A BIOMETRIC APPROACH OF IRIS RECOGNITION BASED ON ORDINAL MEASURE OF DCT-COEFFICIENTS

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Abstract

Iris recognition is one of the most accurate identity verification system. In this paper we have implemented a simple but very effective method for iris recognition based on Discrete Cosine Transform. Here firstly the iris image is preprocessed and segmented. After preprocessing, the segmented image is normalized is order to overcome the dimensional inconsistencies then further processed for feature extraction. This is done by finding the two dimensional Discrete Cosine Transform of the normalized iris image, where the normalized image is divided into 8x8 blocks. The transformed image contains the unique features of the iris embedded in it. This key feature is then matched using simple matching measure such as minkowski distance metric. The proposed approach has been tested on publicly available CASIA Version1-database which contains 756 iris images, i.e. 7 images each of 108 persons. An accuracy of 87% with an reduced FAR of about 0.120 and FRR of about 0.142 has been achieved with this method.

Key Words- *iris recognition , Segmentation, Hough, accuracy*.

1. INTRODUCTION

Biometrics is an emerging field of information technology which aims to automatically identify individuals using their unique biological traits[1-2]. By measuring the physiological and behavioural characteristics using the individual's biological samples, it has been shown that information characteristics of each individual can be extracted in order to verify the identity of that individual in a population. The biometrics has become hot topic in recent years, Among various biometrics, such as fingerprint, facial features, voice, signature etc. Iris recognition has proved to be an emerging security and authentication tool to determine the individual identity. Iris is the internal body organ that is very much visible from outside world but well protected from external threats. It has the unique features which remains same from birth to death. Two eyes from the same individuals although are very similar contain unique patterns. These unique characteristic is used as a biometric feature to identify individuals.

Typical iris recognition system consists of mainly four modules. They are image acquisition, segmentation, normalization and feature extraction and matching. Image acquisition is a module which involves the capturing of iris images with the help of sensors. Pre-processing module provides the determination of the boundary of iris within the eye image, and then extracts the iris portion from the image in order to facilitate its processing. It involves the stages like iris segmentation, iris normalization, image enhancement etc. The performance of the system has been analyzed in the feature extraction and matching stage. The eyelids, eyelashes and specular reflections can occur within the iris region that corrupts the iris pattern. So preprocessing is required to isolate and exclude these corruptions as well as locating the circular iris region. All these stages involve their own developments. The major improvements have been made in the field of iris segmentation, which is very much important in the area of iris recognition.

The normalization stage is to transform the iris region into fixed dimensions in order to allow comparisons. For the accurate and robust recognition of individuals, the most discriminating information present in an individual's iris pattern must be extracted and compared. In feature extraction only the significant features of the iris must be encoded so that comparisons between templates can be made. The unique features are extracted and encode it into a biometric template, which can be stored in a database. This biometric template contains an objective mathematical representation of the unique information stored in the iris, and allows comparisons to be made between templates. When a person is to be identified by iris recognition system, his eye is first photographed, and then a template created for the iris region. This template is then compared with the other templates stored in a data base until a matching template is found and the person is identified. If no match is found the person remains unidentified.

2. RELATED WORK

2.1 Literature review

In this section, we are discussing briefly about the earlier approaches which have been carried out in the field of iris detection. Segmentation technique in iris recognition detects the inner and outer boundaries of iris. The inner and outer boundaries of iris have been approximated as circles. The centre, radius of iris and pupil is then determined.

Daugman integro differential operator approach [3] is regarded as one of the most cited approach in the survey of iris recognition. It finds both inner and the outer boundaries of the iris region. the parameters such as the center and radius of the circular boundaries are being searched in the three dimensional parametric space in order to maximize the evaluation functions involved in the model.

Hough transform is a standard computer vision algorithm used to determine the geometrical parameters [4] in an image such as lines or circles. In this method an edge map is generated by calculating the first derivatives of intensity values in an eye image and then thresholding the result. From the edge map, votes are cast in hough space for the parameters of circles passing through each edge point. these parameters are the centre coordinates and the radius which are sufficient to describe any circle.

Masek introduced an open iris recognition system [5] for the verification of human iris uniqueness and also its performance as the biometrics. The iris recognition system consists of an automated segmentation system, which localise the iris region from an eye image and also isolate the eyelid, eyelash as well as the reflection regions. This automatic segmentation was achieved through the utilization of the circular Hough transform in order to localise the iris as well as the pupil regions, and the linear Hough transform has been used for localising the eyelid occlusion. Thresholding has been employed for isolating the eyelashes and reflections.

