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DWT Based Feature Extraction for Iris Recognition

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Abstract: This paper attempts to describe a unique approach to create an iris recognition system in which a mechanism that uses canny edge detection scheme and a circular Hough transform to determine the iris boundaries in the eye image which are used. Later two level discrete wavelet transform is applied to extract the patterns in a person's iris in the form of a feature vector. Matching is done using pair wise distance, which computes the Euclidean distance between two pairs of iris in data matrix. To conclude, our method has achieved a better total successive rate (TSR) and we have reduced equal error rate (EER),false accept rate (FAR) and false reject rate (FRR).

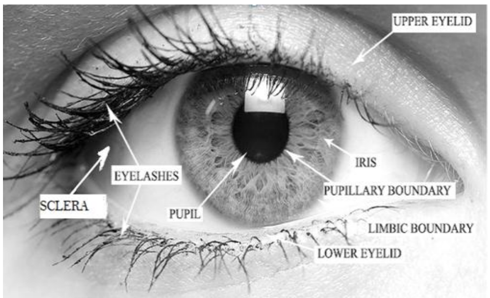
Keywords: Canny Edge, Euclidean Distance, TSR, EER, FAR, FRR.

I. INTRODUCTION

Biometric has been widely used in several applications in our day to day life. Biometric is a technique in which a person will be recognized based on one or more physiological or behavioral characteristics. There are various types of biometric recognition systems which include face, fingerprint, iris, palm, signature, voice, etc. Biometric identification systems rely on number of random variations among people. The more complex the randomness the better it is, as more dimensions of independent variation produce greater uniqueness. The system works by capturing a sample of the iris sample or from a data base, the sample is then transformed using mathematical function into a biometric template. This template provides a normalized, efficient and highly discriminating representation of the feature, which can be compared with other templates to determine the identity.

The human iris is a thin circular structure in the eye, which is responsible for controlling the diameter and size of the pupil thus varying the amount of light reaching the retina. The area of the iris is small but, it has enormous pattern variability which makes it unique from person to person and hence is highly reliable. The cameras used to capture iris is accurate, easy to use, and non-intrusive. This technology is difficult to forge and is quite fast, once initial enrolment has taken place.

The comparison is done by computing the distance between the test sample and its corresponding set of sample which are stored in the system previously. Elements of the eye which are not used in the comparison algorithm are discarded in the template to reduce the file size and to protect the identity of the person. Research is rigorously in progress for iris recognition with the use of advanced technologies like bias corrected fuzzy c-mean and segment based on active contours, identifying iris using haar classifier, histogram of oriented gradients, 2d-gabour wavelets, etc. The image of eye is shown in Figure 1.



Figure,1: Human eye

II. LITERATURE SURVEY

Daouk et al., [1] proposed a technique to create an iris recognition system, in which fusion mechanism was used to merge canny edge detection and circular Hough transform for pre-processing and hamming distance for matching which has a correct recognition average of 93%. Bhawan Chouhan and Shailja Shukla., [2] presents a straight forward approach for segmenting the iris patterns. The used method determines an automated global threshold and the pupil center. B.Sabarigiri and T.Karthikeyan., [3] proposed a technique where of acquisition of Iris images, Iris Localization, Normalization and Quality Enhancement. Algorithms like Circular Hough transform, Canny Edge Detection, Gabor filters, Homogeneous rubber sheet model and Daubechies wavelets methods were used according to the requirement. Hanene Guesmj et al., [4] had used eye image pre-processing by Bias-Corrected Fuzzy C-mean and iris segmentation based on active contours snake.The major drawback of this is method was the cost of the algorithm. Yan Li et al., [5] have discussed how to extract the

