International Journal of Computer Applications (0975 – 8887)
Volume 49– No.2, July 2012

Pattern Recognition using Multilevel Wavelet Transform

Vinayak D. Shinde
Research Scholar
Department of Electronics and Telecommunication,
Vishwakarma Institute of Technology,
Pune, India.

Vijay M. Mane
Assistant professor
Department of Electronics and Telecommunication,
Vishwakarma Institute of Technology,
Pune, India.

ABSTRACT
An approach for feature extraction using wavelet transforms using its property of multilevel decomposition in pattern recognition application is proposed. The multilevel decomposition property of discrete wavelet transform provides texture information of an image at different resolutions. Iris recognition system using multilevel wavelet transform is explained. The technique developed here is implemented using three and four level decomposition of Discrete Wavelet Transform. Four level decomposition gives better results at increased threshold value. Reduced feature vector size improves the speed.

Keywords
Biometrics, DWT, Euclidean distance, Feature vector, FAR,FRR ,RAR,Normalisation,Segmentation.

1. INTRODUCTION
Demand of efficient security systems in current scenario has led the way for improvement in security systems over a period of time. Biometrics [1] are playing vital role in these systems. Facial features ,voice patterns ,hand geometry, retinal patterns ,vein patterns, signature dynamics ,voice verification DNA matching ,gait recognition ,ear shape recognition ,finger print are used as biometrics identifiers. However iris being unique and stable for life period, so is most preferred and reliable biometric identifier. A lot of research work carried out in this area .Various iris recognition methods[2] are proposed by various researchers such as phase based method [3, 4, 5], zero crossing method [6], intensity variations method[7]. texture-analysis based method[8,9,10] . Eye is shown in figure 1 .The innermost black circle is known as pupil, whereas the white part of an eye is sclera. The region between sclera and pupil is iris.

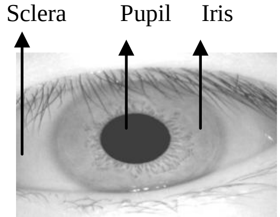

Fig.1. Eye image.

As wavelet transform gives analysis in both spatial and time domain, it has an edge over fourier transform which gives analysis in frequency domain and hence extremely useful in biometric recognition applications. Here iris recognition [11] using multilevel wavelet transform is explained.

This paper is organized as follows. Detailed discussion of proposed method is presented in section 2. Section 3 and section 4 respectively presents experimental results and conclusions. References are included in section 5.

2. PROPOSED METHOD
Iris recognition consists of steps such as capturing image, preprocessing, segmentation, normalisation, feature vector creation, matching. Image acquisition is done using suitable camera and image is pre-processed for further processing. Segmentation of iris is done to remove unwanted part of eye image and to isolate iris from rest of eye image. Eyelids and eyelashes are removed in order to get better representation of an image. Normalisation is process of converting polar coordinates to rectangular coordinates. Normalised image is used for feature extraction. Feature extraction of normalised iris is done using discrete wavelet transform at different resolutions. Identification is done after comparing Euclidean distance of various images.

2.1 Image Acquisition
CASIA iris image database [12] is used for experimentation and it consists of 150 different images. Size of each database iris image is 280 x 320. In our database there are eye images of 50 different people, three different images of the same eye. Thus there are a total of 150 (50 x 3) images in our database.

2.2 Segmentation
Iris region consists of two circles. one for iris sclera boundary and another for iris pupil boundary. To isolate actual iris region in eye image, segmentation is required.. To have segmentation, edge detection, circle detection, eyelid detection are required. Various methods for edge detection are available. Here we used canny edge detection [13] for finding edges and hough transform [14] to find iris and pupil boundaries from the image as shown in figure 2.

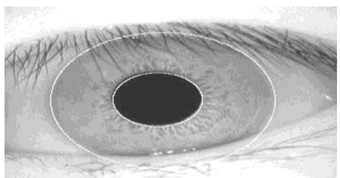

Fig 2. Iris with pupil and sclera boundary

2.3 Normalisation
Iris region needs to be transformed so that it has fixed dimensions to allow comparison. For normalisation of iris regions a technique based on Daugmans rubber sheet model [15] is employed. The center of the pupil is considered as the reference point, and radial vectors pass through the iris region

number of data points are selected along each radial line and this is defined as the radial resolution. The number of radial lines going around the iris region is defined as the angular resolution Each point within iris region transformed to pair of polar coordinates(r, Ɵ) where r is on the interval[0,1] and Ɵ is the angle [0,2π].so normalised iris looks like in figure 3.

