0.13581	-4.5898e-019	-1.7347e-019	-1.3607e-019	0.1626	-1.9588e-019	1.4456e-020	-2.2768e-020
I4	0.088776	-4.9548e-019	6.8485e-019	4.8066e-020	0.099531	-3.0827e-019	-1.3281e-018	1.4456e-021
I5	0.068724	-3.4369e-019	-4.6982e-020	1.4095e-020	0.13964	-4.7127e-019	1.2794e-018	1.7347e-020
I6	0.080938	-4.1886e-019	-3.614e-019	5.3849e-020	0.13089	-6.18e-019	7.228e-020	2.2407e-020
I7	0.05013	-1.7456e-019	-1.3914e-019	-8.2038e-020	0.065078	-2.8009e-019	3.3972e-019	1.7347e-020
I8	0.12596	-6.3209e-019	-1.4817e-019	-1.0878e-019	0.13089	-5.1789e-019	-1.1384e-019	-8.9266e-020
I9	0.10719	-4.9729e-019	-5.0596e-020	-5.9631e-020	0.13107	-4.4019e-019	8.8362e-019	-8.1677e-020
I10	0.11758	-3.5381e-019	-3.9031e-019	1.5721e-020	0.13526	-3.9935e-019	2.7466e-019	-8.4929e-020

IMAGE	CANNY				ZEROCROSS			
	A	H	V	D	A	H	V	D
I1	0.46995	-1.507e-019	-1.8648e-018	3.2165e-020	0.34909	-9.6494e-020	1.2866e-018	-1.1384e-019
I2	0.3613	-6.2305e-019	-5.2042e-019	-6.3906e-020	0.2193	-6.8413e-019	-1.3733e-019	3.9155e-020
I3	0.34836	-7.6147e-019	1.1854e-018	-3.4333e-020	0.22167	-4.2681e-019	5.7824e-019	-8.1553e-020
I4	0.32302	-5.5403e-019	4.915e-019	-4.5536e-020	0.13745	-3.2309e-019	1.9516e-019	-3.7947e-020
I5	0.57659	-6.8594e-019	1.4167e-018	-2.4575e-020	0.30388	-7.5063e-019	-1.3083e-018	9.7217e-020
I6	0.45372	-6.5269e-019	-1.8215e-018	1.1926e-020	0.18995	-3.1044e-019	8.8905e-019	-7.228e-021
I7	0.15148	-1.7167e-019	3.2526e-019	5.3549e-020	0.069453	-7.228e-020	-6.3787e-019	-6.3607e-020
I8	0.30607	-8.7857e-019	9.8301e-020	-1.7094e-018	0.13945	-6.0065e-019	3.614e-021	-1.2504e-019
I9	0.33013	-5.1174e-019	-4.3368e-019	2.9057e-019	0.16443	-4.9729e-019	-7.8424e-019	5.8186e-020
I10	0.30497	-6.498e-019	-1.0452e-018	2.0305e-019	0.23315	-4.5862e-019	5.7824e-019	5.4086e-020