International Journal of Applied Information Systems (IJAIS) – ISSN : 2249-0868
Foundation of Computer Science FCS, New York, USA
Volume 9 – No.7, September 2015 – www.ijais.org

Comparative study of Iris Recognition using Neville's Algorithm and Symmetric Framelet

Shashidhara H.R.
JSS Academy of Technical Education,
Visveswaraya Technological University
Bangalore, India

Aswatha A.R., PhD
Dayanad Sagar College of Engineering
Visveswaraya Technological University
Bangalore, India

ABSTRACT
The iris recognition is a highly secured and unified authentication of a person. In this paper the necessary features of iris region is extracted from the eye image by using two algorithms. The algorithms used for to extract the features are Neville's algorithm and Symmetric framelet. The iris region is extracted through the segmentation process by applying thresholding. The Neville's method is an interpolating subdivision method, which generates the halfway values of the two nearest database segmented iris image pixels. The symmetric framelet calculates the conditional symmetry between two components of iris image. The proposed method improves the efficiency and accuracy of the iris recognition system. The experimental results shows that the iris recognition with low false acceptance ratio and false rejection ratio and high success rate.

Keywords
Segmentation, Doughman, Neville's algorithm, Symmetric framelet, Hamming distance.

General Terms
Biometric System, Iris Recognition

1. INTRODUCTION
The critical attributes of the characteristics for reliable recognition are the variations of selected characteristics of the human population, uniqueness of these characteristics for each individual, their immutability over time [1]. Human iris is one of the best characteristics for any application when these attributes are considered.

The texture of an iris is very stable, complex, and unique throughout life. Iris patterns have a high degree of randomness in their structure. This makes them unique. The iris is a protected internal organ and it can be used as an identity document or a password offering a very high degree of acceptance. The human iris is immutable over time [1].

The unique iris patterns of digitized image of the eye is extracted from some of the image processing technique and encode into a biometric template, which can be stored in a reference database. The mathematical representation of the unique information of iris is contained from the biometric template, these template are made comparisons to authenticate. The initial step of iris recognition system is the photograph of the eye is obtained, and a template is created for the iris region. This created template and other stored templates in the database are made to compared each other. Either the result may be matching template is found otherwise the iris is not acceptable.

From literature, the prototype systems have been proposed earlier. The Cambridge researcher, John Daugman, implemented iris recognition system [2]. Daugman method uses 2-D Gabor filter to extract the features of an iris. This method generates a 256 byte code by quantizing the local phase angle according to the outputs of the real and imaginary parts of the filtered image. Comparing the percentage of mismatched bits between a pair of iris representations via an XOR operator and selecting a separation point in the space of Hamming distance. Even though the Daugman system is most successful and well-known, many other systems have been developed. Other notable methods include the system designed by of Wildes et al.[3], Boles and Boashash [4], Lim et al.[5].

On the contrary, the Wildes system made use of a Laplacian pyramid constructed with four different resolution levels to generate iris code. It exploits a normalized correlation based on goodness-of-match values and Fisher's linear discriminate for pattern matching. Boles implemented the system operating the set of 1-D signals composed of normalized iris signatures for few intermediate resolution levels and obtaining the iris representation of these signals via the zero crossing of the dyadic wavelet transforms. It uses two dissimilarity functions to compare the new pattern with the reference patterns.

The Doughman system has been tested in numerous studies, all reporting a zero failure rate. Wildes et al. proposed a prototype system, which also reports performance with 520 iris images and the system proposed by Lim et al. attains 98.4% of a recognition rate for a database of around 6,000 eye images.

The use of Gabor transform and Haar wavelet transform is compared by Lim et al. The Haar wavelet transform shows slightly better recognition rate than Gabor transform by 0.9%.

Wei-Yu Han et. Al. proposed Iris recognition based on local mean decomposition (LMD). The LMD is used for the feature extraction in their approach and found very high recognition rates compared to local texture analysis and Empirical Mode Decomposition methods [6]

Dr. Sudeep Thepade & Pushpa R. Mandal proposed the iris recognition using the Fractional Energies of Transformed Iris Images using Haar and Kekre Transforms. They proposed Haar transform is having better GAR as compared to Kekre transform [7].