Fuzzy clustering algorithm is a new iris segmentation approach, which has a robust performance in the attendance of heterogeneous as well as noisy images. the process starts with the image-feature extraction where three discrete i.e., (x, y) which corresponds to the pixel position, and z which corresponds to its intensity values has got extracted for each and every image pixel, which is followed by the application of a clustering algorithm which is the fuzzy k-means algorithm[6]. This has been used in order to classify each and every pixel and then generate the intermediate image. This correspondent image is then used by the edge-detector algorithm as it has additional homogeneous characteristics, This eases the tuning of the parameters which were needed by the edge-detector algorithm. The main advantage of this method is that, it provides a better segmentation for non co-operative iris recognition. Segmentation approach based on fourier spectral density[7] for noisy frontal view iris images which is captured with minimum cooperation , has been proposed in this paper. this approach computes the fourier spectral density for each pixel with the aid of its neighborhood and then executes row-wise adaptive thresholding, and thus results in a binary image which gives the iris region in a fairly accurate manner. This segmentation method can also be used in order to calculate limbic as well as the pupil boundaries.

2.2 Outline of the work

The aim of this paper is to propose a method for iris detection using image processing techniques. There are five major stages of iris recognition namely pre processing, iris Localization (segmentation), iris Normalization, Feature Extraction and matching as shown in figure

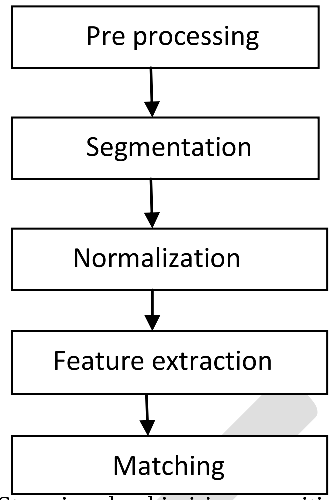


Fig1: Steps involved in iris recognition system

Firstly, the work was carried over to segment iris region by means of circular hough transform ,followed by normalization and feature extraction and matching method by means of minkowski distance metric.

DISCRETE COSINE TRANSFORM

The mathematical theory of linear transforms plays a very important role in the signal and image processing area. They generate a set of coefficients from which it is possible to restore the original samples of the signal. In many situations, a mathematical operation – generally known as a transform – is applied to a signal that is being processed, converting it to the frequency domain. With the signal in the frequency domain, it is processed and, finally, converted back to the original domain. A mathematical transform has an important property: when applied to a signal, i.e., they have the ability to generate decorrelated coefficients, concentrating most of the signal's energy in a reduced number of coefficients. The Discrete Cosine Transform (DCT) is an invertible linear transform that can express a finite sequence of data points in terms of a sum of cosine functions oscillating at different frequencies. The original signal is converted to the frequency domain by applying the direct DCT transform and it is possible to convert back the transformed signal to the original domain by applying the inverse DCT transform. After the original signal has been transformed, its DCT coefficients reflect the importance of the frequencies that are present in it. The very first coefficient refers to the signal's lowest frequency, known as the DC-coefficient, and usually carries the majority of the relevant information from the original signal. The last coefficient refers to the signal's higher frequencies. These higher frequencies generally represent more detailed or fine information of signal and probably have been caused by noise. The rest of the coefficients carry different information levels of the original signal. In the image processing field, it is interesting to use a two-dimensional DCT (2D-DCT), because images are intrinsically two-dimensional elements.

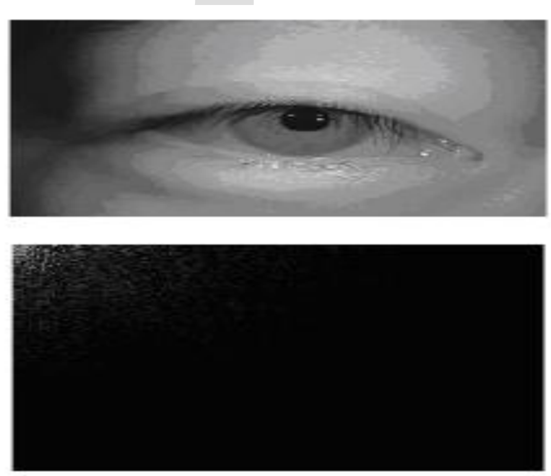


Fig2(a) Original image. (b)Normalized DCT image of the person

Figure2 shows the application of the DCT on one of the eye images Figure 2.a displays the original image, and Figure 1.b displays the result of applying the DCT on the original image. At Figure 2.b, it is possible to verify that most of the image's energy is concentrated in the upper left corner. This is the region that represents the DCT lowest frequency coefficients. The 2D-DCT used in this work is the DCT-II. The DCT-II definition is shown in Equations (1) and (2). In this context, the original image is the gray-scale matrix x[m,n], with dimensions m by n, that represents the image. The DCT-II computation then produces a matrix X[k,l], also with dimensions m by n, of coefficients. The variables m and n are the coordinates in the space domain and k and l are the coordinates in the frequency domain.