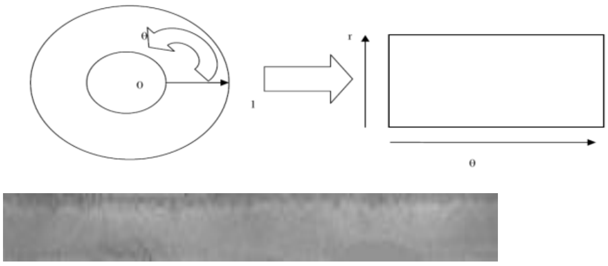

Fig 3. Normalised iris template

2.4 Feature Extraction

Wavelet transforms [16] are based on small waves called wavelets of varying frequency and limited duration. These waves are generated from basic wavelet function by dilation and translation. The wavelet transform provides multiresolution wavelet analysis [17] with dilated windows. The high frequency analysis is done using narrow windows and low frequency analysis using wide windows. Multiresolution analysis is representation and analysis of signals at more than one resolution. Features undetected at one resolution are easy to spot at another.

The function being expanded is sequence of numbers like samples of continuous function $f(x)$, resulting coefficients [18] are called discrete wavelet transform (DWT) of $f(x)$[19].

DWT transform pair is given by,

$$W\varphi(j_0,k) = \frac{1}{\sqrt{M}}\sum_x f(x)\varphi_{j_{0,k}}(x) \quad (1)$$

$$W_\Psi(j,k) = \frac{1}{\sqrt{M}}\sum_x f(x)\,\Psi_{j,k}(x) \quad (2)$$

For $j \geq j_0$ and

$$f(x) = \frac{1}{\sqrt{M}}\sum_k W\varphi(jo,k)\varphi_{j_{0,k}}(x) + \frac{1}{\sqrt{M}}\sum_{j=j_0}^{\infty}\sum_k W_\Psi(j,k)\Psi_{j,k}(x) \quad (3)$$

Here $f(x)$, $\varphi_{jo,k}(x)$, $\Psi_{j,k}(x)$ are functions of discrete variable $x = 0,1,2, \ldots\ldots\ldots M-1$ .Coefficients defined in equation (1) and (2) are approximation and detail coefficients respectively.

In two dimensional functions like images, two dimensional scaling $\varphi(x,y)$ and three two dimensional wavelets $\Psi^H(x,y), \Psi^v(x,y), \Psi^D(x,y)$ are required .Each is product of one dimensional scaling function φ and corresponding wavelet Ψ. Excluding product that produce one dimensional results ,like $\varphi(x), \Psi(x)$ the four remaining products produce separable scaling function.

$$\varphi(x,y) = \varphi(x)\varphi(y) \quad (4)$$

and separable directionally sensitive wavelets.

$$\Psi^H(x,y) = \Psi(x)\varphi(y) \quad (5)$$

$$\Psi^v(x,y) = \varphi(x)\Psi(y) \quad (6)$$

$$\Psi^D(x,y) = \Psi(x)\Psi(y) \quad (7)$$

These wavelets measure functional variation intensity, or gray level variations for images along different directions. Ψ^Hmeasures variations along columns, Ψ^v measures variations along rows ,Ψ^D measures variations along diagonals.The directional sensitivity is a consequence of separability given by equations (5) to (7).

In two dimensions, discrete wavelet transforms of function $f(x,y)$ of size $M \times N$ is,

$$W_\varphi(j_0,m,n) = \frac{1}{\sqrt{MN}}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y)\,\varphi_{j_{0},m,n}(x,y) \quad (8)$$

$$W^i{}_\Psi(j,m,n) = \frac{1}{\sqrt{MN}}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y)\,\Psi^i\, j,m,n(x,y) \quad (9)$$

$$i = \{H,V,D\}$$

Given $W\varphi_{,}\, W^i{}_\Psi$ and $f(x,y)$ is obtained via inverse discrete wavelet transform

$$f(x,y) = \frac{1}{\sqrt{MN}}\sum_m\sum_n W_\varphi\,(j_0,m,n)\varphi_{j_{0},m,n}(x,y) + \frac{1}{\sqrt{MN}}\sum_{i=H,V,D}\sum_{j=j_0}^{\infty}\sum_m\sum_n W^i{}_\Psi(j,m,n)\Psi^i{}_{j,m,n}\,(x,y) \quad (10)$$

Coefficients defined in equation (8) and (9) are approximation and detail coefficients for two dimensional signal respectively. These approximation and detail coefficients give additional details with increased level of decomposition.Normalised iris template is decomposed using multiresolution property of wavelet transform. Three and four level decomposition of iris template is shown in figure 4 and 5 respectively.