Ying Chen et. Al. proposed the feature fusion technique. The features are extracted using multichannel 2-D Gabor filters and separated for KNN and SVM classifier. The experimentally proved for different database iris images, and also shows that the EER of 0.06923 for CASIA V1, CASIA-

V3 Interval 0.09000, MMU-V1 0.10952 And JLUBRIRIS-V1 0.03747 for entirely normalized iris [8].

Abikoye Oluwakemi C. et. Al. used fast wavelet transforms for iris detection. The features iris is extracted from the FWT [9].

This paper describes on optimized and robust methods for improving the performance of human identification system. Neville's method and Symmetric Framelet algorithms are proposed for feature extraction to achieve better performance. To select a good method suitable for iris patterns, the performance comparison is made according to the dimension of a feature vector and rate of recognition.

2. PROPOSED METHODOLOGY

The proposed work is concentrated on segmenting iris region from the eye image and to extract the features of the iris using Neville's and Symmetric Framelet.

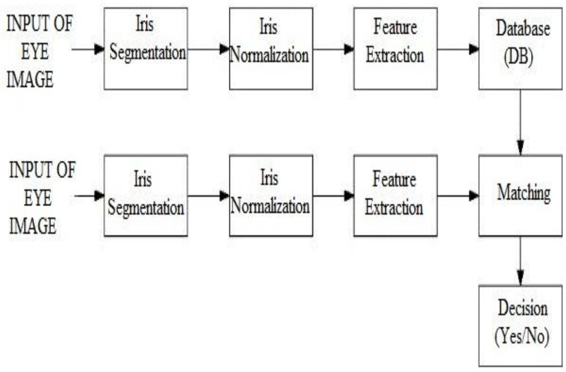

Fig 1. Iris recognition system

The iris recognition is done using the following steps:

a. Segmentation and Normalization.

b. Feature extraction and

c. Matching.

Fig 1 shows the iris recognition system, the segmentation and normalization is extract the iris region from the eye image and the feature extraction will extract the necessary unique feature of the iris. The database and eye image and the testing eye image both will process through the same steps up to matching. For matching hamming distance is used which compares the features of database iris and test iris. With respect to the threshold of hamming distance the decision is made for authentication.

2.1 Segmentation and Normalization

2.1.1 Segmentation

The segmentation is the fact that the intensity of iris lies between the intensities of pupil and rest of the eye. A simple vertical and horizontal scan is done over the image to get the tangents of the circles. A mathematical analysis is done on the images to get the radius and the center of the circle and hence the inner and outer circles of the iris are drawn (10). The algorithm for segmentation is as follows

a. The iris image is converted into black & white with defined threshold value.

b. Reduce the noise using the Gaussian filter and smoothen the image.

c. Apply edge detection to find the circle edges

d. Scan vertically to get the tangent and hence the radius and the center.

e. This process is repeated with slightly higher threshold value to obtain the outer circles. Vertical scan from the center of the circle to obtain the tangent and hence the radius.

f. Inner and outer circles are reconstructed using the calculated values.

2.1.2 Normalization

Daugman's rubber sheet model was employed for normalization of iris region. The radial vectors are generated by considering the center of the pupil as reference point. Along this radial line the numbers of data points are selected. Using these data point the remapping formula is used to convert from circular co-ordinate to rectangular co-ordinate. This is given by [1]

$$r' = \sqrt{\alpha}\beta \pm \sqrt{\alpha\beta^2 - \alpha - r_1^2} \qquad (1)$$

With

$$\alpha = o_x^2 + o_y^2 \qquad (2)$$

$$\beta = \cos\left(\pi - arctan\left(\frac{o_y}{o_x}\right) - \theta\right) \qquad (3)$$

2.2 Feature Extraction

2.2.1 Neville's Algorithm

The features of an iris region are obtained by interpolating subdivision algorithm. Neville's algorithm is one of polynomial interpolating subdivision algorithm. This extracts all the features of the iris region. Deslauriers and Dubuc define a recursive procedure for finding the value of an interpolating function at all dyadic point [11]. This is referred as interpolating subdivision. All interpolating subdivision constructions obey refinement relations. The new sample value is then simply given by the evaluation of this polynomial at the new, refined location [12]. Neville's method is applied to interpolate a function f(x) at a given point x = p with increasingly higher order Lagrange's interpolation polynomials.

