EFFICIENT IRIS RECOGNITION ALGORITHM USING METHOD OF MOMENTS

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ABSTRACT

This paper presents an efficient biometric algorithm for iris recognition using Fast Fourier Transform and moments. Biometric system provides automatic identification of an individual based on a unique feature or characteristic possessed by the individual. The Fast Fourier Transform converts image from spatial domain to frequency domain and also filters noise in the image giving more precise information. Moments are area descriptors used to characterize the shape and size of the image. The moments values are invariant to scale and orientation of the object under study, also insensitive to rotation and scale transformation. At last Euclidean distance formula is used for image matching.

The CASIA database clearly demonstrates an efficient method for Biometrics. As per experimental result,the algorithm is achieving higher Correct Recognition Rate.

KEYWORDS

Biometrics, Fast Fourier Transform, Normalized moments, Euclidean distance formula, Correct Recognition Rate.

1. INTRODUCTION

Biometric authentication has been receiving extensive attention over the past decade with increasing demands in automated personal identification. Among many biometrics techniques, iris recognition is one of the most promising approaches due to its high reliability for personal identification [1–8].

Automated iris recognition is noninvasive unique and highly robust method for verification and identification of people. Interestingly, the spatial patterns that are apparent in the human iris are highly distinctive to an individual [13], [14] (see, Fig. 2). The iris is an overt body that is available for remote (i.e., noninvasive) assessment.

A major approach for iris recognition today is to generate feature vectors corresponding to individual iris images and to perform iris matching based on some distance metrics [3–6]. Most of the commercial iris recognition systems implement a famous algorithm using iris codes proposed by Daugman [3]. One of the difficult problems in feature-based iris recognition is that the matching performance is significantly influenced by many parameters in feature extraction

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process (eg., spatial position, orientation, center frequencies and size parameters for 2D Gabor filter kernel), which may vary depending on environmental factors of iris image acquisition. Given a set of test iris images, extensive parameter optimization is required to achieve higher Recognition Rate.

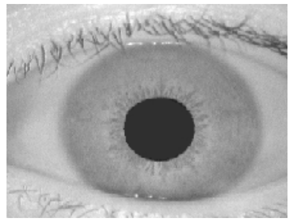
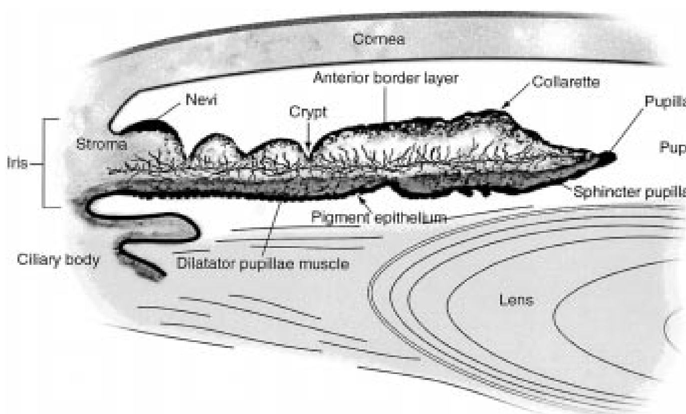
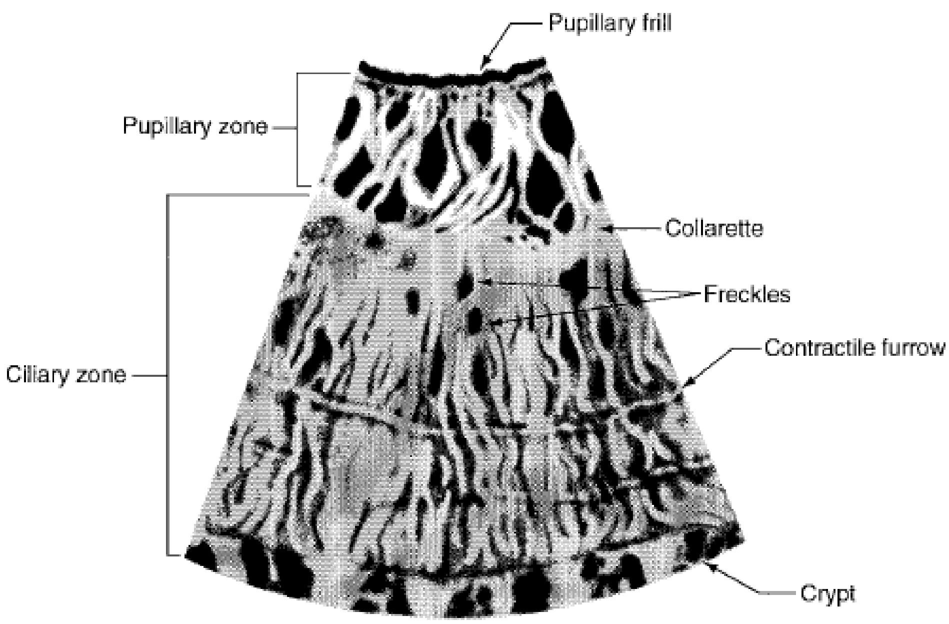


