A MULTILEVEL WAVELET TRANSFORM FOR PATTERN RECOGNITION

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ABSTRACT
Pattern recognition has become one of the fastest growing research topics in the fields of computer science and electrical and electronic engineering in the recent years. Advanced research and development in pattern recognition have found numerous applications in such areas as artificial intelligence, information security, biometrics, military science and technology, finance and economics, weather forecast, image processing, communication, biomedical engineering, document processing, robot vision, transportation, and endless other areas. The achievement of pattern recognition is most likely to benefit from some new developments of theoretical mathematics including wavelet analysis. An approach for feature extraction using wavelet transforms using its property of multilevel decomposition in pattern recognition application is proposed. The multilevel decompositionproperty 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 and Segmentation.

INTRODUCTION

Wavelet is a relative recent development mathematic in 1980s, and it can beapplied in lots of field, like JPEG2000. JPEG2000 is a new technique for imagecompression. In the standard JPEG, we use discrete Fourier transform (DCT), and in the JPEG2000, we use discrete wavelet transform to replace DCT. It not only increase the compression ratio but also has better performance and in image. So we try to use wavelet on every field. Now i will introduce wavelet for pattern recognition. Pattern recognition can do with not only wavelet transform but also other transforms and mathematics. As for the applications of wavelet theory to pattern recognition, we can consider them to be two ways:

- System-component-oriented
- Application-task-oriented

And Fig. 1.1 displays the two ways. It is clear that the two sides are related to eachother. Each group of the right side relates to the component of left side. For instance, singularity detector and invariant representation are related to feature extraction.Pattern recognition can subdivide into face recognition, image recognition, handwritten and printed character recognition, etc. Pattern recognition is an advanced knowledge and there are lots of new techniques arising nowadays, and there is not an absolute answer for pattern recognition.

Biometrics 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 are proposed by various researchers such as phase based method, zero crossing method, intensity variations method. Texture-analysis based method. 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.

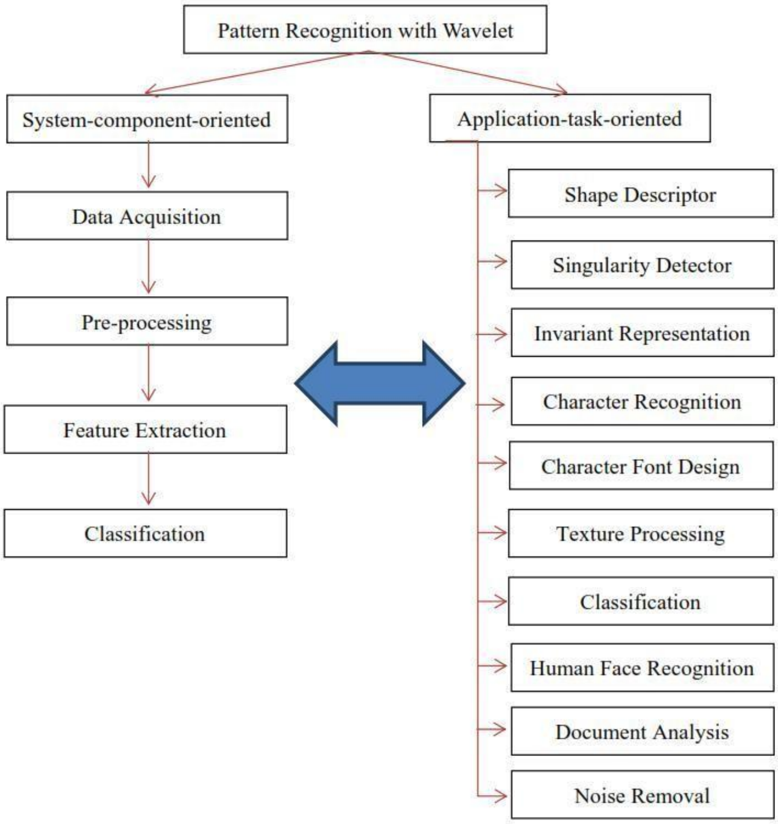

Fig. 1.1 Pattern recognition with wavelet

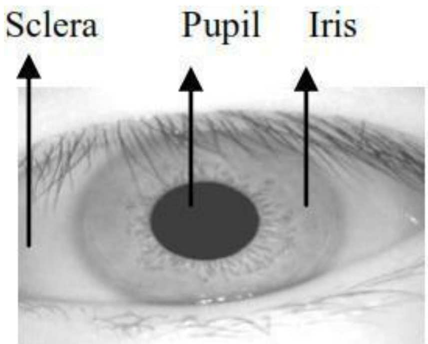

Fig.1. Eye image.