Let us consider three distinct points x0, x1 and x2 at which the function evaluating the f(x) exactly at three points (f(x0); f(x1); f(x2)) to construct an zero, first and second order polynomial to approximate of function f(p).

The Neville's methods convert the given two-dimensional matrices into Row vector. The converted row matrix is then segregated into block of ten pixels. The processes of interpolation are done by polynomial root generation. The polynomial roots are generated by using Chebyshev polynomial for ten pixel elements (one block of segmented iris region). The process of Chebyshev polynomial is a recursive type relation given in the equation 1 and other blocks of segmented iris region are obtained using this equation.

T0(x) = 1; T(n + 1)(x) = 2Tn(x) - T(n - 1)(x); (1)

A recurrence relation is an equation that recursively defines a sequence, one or more initial terms are given: remaining term of the sequence is defined as a function of the preceding terms. The equation 1 is calculated for n number of iterations to generate the required nodes for the interpolation. In the generated set is obtained by iterating equation 1 for number of pixel block times (the segmented iris blocks are considered as n pixel element) and normalizing. The mean of the group is calculated which is required for Neville's interpolation. For creating n^{th} order interpolation factor, an (nXn) matrix is constructed with Chebyshev nodes as the first row and appending zeros for rest n-1 rows.

The 1^{st} order polynomial values of x_i are P(f(p)) and it is given by,

$f^1(p) \approx P_0(p) = f(x_0)$; $f(p) \approx P_1(p) = f(x_1)$; $f(p) \approx P_2(p) = f(x_2)$ (2)

Therefore, in general, the n^{th} order polynomial of Neville's algorithm is given by,

$f^n(p) \approx P_{(0,1,2,\ldots\ldots,n)}(p) = ((p-x_n)P_{(0,1,\ldots\ldots,n)}(p) - (x-x_0)P_{(1,2,\ldots\ldots,n-1)}(p))/(x_0-x_n)$ (3)

The n^{th} order polynomial obtained is unique as compared other order polynomials, which relates more correctness in the interpolating values. It can be observed that for every higher order, an increasing number of values are obtained. Since the second order is calculated for higher orders, is decreasing for every following column.

The feature extraction is done for higher number of pixels as polynomials. Two steps should be observed here are

a. The input two-dimensional matrix is converted into one-dimensional matrix.

b. The entire groups of pixels are clustered into groups and the order of the polynomial is equal to the number of pixels in a group. The interpolated values give much more samples depending upon the order of a polynomial. These extracted features are used for the matching.

2.2.2 Symmetric Framelet

Wavelet is used to decompose the iris region into components that appear at different resolutions. Wavelets have the advantage over Fourier transform in that the data frequency is localized, allowing features at the same position and resolution. A number of wavelet filters (bank of wavelets) is applied to the iris region, the resolution of each wavelet is scaled to some basis function. The scaled wavelets is then encoded to provide a compact and discriminating representation of the iris pattern.

When the low pass scaling filter is of even-length is provided. One wavelet is symmetric and the other is anti-symmetric. The wavelet filters can be obtained by a matching the roots of associated polynomials.

The low pass filter coefficient $h_0(n)$ is designed to ensure that the both the wavelets have specified number of vanishing moments.

In general, for scaling function the wavelet and dilation equations are given by,

$$\emptyset(t) = \sqrt{2} \sum_n h_0(n)\emptyset(2t-n) \quad (4)$$

$$\varphi_i(t) = \sqrt{2} \sum_n h_i(n)\emptyset(2t-n) \quad (5)$$

The poly-phase components are so that:

$$H_i(z) = H_{i0}(z^2) + z^{-1}H_{i1}(z^2) \quad i = 0,1,2,\ldots\ldots \quad (6)$$

If $h_i(n)$ must satisfy the perfect reconstruction conditions and $h_i(t)$ is sufficiently regular, then the dyadic dilations and translations of $h_i(t)$ form a tight frame for $L^2(IR)$.