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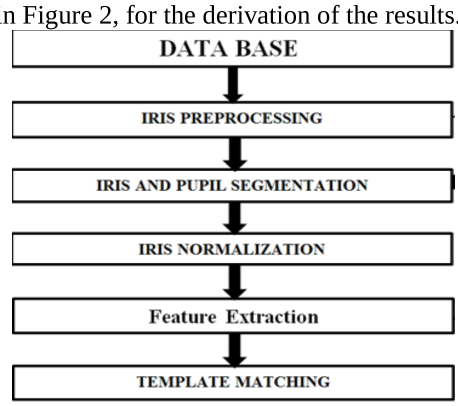
complete iris information which is automatically extracted from the original image by Histogram of Oriented Gradients (HOG) this information is taken into Support Vector Machines (SVM) to obtain the decision function. Afsana Ahamed and Mohammed Imamul Hassan Bhuiyan., [6] have discussed about low complexity technique for iris recognition using curvelet transform. Sambita Dalal et al., [7] have used Daubechies wavelet transform to extract textural features which is combined with the normalized correlation of the wavelet coefficients of optimized decomposition level with existing approach. Penny Khaw., [8] had discussed about capturing the image of the eye then applying 2-D Gabor wavelets to filter and map the segments of the iris and matching was done using Hamming distance, disadvantage of the Gabor filter is that the even symmetric filter will have a DC component whenever the bandwidth is larger than one octave. Robert W. Ives et al., [9] had used pre-processed one dimensional histograms and matching was done using Du Measure. Bimi jain et al., [10], discussed about using fast Fourier transform and moments for iris recognition, the fast Fourier transform converts image from spatial domain to frequency domain, the drawback is that images of bigger eye gives higher moment value.

III. PROPOSED METHODOLOGY

A. Proposed Iris Recognition Block Diagram

The paper intends to use the block diagram which is shown in Figure 2.The proposed iris recognition block diagram using pre-processing, iris and pupil segmentation, normalization, feature extraction and template matching is shown in Figure 2, for the derivation of the results.

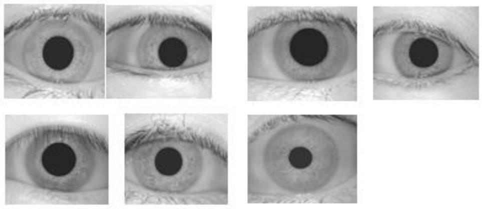


Figure, 2: Block Diagram of Iris Recognition System.

i) Data Base

- Eye Image Acquisition

A very important step in iris recognition system is to obtain a good and clear image of the eye. In this paper a set of eye images provided by cassia (institute of automation, Chinese academy of science) are used**.** The images were mainly taken for the purpose of iris recognition software research and implementation, where infrared light was used for illuminating the eye, and hence they do not involve any specular reflections. Cassia iris VI contains a total of 756 iris images from more than 108 subjects. All the images are 8-bit gray level bitmap files which are collected under near infrared illumination. The data samples are as shown below in Figure 3.

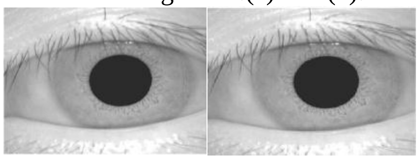

Figure, 3: Cassia Database Images

ii) Iris pre-processing

The image contains not only the region of interest i.e. iris, but also contains other parts of the eye. Furthermore, there will be disturbance in the image if the camera- to- eye distance is altered. The brightness also plays an important role as it will not be uniformly distributed because of non-uniform illumination. Before extracting the features from the original image, the image needs to be pre-processed to localize and normalize iris to reduce the influence of the factors which are mentioned. There are two methods involved in Iris pre-processing which are as follows:

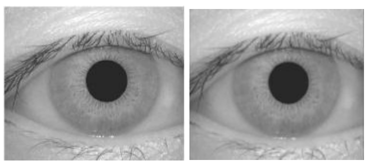
- Image resizing:

The image in the data base is resized to the desired pixel density (256 x 256) to have uniformity in the input image samples. The original database image and the resized image are as shown in Figures 4.(a) and (b).


Figure, 4: (a) Original Database Image (b)Resized Image

- Gaussian Smoothing: Digital images are prone to a variety of noises. Noise is the result of errors that occur during image acquisition process which results in pixel values that do not reflect the true intensities of the real scene. There are several ways that noise may be introduced into an image, depending on how the image is created. The most preferred approaches to reduce the noise to smooth the image. Hence, smoothing filters are used for blurring and noise reduction before trying to locate and detect any edges. The Gaussian filter produces a `weighted average' of each pixel's neighborhood, with the average weight more towards the value of the central pixels. This is in contrast to the mean filter's uniformly weighted average. Because of this, a Gaussian filters provides gentler smoothing and preserves edges better than a similarly sized mean filter. The image after application of Gaussian filter is as shown in Figures 5.(a) and (b).Mathematically, 2-D Gaussian function is written as shown in Equation 1.