Fig .1 Eye image captured from high resolution camera



(a) The structure of the iris seen in transverse section.



(b) The structure of the iris seen in a frontal sector. The visual appearance of the human iris derives from its anatomical structure

Fig. 2 Anatomy of human iris[13]

Addressing the above problem, as one of the algorithms which compares iris images directly without encoding [7, 8], this paper presents an efficient algorithm using FFT,and normalized Moment. The technique can be successfully applied to high accuracy image registration tasks for computer vision applications [9–11]. The use of Fourier frequency information of iris images makes possible to achieve highly robust iris recognition in a unified fashion with a simple matching Technique.

Experimental performance evaluation using the CASIA iris image database ver. 1.0 and ver. 2.0 [12] clearly demonstrates an efficient matching performance of the proposed algorithm. The technique of present work is shown in algorithmic form in figure .3.

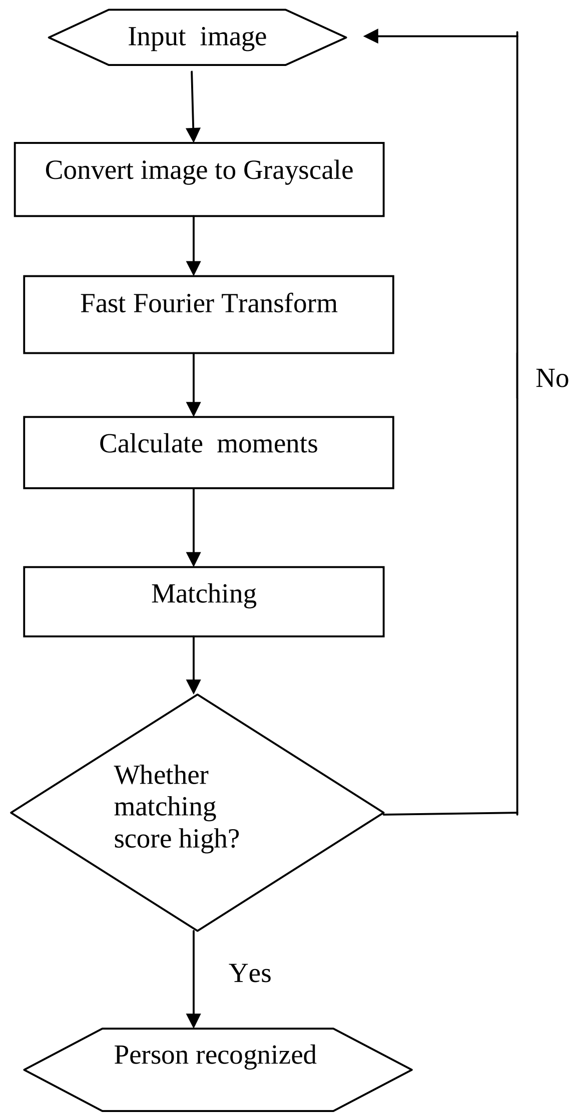


Fig. 3 Algorithm for iris matching

2 FAST FOURIER TRANSFORM

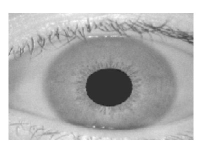
Fourier Transform decomposes an image into its real and imaginary components which is a representation of the image in the frequency domain[17] . If the input signal is an image then the number of frequencies in the frequency domain is equal to the number of pixels in the image or spatial domain. The Fourier Transform is named in honour of Jean Baptiste Joseph Fourier, a French mathematician of the late eighteenth and early nineteenth centuries, born in 1768[18].