The perfect reconstruction condition can also be written in matrix form as:

$$H^t\left(\frac{1}{z}\right)H(z) = I \quad (7)$$

where,

$$H(z) = \begin{matrix} H_{00}(z) & H_{01}(z) \\ H_{10}(z) & H_{11}(z) \\ H_{20}(z) & H_{21}(z) \end{matrix} \quad (8)$$

The goal is to design a set of three filters satisfying the perfect reconstruction conditions where the low-pass filter $h_0(n)$ is symmetric and the filters $h_1(n)$ and $h_2(n)$ are each either symmetric or anti symmetric. There are two cases. Case I will denote $h_1(n)$ is symmetric and $h_2(n)$is anti-symmetric. Case II will denote both $h_1(n)$ and $h_2(n)$ are anti-symmetric.

The symmetry condition for $h_0(n)$ is:

$$h_0(n) = h_0(N-1-n) \quad (9)$$

CASE I**:** In this case $h_2(n)$ is a time-reversed version of $h_1(n)$(and where neither filter is (anti-) symmetric).

Let,

$$h_2(n) = h_1(N-1-n) \quad (10)$$

The solutions are,

$$h_1^{new}(n) = \frac{1}{\sqrt{2}}(h_1(n) + h_2(n-2d)) \quad (11)$$

$$h_2^{new}(n) = \frac{1}{\sqrt{2}}(h_1(n) - h_2(n-2d)) \quad (12)$$

CASE II**:** The two Dyadic wavelet tight frames are anti-symmetric compactly supported wavelets can be obtained with filters $h_i(n)$ satisfying the following symmetry conditions:

$$h_0(n) = h_0(N-1-n) \quad (13)$$

$$h_1(n) = -h_1(N-1-n) \quad (14)$$

$$h_2(n) = -h_2(N-3-n) \quad (15)$$

The unique information present in an iris pattern is extracted to provide accurate recognition of individuals. These unique features are encoded for the comparisons made between the iris templates. Most iris recognition systems biometric template is created by using band pass decomposition.

The generated feature encoded is considered for the corresponding matching metric to measure the similarity between two iris templates. This metric should generate for intra-class comparisons or inter-class comparisons. These two values should be distinct and separate, to show the decision made with high confidence [13].

2.3 Matching

The matching is done from the distance calculation using hamming distance formula. Hamming distance shows a measure of two bit patterns as a distance, a decision is made based on the two iris patterns. In comparing the two iris bit patterns X and Y, the Hamming distance (HD), is defined as the sum of dissimilar bits over the total number of bits in the bit pattern is calculated using the following equations,

$$HD = \left(\frac{1}{N}\sum_{k=1}^{N} X_{nk}(OR)Y_{nk}\right)\sum_{j=1}^{N} X_j(XOR)Y_j(AND)X'_{nj}(AND)Y'_{nj} \qquad (16)$$

Where X_j and Y_j are the two bit-wise templates to compare, X_{nj} and Y_{nj} are the corresponding noise masks for X_j and Y_j. N is the number of bits represented by each template.

When comparing two iris images, their corresponding binary feature vectors are passed to a function responsible of calculating the hamming distance between the two iris image pixels. The decision of whether these two images belong to the same person depends upon the following result:

1. If HD <= 0.30 decide that it is same person
2. If HD > 0.30 decides that it is different person

Since an individual iris region contains features with high degrees of freedom, each iris region produces an independent bit patterns to that produced by another iris. On the other hand, two iris codes are highly correlated from the same iris. If two bit patterns are completely separate, the hamming distance will be greater than 0.3. If the two iris patterns are from the same iris, the hamming distance between them is close to zero.

3. RESULTS AND OBSERVATIONS

This section discusses the results procured on the implementation of design. The results of the various steps such as Segmentation, Feature extraction, and Matching have been determined. The output of the matching step has been used for the calculation of the recognition rate False Acceptance Ratio (FAR) and False Rejection Ratio (FRR).

The segmentation starts with extracting inner circle of a pupil region of the eye image as shown in Fig 2 by setting the lower threshold of the given eye image. After finding the inner pupil, the outer circle of the iris is extracted by setting at higher threshold of the eye image. The total two concentric circles are illustrated in Fig 3. From those two circles. The total iris region is extracted as shown in the Fig 4.