$$g(x,y) = \frac{1}{2\pi\sigma^2} e^{\frac{-x^2+y^2}{2\sigma^2}} \qquad \text{------------------------------ (1)}$$


Figure, 5: (a) Original Image (b) Smoothened Image

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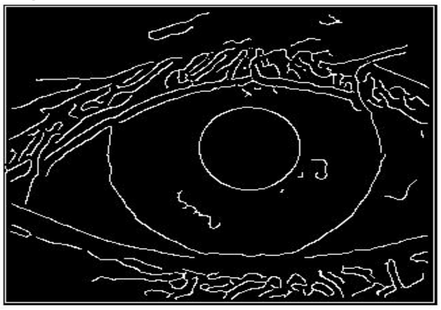
iii) IRIS and Pupil segmentation

The iris and pupil segmentation is an important step in the iris recognition system. The segmentation involves various steps to determine the iris and pupil region in the eye. The stages involved in segmentation are explained below:

- Edge Detection: The first step in pre-processing stage is to apply one of the edge detection techniques to get an edge map of the iris image so that we can determine all boundaries of the iris. An edge is a set of connected pixels that lie on the boundary between two regions in the image. The canny edge detection techniques which allowed for weighting of the gradients and use a multiple stage algorithm to detect wide range of edges are used as shown in Figure6.



Figure, 6: Canny Edge

- Gradient magnitude and angle: Gradient is a tool for finding edge strength and direction at location (x, y) of an image. Gradient is found by computing the first order derivatives by using :

Grad (im) = $[gx, gy] = [\partial_{im}/\partial_x, \partial_{im}/\partial_y]$ -----------------(2)

This is done by subtracting the pixel in the top row of neighborhood from the pixel in the bottom row, to obtain the partial derivative in x-direction. Similarly we subtract the pixel in the left column of neighborhood from the pixel in the right column, to obtain the partial derivative in y-direction. The magnitude of vector is denoted as M(x,y).

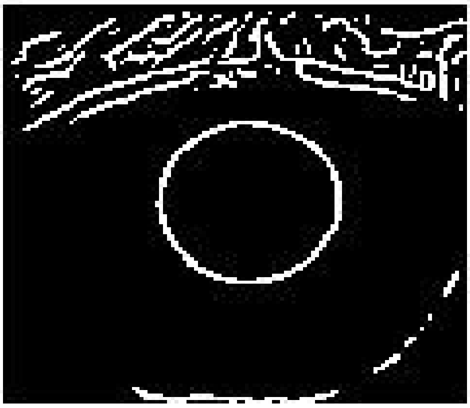
Where:

$M(x,y) = mag(grad(im)) = \sqrt{g_x^2 + g_y^2}$ ------------.(3)

The direction of gradient vector is given as

$\propto (x,y) = \arctan\left[\frac{g_y}{g_x}\right]$ ------------------------------- (4)

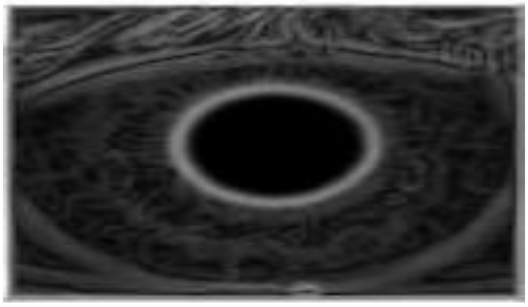
The image after canny edge applied for iris and pupil with scaling factor is as shown in Figures 7.(a) and (b).



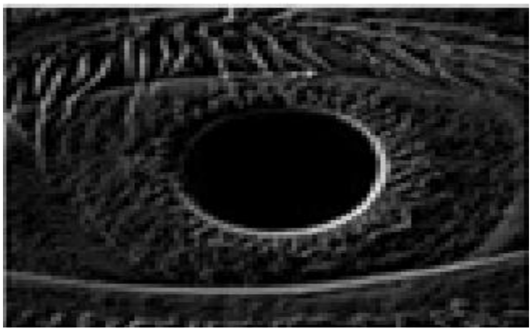
Figure,7:(a) Iris Canny Edges (scaling=0.2)

Figure 7(b):Pupil Canny Edges (scaling=0.6)

- Gamma adjustment: to perform further operations we need to enhance the contrast of the image obtained after edge detection operation. Gamma correction controls the overall brightness of an image, by varying the amount of gamma correction there will be a change in the brightness and contrast. Here the gamma value in the range 0-1 enhances the contrast of bright regions and values >1 enhances the contrast in dark. The typical value of 1.9 is assumed based on best select value to get good contrast of iris image. The images after gamma adjustment for iris and pupil are as shown in Figures 8. (a) and (b).