Fourier transform provides a powerful alternative to linear spatial filtering. For a large filter it would be more efficient to use fourier transform. Fourier transform allow to isolate and process particular image frequencies and thus to perform low-pass filtering with a great degree of precision.

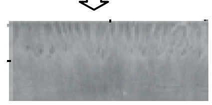
The working of fourier transform can be studied as analogous to working of a prism. White light is passed through a prism, the prism splits white light into separate colours (wavelengths).What the prism does to light, the fourier transform does to signals. So fourier transform is all about splitting signals into its component signals, so that analysis, different operations and comparisons can be done. Fourier transform states that any function that periodically repeats itself can be expressed as the sum of sine and cosine of different frequencies and different amplitudes.

Y = fft(X) in Matlab returns the discrete Fourier transform (DFT) of vector X , computed with a fast Fourier transform (FFT) algorithm.

Fast Fourier Transform is applied to convert an image from the image (spatial) domain to the frequency domain. The advantage of representing an image in the frequency space is that performing many operations on the frequencies is much more efficient than doing the same in the spatial image. Many of the convolutions are just multiplications in the frequency domain. FFT have the advantage of high speed over DFT. Also the complexity of DFT is $O(N^2)$ while complexity of FFT is only $O(N \log N)$. FFT works recursively by dividing the original vector into two halves, computing the FFT of each half, and putting the result together. FFT is most efficient when the vector length is a power of two.



(a) eye image



(b) Part of iris in eye image in spatial domain

FFT

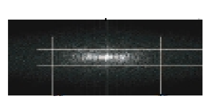


Fig . 4 (c) The above image in frequency domain after taking FFT

3 MOMENTS

Moments are area descriptors used to characterize the shape and size of the image. In method of moments, a sequence of numbers is computed, this sequence is called moments. These moments identify the shape of the object such as area, centroid, moment of inertia, orientation etc.

Image f(x,y) is taken as object and grey level of pixel is considered as the mass at a point of the object. For an N*N image, the (i,j)th moment of the image f(x,y) is defined as :

$$m(i,j) = \sum_x \sum_y x^i y^j f(x,y)$$

Now $m(0,0) = \sum_x \sum_y x^0 y^0 f(x,y) = \sum_x \sum_y f(x,y)$

The m(0,0) is the zeroth order moment .The moment m(0,0) is the mass of the object

Similarly, $m(1,0) = \sum_x \sum_y x^1 y^0 f(x,y) = \sum_x \sum_y x f(x,y)$, and $m(0,1) = \sum_x \sum_y y f(x,y)$
m(0,1) and m(1,0) are first order moments .

Any region-based feature requires a datum point from which further features can be derived. The centroid which is the center of area, (the center of mass) is a good parameter for specifying the location of the object.

If the coordinates of the centroid be x′ and y′ such that the sum of square of the distance from this point to all other boundary points within the object is minimum.

Here, $x' = m(1,0)/ m(0,0)$ and $y' = m(0,1)/ m(0,0)$
Moments m(2,0) and m(0,2) are the moments of inertia of the object:

$$m(2,0) = \sum_x \sum_y x^2 f(x,y)$$
$$m(0,2) = \sum_x \sum_y y^2 f(x,y)$$

These basic moments are limited in their usefulness since they vary according to their position with respect to the origin, the scale and orientation of the object under study. The invariant moments are the central moment μ , in terms of its centroid.

$$\mu(i,j) = \sum_x \sum_y (x-x')^i (y-y')^j f(x,y)$$

These central moments are still sensitive to rotation and scale transformation.
The normalized central moments η are given by :

$$\eta(i,j) = \mu(i,j)/(\mu(0,0))^\lambda = \mu_{ij}/ \mu_{00}{}^\lambda$$
Where $\lambda = (i + j)/2 + 1$ and $i + j \geq 2$

Orientation of any object is defined as the angle of the axis of the minimized moment of inertia and is given by

$$\theta = 1/2 \tan^{-1} [2 \mu(1,1)/ \mu(2,0) - \mu(0,2)]$$

Due to the above relation first-order moments are always invariant [18].