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 using multilevel wavelet transform is explained.

This paper is organized asfollows. 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.

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.

Image Acquisition

The first step of pattern recognition is data acquisition. In the real world, the analog data from the physical world are acquired through a transducer, and further digitized to discrete format suitable for computer processing.

CASIA iris image database 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.

Data Pre-Processing

A major function of the data pre-processing part is to modify the measured data obtained from the data acquisition part so that those data can be more suitable for the further processing in feature extraction and classification. There are many modifications in the data pre-processing part. For example, some of them are listed below:

- Gray-level histogram modification
- Smoothing and noise elimination
- Edge sharpening
- Boundary detection and contour tracing
- Thinning
- Segmentation
- Morphological processing
- Texture object from textural background
- Approximation of curves and surfaces

In the above modifications, many items, such as noise, edges, boundaries, surfaces, textures, curves, etc., are of singularities in different patterns.

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 for finding edges and hough transform to find iris and pupil boundaries from the image as shown in figure 2.

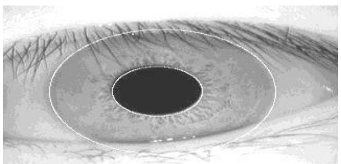

Fig 2. Iris with pupil and sclera boundary

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 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 resolutionEach point within iris region transformed to pair of polar coordinates(r, Θ) where r is on the interval[0,1] and Θ is the angle $[0,2\pi]$.so normalised iris looks like in figure 3.

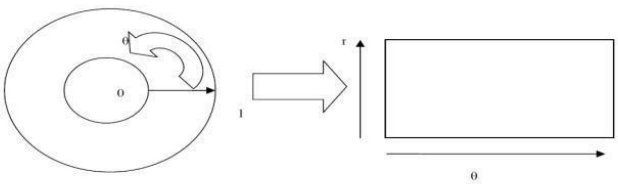

Fig 3. Normalised iris template

Feature Extraction

Wavelet transforms 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 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 ( ), resulting coefficients are called discrete wavelet transform (DWT) of ( ).

DWT transform pairis 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

( ), , ( ), , ( ) are functions of discrete variable = 0,1,2, … … - 1.Coefficients defined in equation (1) and (2) are approximation and detail coefficients respectively.

In two dimensional functions like images, two dimensional scaling (,)and three two dimensional wavelets (,), (,), (,) are required .Each is product of one dimensional scaling function and corresponding wavelet . Excluding product that produce one dimensional results, like ( ), ( )the four remainingproducts produce separable scaling function.

(,) = ( ) ( ) (4)

and separable directionally sensitive wavelets.

(,) = ( ) ( ) (5)

(,) = ( ) ( ) (6)

(,) = ( ) ( ) (7)

These wavelets measure functional variation intensity, or gray level variations for images along different directions. measures variations along columns, measures variations along rows, measures variations along diagonals. The directional sensitivityis a consequence of separability given by equations (5) to (7). In two dimensions, discrete wavelet transforms of function (,) of size × is,

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

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

= { , , }

Given , and (,) 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 detailswith 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. Fourlevel decomposition of normalised iris template

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 |(,)|is function whose energy is to becomputed

Standarddeviation 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 (i, j) is h wavelet decomposed subband, MxNis size ofwavelet decomposed subband. is mean value of h subband.

Feature vectoris created by calculating standard deviation and energy for each sub-band.for each subband feature vector is created either using only standard deviation features orenergy featuresor combining both to form a vector. Feature vectorcan be created as follows, Using only energy, feature vector is given by equation (13).

= [1, 2, … … … .] (13)

Using only standard deviation, feature vector is given by equation (14)

= [1, 2, … . .] (14)

Using combination of standard deviation and energy, feature vector is given by equation (15).

= [1, 2, … … , 1, 2, … … . .]. (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.

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. Euclideandistance 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.

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

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. Hereirissignaturelengthisvery smallresultinginbetter speed as compared to daugmans method whose signature lengthisveryhigh.The proposed approach gives better results and can be effectively used in pattern recognition applications. Proposed method can be improved by applying variousiris segmentation methods and avoid eyelids and eyelashes which will give improved accuracy.

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