Figure, 8: (a) Iris Gamma Adjustment



Figure, 8: (b) Pupil Gamma Adjustment

- Hysteresis Thresholding: is a better alternative to the single static thresholding which is a dynamic thresholding method. In hysteresis thresholding we use two threshold values t_h the high threshold value and $t_l$as the lower threshold value where t_h> tl. Pixel values that are above the t_h value are immediately classified as edges. The neighboring pixel values with gradient magnitude values less than th can also be classified as edges as long as the they are above the lower threshold value tl. This process alleviates problems associated with edge discontinuities by identifying strong edges, and preserving the relevant weak edges, maintaining some level of noise

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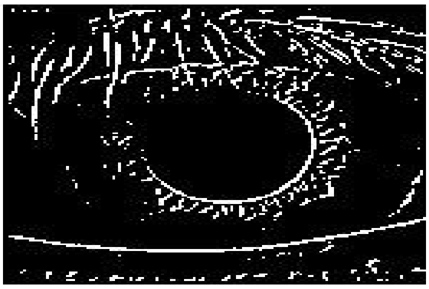
suppression. If pixel (x, y) has gradient magnitude between t_{low} and t_{high} and any of its neighbors in a 3×3 region around it have gradient magnitudes greater than t_{high}, then edge are presumed. The images after hysteresis thresholding applied to iris and pupil is as shown in Figures 9.(a) and (b).

Figure, 9: (a) Iris Hysteresis Thresholding



Figure, 9: (b)Pupil HysteresisThresholding

- ircular Hough Transform [12]: is a technique that locates shapes in images; particularly it has been used to extract lines, circles and ellipses (or conic sections). The parametric shapes in an image are detected by looking for accumulation points in the parameter space. If a particular shape is present in the image, then the mapping of all of its points into the parameter space must cluster around the parameter values which correspond to that shape. Hough transform converts a point in the x, y-plane to the parameter space, this parameter space is defined according to the shape of the object of interest. The circular Hough transform can be defined by considering the equation for a circle given by the Equations5, 6 and 7.

$r^2 = (x-a)^2 + (y-b)^2$ -------------------------------- (5)

Where,

$x = a + r\cos\theta$ --- (6)

$y = b + r\sin\theta$ --- (7)

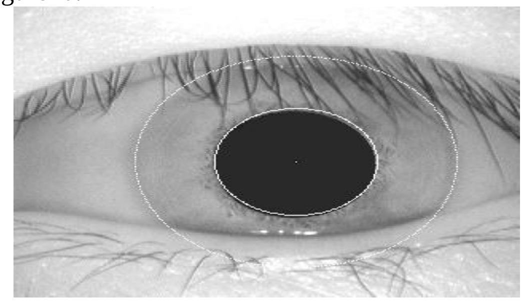
This equation defines a locus of points (x; y) centered on an origin (a, b) with radius r. This equation can again be visualized in two ways: as a locus of points (x; y) in an image, or as a locus of points (a; b) centered on (x; y) with radius r.The advantage of this representation is that it allows us to solve for the parameters.

Thus, the HT mapping is defined by Equations 8 and 9

$a = x - r\cos\theta$ --- (8)

$b = y - r\sin\theta$ --- (9)

Iris localization can be verified by drawing the circles in the image using the circle coordinates of both iris and pupil derived from the above techniques, which is shown in Figure10.