3 MATCHING

The extracted features of the eye are compared with the eye images in the database by Euclidean distance formula.[16]

Euclidean Distance: The Euclidean distance is one way of defining the closeness of match between two iris feature templates. It is calculated by measuring the normal between two moment vectors. X2 and X1 are x-axis moment values and Y2 and Y1 are y-axis moment values.

$D = Sqrt\{ (X2-X1)^2 + (Y2-Y1)^2\}$

4 RESULT

4.1. Algorithm :

The database of eye images is taken from CASIA database. For showing result ten images are taken from the huge database. The algorithm is implemented in Matlab.

(1) First step is to input the image.
(2) In next step the Matlab code changes the image to grayscale.
(4) Then code computes the FFT point sequences for the image.
(5) Next step calculates the all the possible sets of normalized moment of FFT point sequence.
(6) Input other images for making Database.(we have taken 10 images).
(6) Input an image for matching.
(7) The match is found by Euclidean Distance Formula giving lowest distance.
(8) Repeat step 6.

All the 10 images are recognized and the recognition rate is approximately 100%.

4.2. Results

Matching result from CASIA Iris Database Ver.1 has been obtained which is shown in the table given below:

User/ Image No.	Moment values	Moment values during matching	Difference in moment values in matching	Matching
1.	328960	328963	3	yes
3.	617640	617645	5	yes
2.	472460	472435	5	yes
4.	512140	512144	4	yes
5.	300710	300712	2	yes
6.	373450	373448	2	yes
7.	628940	628937	7	yes
8.	417830	417829	1	yes
9.	347310	347311	1	yes
10.	675000	675003	3	yes

Table.1.Iris matching results from CASIA iris Database Ver.1

Number of images taken for matching – 10,Number of images correctly matched - 10 Correct Recognition rate – Since all the images are correctly recognized and the matching difference is very small, the Correct Recognition rate can be approximated to 100%.The above result have been evaluated with database having single image of an eye of a particular person. The images are correctly recognized. Each of the eye images belong to different persons.The images are taken from CASIA (Chinese Academy of Sciences' Institute of Automation) Version1 iris database .

Next results are taken for eye images having two templates of the eye of a single person. In this case also all the persons are recognized. One of the template of eye of each person is stored and other template is matched. The match is found for the stored template giving lowest matching difference with the matched template. All the eye images are correctly recognized . The images are taken from CASIA (Chinese Academy of Sciences' Institute of Automation) Version2 iris database.

Matching result from Ver.2 has been obtained which is shown in the table given below:

User/ No.	**Moment values**	**Moment value of matching template**	**Difference in moment values in matching**	**Matching**
1.	218190	230670	12480	yes
2.	285362	288463	3101	yes
3.	428990	414946	14044	yes
4.	341575	341361	214	yes
5.	370868	376950	6082	yes
6.	311104	307009	4095	yes
7.	258448	257064	1348	yes
8.	298511	296617	1894	yes
9.	329052	335228	6178	yes
10.	276713	277682	969	yes

Table.2. Iris matching results from CASIA iris Database Ver.2

Number of images taken for matching – 10,Number of images correctly matched - 10 Correct Recognition rate – Since all the images are correctly recognized and the matching difference is very small, the Correct Recognition rate can be approximated to 100%. The eye images have been taken from CASIA iris database version2.