The normalization process results are shown in Fig 6. However, the normalization process will not reconstruct the same iris patterns from images with varying pupil dilation.

The normalized iris contains the values of the iris pixel coordinate that are used in the feature extraction process. Extracted features are compared to a certain test image. Based on a range of threshold values, the authentication process is evaluated. In Fig 7 the hamming distance is less than 0.3, such that the authentication is approved, if the hamming distance is greater than 0.3 such that the authentication is invalidated as shown in Fig 8.

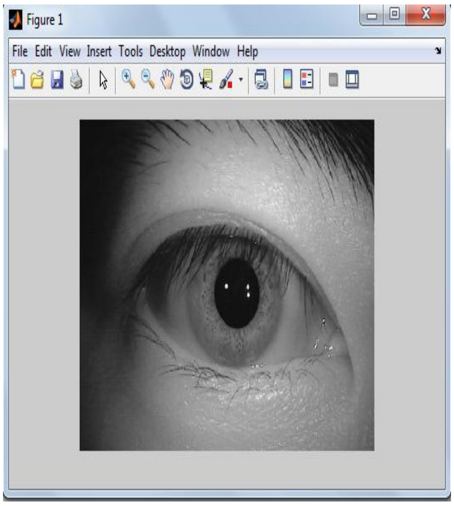

Fig 2. Eye Image

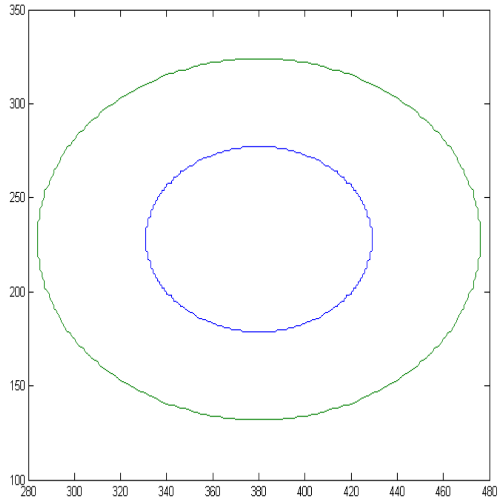

Fig 3. Constructed Inner and Outer Circle

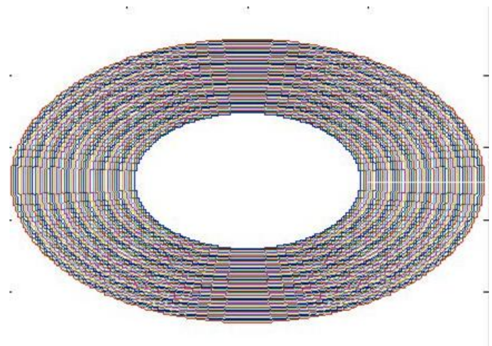

Fig 4.Segmented Iris Region (Before Normalization)

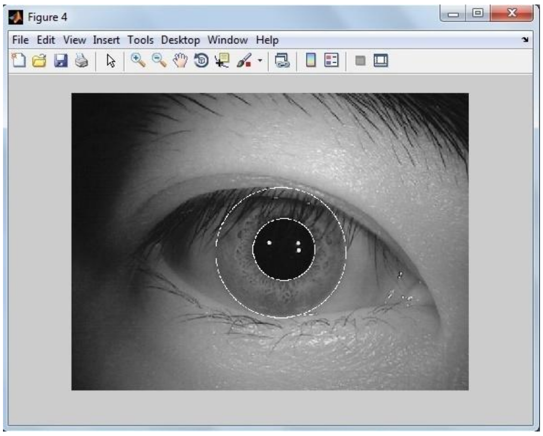

Fig 5 Segmentation output of iris image

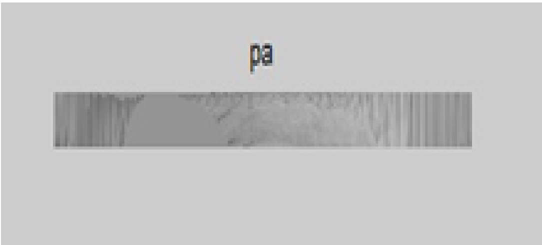

Fig 6 Normalized polar array of iris

Fig 7 Hamming Distance for Matching

Fig 8 Hamming Distance for not Matching

In comparison of recognition rates FAR and FRR of various methods used in Biometric, recognition system has been shown in Table 1. From the Table 1 it can be inferred that the best FAR is offered by Symmetric framelet, which shows a rate of 0.25% and Neville's method has a rate of 0.55%, similarly the FRR by symmetric framelet has 1.23% and Neville's method has 1.6%.