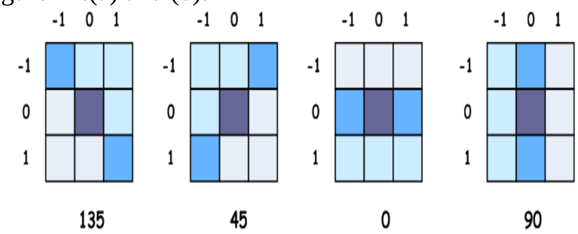


Figure, 10:Circular Hough transforms

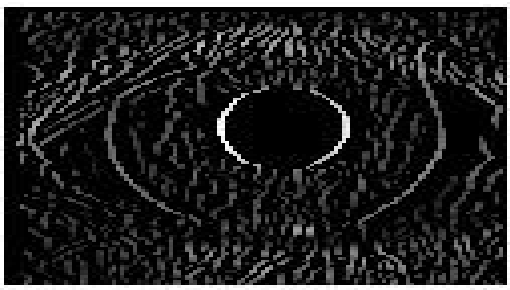
- Eyelid Detection:is used to detect lines in the image. Line on Cartesian system is denoted by the intersecting point in hough space. A straight line on Cartesian space y+mx+c can be given as below
$r = x\cos\theta + y\sin\theta$ on Hough Space.

Where,
r is the length of a normal, from the origin to this line.
θ is the orientation of r with respect to the X-axis, for any point(x, y) on this line, r and θ are constant.

- Non-maximum Suppression**:**Non-maximum suppression stage finds the local maxima in the direction of the gradient, and suppresses all others, minimizing false edges. The local maximum is found by comparing the pixel with its neighbours along the direction of the gradient. This helps to maintain the single pixel thin edges before the final thresholding stage. The comparing of pixels with its neighbour is as shown in Figure 11 which is represented in matrix form. The obtained result after applying the non-maximum suppression is as shown in Figure 12.(a) and (b).



Figure,11: Possible direction of an edge



Figure,12: (a)Iris Non Max Suppression

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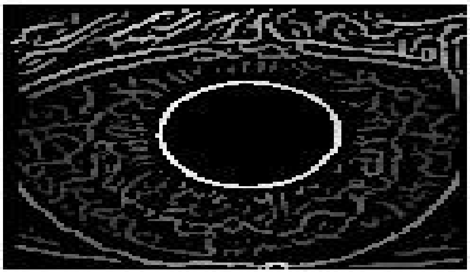


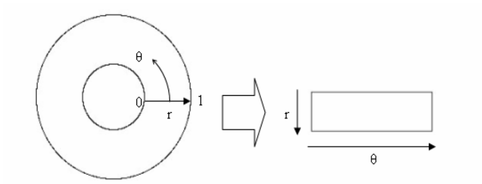
Figure, 12:(b) Pupil non max Suppression

iv) Iris Normalization

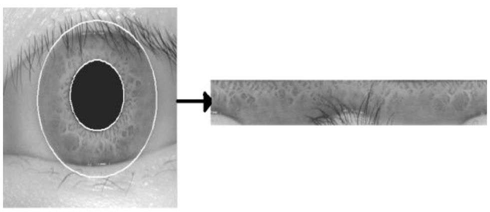
Iris of different people may be captured in different size, for the same person also size may vary because of the variation in illumination and other factors like varying imaging distance, rotation of the camera, head tilt, and rotation of the eye within the eye socket.

The purpose of iris normalization is to get the same region of iris to do matching regardless of pupil dilation, caused by varying level of illumination and the different iris size caused by the different distance between the eye and video zoom factor. Thus, the normalizations process will produce iris regions, which have the same constant dimensions, so that two photographs of the same iris under different conditions will have characteristic features at the same spatial location. The pupil region and the iris region are not always concentric which is taken into account while normalizing iris region to have constant radius. The normalization algorithm always depends on the feature vector extraction and match so that the texture on iris becomes clearer and removes the factors that will lead to error, to achieve this we are using following model

- Daugman's Rubber Sheet Model: John Daugman [11] mapped image coordinates to polar image coordinates whose angular coordinate ranges between 0-2π and the radial coordinate ranges from the iris inner boundary to its outer boundary as a unit interval which is known as the rubber sheet model. The rubber sheet model re-maps each point within the iris region to a pair of polar coordinates (r,θ) where r is on the interval [0,1] and θ is on the interval [0, 2θ] as shown in the figure below in Figure 13.(a) and (b).