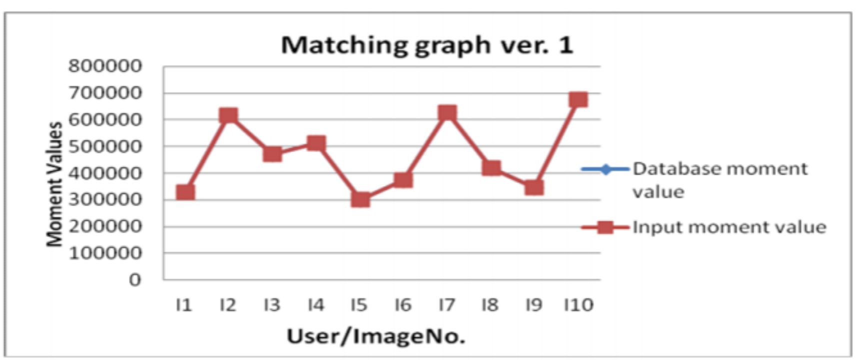


Fig .5.Graph showing results from CASIA iris Database Ver.1

Fig . 5 is showing matching results in graphical form. The line of database moment values and matching/input moment values are just coinciding, revealing higher Correct Recognition Rates (100%).,The differences are quiet small. This is according to table.1.

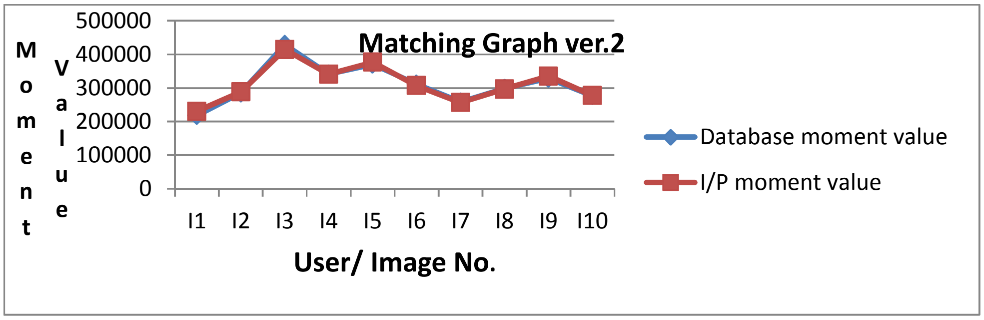


Fig.6. Graph showing results from CASIA iris Database Ver.

Fig. 6 shows showing matching results in graphical form. The line of database moment values and matching/input moment values are just coinciding, revealing higher Correct Recognition Rates (100%).,The differences are quiet small. This is according to table.2

4.3. Comparison of Methods

Serial No.(a)	Method (b)	Recognition Rate% (c)	Equal Error Rate% (d)
1.	Boles [5]	92.64%	8.13%
2.	Daugman [3]	100%	0.08%
3.	Tan [19]	99.19%	0.57%
4.	Moment method (present work)	100%	0.0032%&0.58%
5.	Characterizing key local variables[4]	100%	0.07%

Table.3.Comparison of available Iris Recognition Algorithms [4]

The table given above shows the comparison of different important types of Iris Recognition method developed by various persons. Present work showing improvement in results over earlier existing methods.

4.4. Important Terms

Equal Error Rate (EER) shown in table.3(d) is the rate at which both accept (FAR) and reject errors (FRR) are equal.When quick comparison of two systems is required, the ERR is commonly used . EER is obtained from the ROC(relative operating curve) plot by taking the point where FAR and FRR have the same value. ROC is the relative operating characteristic. The lower the EER, the more accurate the system is considered to be.

False Accept Rate(FAR) or False Match Rate (MAR) is the probability that the system incorrectly declares a successful match between the input pattern and a non matching pattern in the database. It measures the percent of invalid matches. These systems are critical since they are commonly used to forbid certain actions by disallowed people. False Reject Rate (FRR) or False Non-Match Rate (FNMR) is the probability that the system incorrectly declares failure of match between the input pattern and the matching template in the database. It measures the percent of valid inputs being rejected.