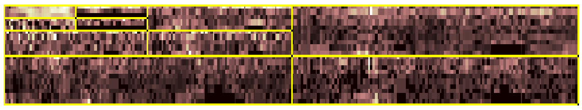

Fig 4.Three level decomposition of normalised iris template

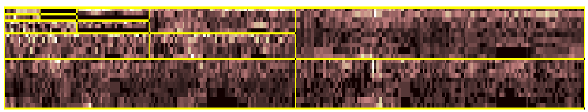

Fig 5. Four level decomposition of normalised iris template

2.5. Feature Vector Creation

Energy (11) and Standard deviation (12) of each subband is calculated as,

$$\text{Energy}=\sum_{m=0}^{m-1}\;\sum_{n=0}^{n-1}\;|X(m,n)| \quad (11)$$

Where $|X(m,n)|$ is function whose energy is to be computed

Standard deviation is given by ,

$$\sigma_k = \frac{1}{MN}\sum_{i=1}^{n}\sum_{j=1}^{n} E[W_k(i,j) - \mu_k] \quad (12)$$

Where W_k(i,j) is k^{th} wavelet decomposed subband, MxN is size of wavelet decomposed subband. μ_k is mean value of k^{th} subband.

Feature vector[20] is created by calculating standard deviation and energy for each sub-band.for each subband feature vector is created either using only standard deviation features or energy features or combining both to form a vector. Feature vector can be created as follows,

Using only energy, feature vector is given by equation (13).

$$f_E = [E_1, E_2, \dots \dots \dots . E_n] \quad (13)$$

Using only standard deviation, feature vector is given by

equation (14).

$$f_\sigma = [\sigma_1, \sigma_2, \dots . . \sigma_n] \quad (14)$$

Using combination of standard deviation and energy, feature

vector is given by equation (15).

$$f_{\sigma E} = [E_1, E_2, \dots \dots E_n, \sigma_1, \sigma_2, \dots \dots . . \sigma_n]. \quad (15)$$

Feature vector formed by above equations can be used for matching. For three level decomposition feature vector size is 1x24 and for four level, feature vector size is 1x32.The feature vectors for all database images are obtained and stored in database.

2.6 Matching

Feature vector of query image is calculated and is matched with existing feature vectors in the database. Euclidean distance (16) is used for comparison. Euclidean distance is zero for exact image and it increases as similarity between query image and database image decreases. Euclidean distance is given by

$$D_{x,y} = \sqrt{\sum_{i=0}^{N} (x_i - y_i)^2} \quad (16)$$

Performance is measured using FAR, FRR,RAR. Where FAR is false acceptance ratio,FRR is false rejection ratio,RAR is right acceptance ratio.

3. RESULTS

Results are obtained for three and four level decomposition in terms of FAR, FRR, RAR and shown below. Threshold used is normalized Euclidean distance.

Table 1. Results obtained for 3 level decomposition

Threshold	RAR(%)	FRR(%)	FAR(%)
0.135	81.82	18.18	6.82
0.140	86.31	13.69	6.82
0.145	90.91	9.09	11.36
0.150	93.18	6.82	13.64

Table 2. Results obtained for 4 level decomposition

Threshold	RAR(%)	FRR (%)	FAR(%)
0.330	88.64	11.36	13.64
0.340	93.18	6.82	15.91
0.350	93.18	6.82	15.91
0.360	95.45	4.55	22.73

4. CONCLUSION

Results obtained by the proposed method are as shown. Results are shown using daubechies wavelets. It is observed that threshold value is increased in four level decomposition, implies that added level of decomposition adds more texture information resulting in improved accuracy of the system. Here iris signature length is very small resulting in better speed as compared to daugmans method whose signature length is very high. The proposed approach gives better results and can be effectively used in pattern recognition applications. Proposed method can be improved by applying various iris segmentation methods and avoid eyelids and eyelashes which will give improved accuracy.