Figure, 13: (a) Daugman's Rubber Sheet Mode



Figure, 13 (b):Normalized Iris template

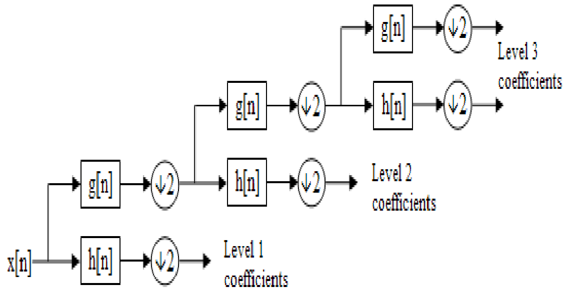
v) Feature Extraction

The main purpose of 2 level feature selection and extraction [12] is to find out the important features to perform matching. We know that the visible features of an iris are ciliary processes, contraction furrows, crypts, rings, cornea, and freckles and so on. To set a model to extract the feature of different irises and match them is especially important for it determines the results of the whole system directly. A feature vector is formed which consists of the ordered sequence of features extracted from the various representations of the iris images which will be accomplished using wavelet. Consider the transform that replaces the original sequence with its pair wise average X_{n-1}, i and difference d_{n-1}, i defined in Equations 10 and 11.

$$X_{n-1,i}=\frac{X_{n,2i}+X_{n,2i+1}}{2} \qquad \text{-------------------------------- (10)}$$

$$d_{n-1,i}=\frac{X_{N,2i}-X_{n,2i+1}}{2} \qquad \text{------------------------------- (11)}$$

The above two equations implements the Forward Discrete Wavelet Transform or just Discrete Wavelet Transform (DWT) of the Haar- wavelet transform as shown in Figure 14.



Figure,14: 2-Level DWT

vi) Template Matching

Matching process requires a threshold value to decide whether the iris is of an authenticated user or an imposter. A separation or threshold value of pairwise distance value can be chosen which allows a decision to be made when comparing two templates. If the pairwise distance between two templates is less than the threshold, the templates were generated from the same iris and a match is found. Otherwise if the pairwise distance is greater than the threshold the two templates are considered to have been generated from different irises. Pairwise distance: Matching is done using pairwise distance (Pdist) which computes the Euclidean distance between pairs of objects in data matrix.

The Euclidean distance or Euclidean metric is the ordinary distance between two points that one would measure with a ruler, and is given by the Pythagorean formula. By using this formula as distance, Euclidean space becomes a metric space. The position of a point in a Euclidean n-space is a Euclidean vector where p and q are Euclidean vectors, starting from the origin of the space, and their tips indicate two points. In general, for an n-dimensional space, the distance can be calculated using Equation 12.

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$$d(p,q)=\sqrt{(p_1-q_1)^2+(p_2-q_2)^2+\cdots+(p_i-q_i)^2+\cdots(p_m-q_m)^2} \quad (12)$$

B. Performance Parameters

The False Reject Rate (FRR), False Accept Rate (FAR) are the two error metrics that are been used to measure the success of the matching rate. The performance metrics used is the Total Successive Rate (TSR) And Equal Error Rate (EER). The TSR is the measure of number of persons correctly matched from the set of data base. The EER is the point at which the likelihood of FAR and FRR are the same. The FRR, also known as Type I error, which measures the probability of an enrolled individual not being identified by the system. The FAR, also known as Type II error, measures the probability of an individual being wrongly identified as another individual. To calculate FAR, FRR, TSR and EER 13, 14, 15 Equations are used.

$$\text{FAR}=\frac{\text{Number of Unauthorized Persons Accepted}}{\text{Person Not In Database}}*100\text{--------} \ (13)$$

$$\text{FRR}=\frac{\text{Nnumber of authorized person rejected}}{\text{Person Not In Database}}*100 \text{-----} \ (14)$$

$$\text{TSR}=\frac{\text{Number of Person Correctly Matched}}{\text{Number of Person In The Database}}*100\text{----------} \ (15)$$

Equal Error Rate is obtained by :
Intersection between FAR and FRR as shown in graph .

IV. ALGORITHM

Problem definition: The biometric iris recognition is verified using two levels DWT with pair wise matching are proposed to identify the iris in the data base.

The objectives:

- The iris recognition using pair wise distance, this computes the Euclidean distance.
- Reduce the value of FAR, FRR AND EER.
- Increasing the TSR thus increasing the overall efficiency.