Relative Operating Characteristic (ROC): In general, the matching algorithm performs a decision using some parameters (e.g. a threshold). In biometric systems the FAR and FRR can typically be traded off against each other by changing those parameters. The ROC plot is obtained by graphing the values of FAR and FRR, changing the variables implicitly.[20]

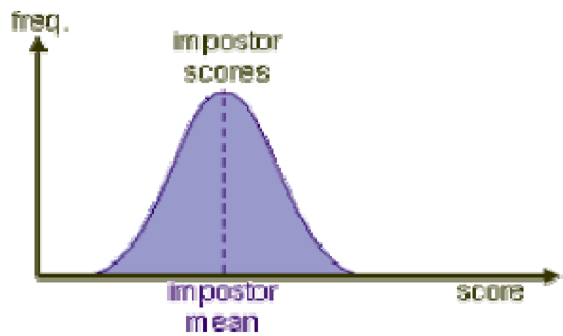


Fig.7(a) Impostor distribution

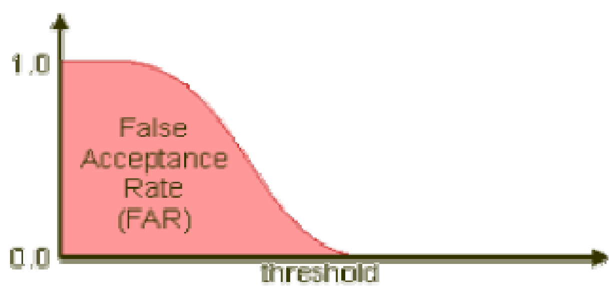


Fig.7(b)Values of FAR for Fig.7(a)

Think of a biometric verification system, which is tested with a large amount of test data. The test data consists of both impostor and client patterns. Let's first take a look at the impostor patterns. The belonging scores would be somehow distributed around a certain mean score. This is depicted in the first image in Fig . 7(a). A gaussian normal distribution is chosen in this image.
Depending on the choice of the classification threshold, between all and none of the impostor patterns are falsely accepted by the system. The threshold depending fraction of the falsely accepted patterns divided by the number of all impostor patterns is the False Acceptance Rate (FAR). Its value is one, if all impostor patterns are falsely accepted and zero, if none of the impostor patterns is accepted.

In Fig . 7(b) to see the values of the FAR for the score distribution of image Fig. 7(a) for varying threshold.

Now considering client pattern, a classification threshold that is too high is applied to the classification scores, some of the client patterns are falsely rejected. Depending on the value of the threshold, between none and all of the client patterns will be falsely rejected. The fraction of the number of rejected client patterns divided by the total number of client patterns gives the False Rejection Rate (FRR). According to the FAR, its value lies in between zero and one. The image of Fig .8(b) given below shows the FAR for a varying threshold for the score distribution shown in the image of Fig . 8(a).

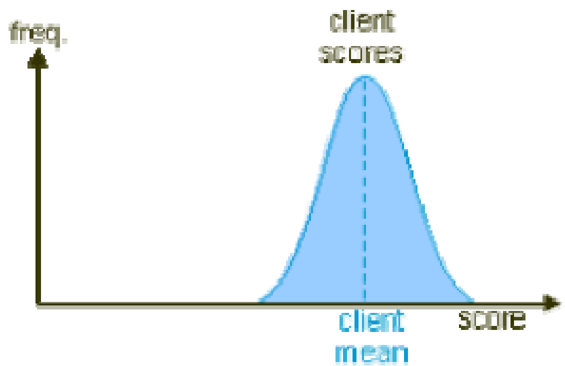


Fig . 8(a)Client pattern-Gaussian Distribution

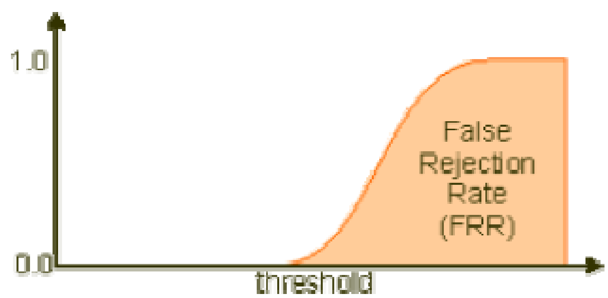


Fig . 8(b) FRR distribution for distribution of Fig.8(a)

The choice of the threshold value becomes a problem if the distributions of the client and the impostor scores overlap, as shown in the next image of Figure 9(a). In the Fig ure 9(b) corresponding false acceptance and false rejection rates are displayed. When the score distributions overlap, the FAR and FRR intersect at a certain point. The value of the FAR and the FRR at this point, which is of course the same for both of them, is the Equal Error Rate (EER). It is shown in Figure 9(b). [21]The above mentioned FAR, FRR and EER are calculated by exhaustive matching. Approxima- tely 1000 images were matched during experiment. Then these rates are obtained.