Due to clear in the boundaries between the iris pupil and sclera the segmentation the automatic model is successful. The segmentation technique is used to correctly segment the iris region from 756 eye images. The Neville's method shows the Success rate of around 95.23% for 720 eye images out of 756 eye images. The Symmetric Framelet has success rate of 97.88%, which generated from 740 eye images out of 756 eye images.

Table I. Comparative results of Recognition Rates

Methods	FAR(%)	FRR(%)
Neville's Method	0.55	1.6
Symmetric framelet	0.25	1.23
1D Log-Gabor Wavelet [3]	0.5	23.8
2D Hilbert Transform [3]	0.3	11
Haar Wavelet [7]	2.9	1.65
Circular Symmetric Filter[8]	5	20

4. CONCLUSION

The comparative study reveals the very high efficiency in symmetric framelet as comparing to Neville's algorithm. The symmetric framelet uses low pass components of the iris images and the Neville's algorithms generates average of the neighboring pixels. The feature vectors generated are very large in Neville's algorithm as compared to symmetric framelet. The iris region is efficiently extracted in segmentation process. The credibility to use both algorithms has been justified with improved recognition rate when compared to other algorithms. In future the features can be concentrated only on the required region of the iris and can be derived for higher recognition rate.

5. REFERENCES

[1] J. Daugman: How iris recognition works: IEEE Transactions on Circuits and Systems for Video Technology, Vol. 14, no. 1, pp. 21–30(2004).

[2] J. G. Daugman: High confidence visual recognition of persons by a test of statistical independence: IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 15, no. 11, pp. 1148–1161 (1993).

[3] R. P. Wildes:Iris recognition: an emerging biometric technology: Proceedings of the IEEE, vol. 85, no. 9, pp.1348–1363 (1997).

[4] 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, pp. 1185–1188 (1998)

[5] S. Lim, K. Lee, O. Byeon, and T. Kim:Efficient iris recognition through improvement of feature vector and classifier: ETRI journal, vol. 23, no. 2, pp. 61–70, (2001).

[6] W.-Y. Han, W.-K. Chen, Y.-P. Lee, K.-s. Wu, and J.-C. Lee: Iris recognition based on local mean decomposition: Appl. Math, vol. 8, no. 1L, pp. 217–222,(2014).

[7] S. Thepade and P. R. Mandal: Novel iris recognition technique using fractional energies of transformed iris images using haar and kekre transforms: International Journal Of Scientific & Engineering Research, vol. 5, no. 4 (2014).

[8] Y. Chen, Y. Liu, X. Zhu, H. Chen, F. He, and Y. Pang: Novel approaches to improve iris recognition system

performance based on local quality evaluation and feature fusion: The Scientific World Journal, vol. 2 (2014).

[9] C. Abikoye Oluwakemi, J. Sadiku, S. Adewole Kayode, and G. Jimoh Rasheed:Iris feature extraction for personal identification using fast wavelet transform (fwt): International Journal of Applied Information Systems**:**structure: vol. 6, no. 9,pp-1-5, (2014).

[10] H. R. Shashidhara and A. R. Aswath: A novel approach to circular edge detection for iris image segmentation: 2014 Fifth International Conference on Signal and Image Processing (ICSIP). pp. 316–320:IEEE (2014)

[11] G. Deslauriers and S. Dubuc: Symmetric iterative interpolation processes: Constructive approximation: pp. 49–68: Springer (1989).

[12] W. H. Press, S. A. Teukolsky,W. T.Vetterling, and B. P. Flannery:Numerical recipes:The art of scientific computing :Cambridge, (1992)

[13] Ivan W. Selesnick, A. Farras Abdelnour: Symmetric Wavelet Tight Frames with Two Generators: Applied and Computational Harmonic Analysis, vol-17, issue-2:pp-211-225, (2004)