The algorithm is to verify a person using DWT and matching the results in the data base using pairwise distance technique is given in the Table I

TABLE I: Algorithm

- Input : iris database, test iris image
- Output : match/mismatch iris image

1) Read iris image from CASIA database.
2) Resize the iris images to obtain uniform image size for preprocessing.
3) Applying Gaussian smoothening to remove the noise from the resized image.
4) Applying canny edge detection to obtain the edges of the image.
5) Removing the unwanted edges using hysteresis thresholding.
6) Obtaining the circles on iris and pupil using circular Hough transform for normalization process.
7) Repeating the procedure for removing eyelid and eye lashes.
8) Then applying Daugman's rubber sheet model for normalization process, which remaps each points within the iris region to a pair of polar coordinates.
9) Apply 2-level DWT for the normalized image and consider only LL sub band for matching process.
10) Matching of iris is performed using pairwise distance matching which in turns computes Euclidean distance between pairs of objects.

V. RESULTS AND PERFORMANCE ANALYSIS

For performance analysis we have used available database such as CASIA. The CASIA database contains a total of 756 iris images from more than 108 subjects. To evaluate FRR and FAR, 20 persons with 6image samples per person are considered to create database and one image per person is used as test image.

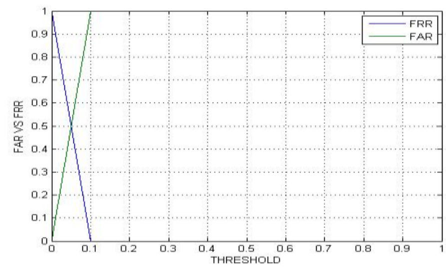
The performance of iris recognition rate of the proposed algorithm is compared with other iris recognition techniques in Table II.

TABLE II. Comparison Table

Sl.No.	Author	Technique	EER%	Efficiency /recognition rate
1	Mayank Vatsa et.al	2V-svm fusion with indexing		97.21%
2	Hanene Guesmj et.al	Bias-Corrected Fuzzy C-Mean (BCFCM) and iris segmentation based on the active contours "Snake".	0.77	99.07%
3	Afsana Ahamed and Mohammed Imamul Hassan Bhuiyan	iris recognition is done using curvelet transform, matching is done employing the correlation Coefficient.	0.72	99.3%
4	Ajay Kumar et.al	sparse representation of local orientation feature	0.71	99.01%
5	Asama Kuder Nsaef et. al	Daugman's Integro-Differential Operator, matching using hamming distance		98.76%
6	Gundeep Singh Bindra et .al	2D-wavelet transforms. using sobel edge detection, matching Euclidean distance	1.67	92.82%
7	Proposed Work	Two level DWT, canny edge detection, matching is done using pairwise distance technique which is computed in Euclidian distance	0.4	93.57

From the above stated tables we can say that the proposed method has a better efficiency in terms of EER as compared to the existing methods.

The ROC graph of FAR AND FRR Vs threshold is as shown below in Figure 15.



Figure, 15: FAR and FRR vs Threshold

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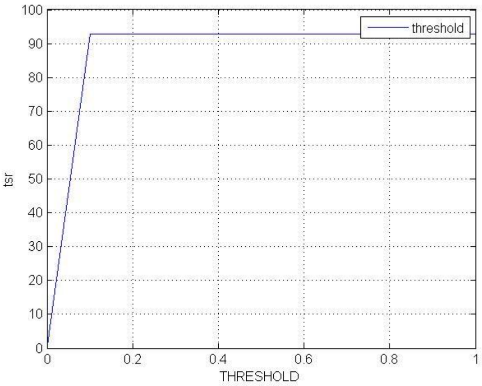
The efficiency or recognition rate TSR graph is as shown below in Figure 16.



Figure, 16:TSR vs Threshold

VI. CONCLUSION

The current study revealed that that the proposed technique was successful in obtaining higher TSR and better EER values. The FAR and FRR values are reduced. This has been achieved as the proposed method uses two level DWT techniques, which gives a better transform results and the matching process is implemented using Pairwise distance which computes the Euclidean distance between pairs of objects in data matrix. To conclude, the study was limited to certain aspects, and several useful aspects have been suggested in this study as to carry out future research in this area.

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