5. REFERENCES

[1] Jain A.K., Ross A, Prabhakar S. 2004, ―An introduction to biometric recognition, IEEE transactions on circuits and systems for video technology—special issue on image and video-based biometrics, vol. 14(1).

[2] S V Sheela and P A Vijaya. "Iris Recognition Methods – Survey". International Journal of Computer Applications 3(5):19–25, June 2010. Published By Foundation of Computer Science.

[3] Daugman J, "How iris recognition works", IEEE Transactions CSV, Vol.14, No.1, pp. 21-30, 2004.

[4] J. Daugman, "High Confidence Visual Recognition by a test of Statistical Independence", IEEE Trans. Pattern Analysis and Machine Intelligence, Vol. 15, No.11, pp.1148-1161,1993.

[5] J.Daugman, New Methods in Iris Recognition. "IEEE Transactions on Systems, Man, and Cybernetics, Part B:Cybernetics". 37 (5), 1167-1175 (2007).

[6] W. W. Boles and B. Boashash , "A Human Identification Technique Using Images of the Iris and Wavelet transform",IEEE Transactions On Signal Processing, Vol. 46, No. 4, April 1998.

[7] Li Ma, Tieniu Tan, Yunhong Wang, Dexin Zhang, "Personal Identification based on Iris Texture Analysis", IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol.25, No.12, pp. 1519 – 1533, 2003.

[8] R. Wildes, J. Asmuth, G. Green, S. Hsu, R. Kolczynski, J.Matey, and S. McBride, "A machine-vision system for iris recognition", Machine Visual Application, Vol. 9, pp. 1-8, 1996.

[9] R. Wildes, "Iris recognition: an emerging biometric technology", IEEE Proceedings, Vol. 85, pp. 1348-1363, 1997.

[10] R.P.Wildes, J.C.Asmuth, G.L. Green, S.C.Hsu, R.J,Kolczynski, J.R.Matey, S.E.McBride, David Sarno_ Res.Center, Princeton, NJ, "A System for Automated Iris Recognition", Proceedings of the Second IEEE Workshop on Applications of Computer Vision, 1994.

[11]Prof. Mane Vijay M,Prof .S.M.Tayde, Prof.(Dr.) Mrs.S.Subbaraman, "Efficient Identification of Humans

by iris", International conference on signal and image processing ICSIP2009,Mysore ,pp.12-14, Aug 2009.

[12] Chinese academy of sciences –institute of automation, "CASIA-irisV1, http://biometrics.idealtest.org.

[13] John Canny, "A computational approach to edge detection." *IEEE Transactions on PAMI*, 8(6):679–698, 1986.

[14] R.O.Duda and P.E.Hart, "Use of the Hough Transformation to Detect Lines and Curves in Pictures" Comm.ACM,vol .15,No.1,pp. 11-15(January 1972).

[15] Hugo Proenc¸a , Lu´ıs A. Alexandre, "Iris Recognition: An Analysis of the Aliasing Problem in the Iris Normalization Stage" ,IEEE proceedings of 2006. International Conference on Computational Intellligence and Security-CIS 2006, Guangzhou,China,November 3-6,2006,vol.2,pp.1771-1774.

[16] R.C.Gonzalez,R.E.Woods "Digital Image Processing" second edition,Pearson Education.pp.371-426.

[17] Bruno Garguet-Duport, Jacky Girel, Jean-Marc Chassery, and Guy Pautou"The Use of Multiresolution Analysis and Wavelets Transform for Merging SPOT Panchromatic and Multispectral Image Data" PE&RS September 1996,pp. 1057-1066.

[18] E.Y. Lam "Statistical modelling of the wavelet coefficients with different bases and decomposition levels" IEE Proc.-Vis. Image Signal Process., Vol. 151, No. 3, June 2004,pp-203-206.

[19] Lenina Vithalrao Birgale,Manesh Kokare, "Iris recognition using discrete wavelet transform "International conference on digital image processing,2009.pp.147-151.

[20] V.Balamurugan,P.Anandhakumar "multiresolution image indexing technique based on texture features using 2D wavelet transform",Europian journal of scientific research, vol. 48,N0.4,(2011).pp 648-664