EER of present method is mentioned Table. 3.

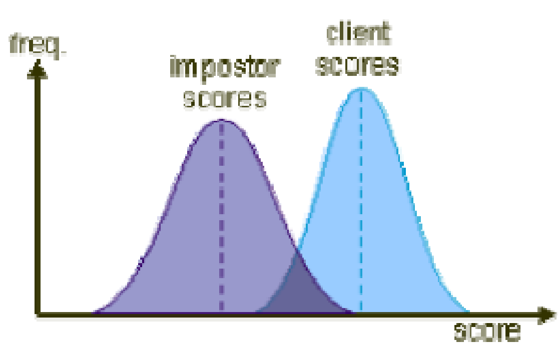


Fig .9(a) Impostor and client Gaussian Distribution

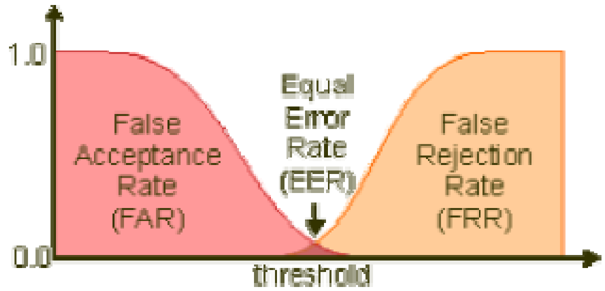
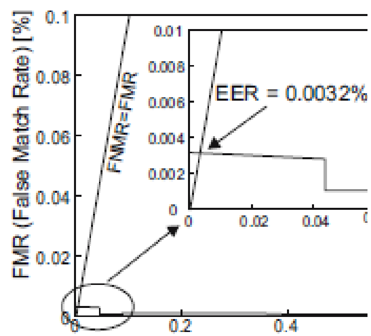


Fig. 9(b) EER in between FAR and FRR according to Fig.9(a)



FNMR or FRR(False non-match rate)[%] →

Fig . 10 (a) EER for CASIA Iris Database version. 1.0

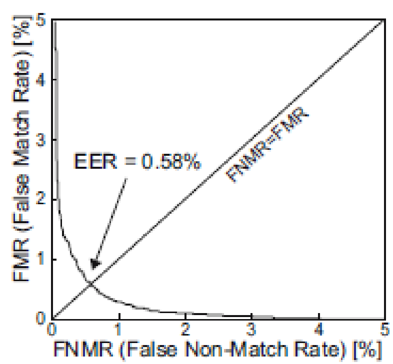


Fig . 10(b) EER for CASIA Iris Database Version. 2.0

Fig . 10- ROC curve and EER: (a) CASIA iris image database ver. 1.0, and (b) ver. 2.0.

The above two figures shows the relative operating curve(ROC) and equal error rate (EER) based on experimental analysis.

4.4 Observations

During experimentation following points were observed:

1.) Intensity of light in room of image capturing and camera be kept constant.
2.) The distance between capturing camera and person be kept constant.
3.) Images of bigger eye gives higher moment values.

4.) The Correct Recognition Rate is 100%.
5.) If Brightness of capturing camera is increased or decreased the moment values will change for a particular image.

5. CONCLUSIONS

A biometric system provides automatic identification of an individual based on a unique feature or characteristic possessed by the individual .Iris recognition is regarded as the most reliable and accurate biometric identification system available.

An efficient and novel Biometric algorithm is developed in this work using Fast Fourier Transform and calculating all possible sets of Normalized Moment.FFT converting image to Frequency domain and filtering noise, then moments are calculated which are invariant to rotation and scale transformation .At last Euclidean Distance is used for matching. However, results have been produced under favourable conditions, and there have been no independent trials of the method.

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