$$X[k,l] = \frac{2}{N} ckcl \sum_{m=0}^{a-1}\sum_{n=0}^{b-1} x[m,n] \cos\left[\frac{(2m+1)k\pi}{2N}\right] \cos\left[\frac{(2m+1)l\pi}{2N}\right] \quad (1)$$

Where,in equation(1):

$$ck, cl = \begin{cases} \left(\frac{1}{2}\right) to k = 0, l = 0 \\ 1 to k = 1,2,...a-1 and l = 1,2,..b-1 \end{cases} \quad (2)$$

The first coefficient, X[0,0], is referred as the DC(Direct Current) coefficient and depends only on the average brightness of the image. The other coefficients are known as AC (Alternate Current) factors. In this paper, the DCT used is always the 2D-DCT so, from now on, the term DCT actually means the 2D-DCT.

3. PROPOSED METHOD

The proposed method adopts Hough transform method for iris localization and daugman's rubber sheet model method for iris image normalization.The approach followed in features extraction is different from conventional method of features extraction and matching. This method involves transforming segmented Iris image using DCT transforms and ordinal measure of DCT coefficients i.e., DCT coefficients of normalized iris images is computed (for both database and query images). Then absolute value of AC coefficients was ordered in ascendant manner to obtain the ordinal measure. Distance between those images was measured by Minkowsky distance metrics. The match is obtained with the image of the lowest distance

3.1 Flowchart of the Proposed Work

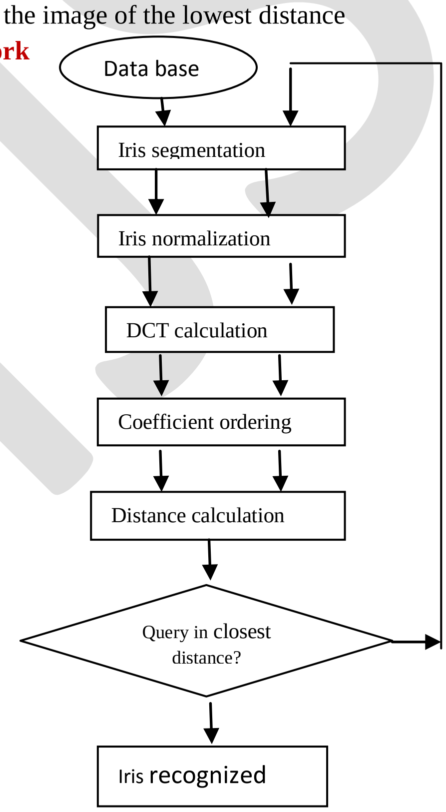


Fig 3: Proposed method of recognition system

Figure. 3 shows block diagram for a biometric system of iris recognition in unconstrained environments in which each block's function is briefly discussed as follows:
1. Image acquisition: in this stage, a photo of iris(eye image) is taken.
2. Pre-processing: involving edge detection, contrast adjustment.
3. Segmentation: including localization of iris inner and outer boundaries and localization of boundary between iris and eyelids.
4. Normalization: involving transformation from Cartesian to polar coordinates and normalization of iris image.
5. Feature extraction: including noise removal from iris image and generating DCT transform of the normalized image
6. Classification and matching: involving comparing and matching by means of Minkowsky distance metrics
Regarding the fact that in an unconstrained environment iris may have occlusions caused by upper or lower eyelids or eye ball may roll left and rightwards.

3.2 IRIS SEGMENTATION

Iris segmentation refers to the process of detecting pupil and iris boundaries The main purpose of segmentation stage is to localize the two iris boundaries namely, inner boundary of iris-pupil and outer one of iris-sclera.The precise iris segmentation is the very important part of the iris recognition system as success of the system in upcoming stages is directly dependent on the precision of this stage. Segmentation stage includes the following steps:
1. Localization of iris inner boundary (the boundary between pupil and iris).
2. Localization of iris outer boundary (the limbic border between sclera and iris).

3.2.1 IRIS INNER BOUNDARY LOCALIZATION

The iris image is converted into grayscale to remove the effect of illumination. As pupil is the largest black area in the intensity image, its edges can be detected easily from the binarized image by using suitable threshold on the intensity image. But the problem of binarization arises in case of persons having dark iris. Thus the localization of pupil fails in such cases. In order to overcome these problems Circular Hough Transformation [4] for pupil detection can be used. The basic idea of this technique is to find curves that can be parameterized like straight lines, polynomials, circles, etc., in a suitable parameter space. The transformation is able to overcome artifacts such as shadows and noise. The approach is found to be good particularly dealing with all sorts of difficulties including severe occlusions.

The procedure first finds the intensity image gradient at all the locations in the given image by convolving with the sobel filters. The gradient images ($G_{vertical}$ and $G_{Horizontal}$) along x and y direction, is obtained by kernels that detect horizontal and vertical changes in the image. The sobel filter kernels are $C_{vertical}$ ={-1 -2 -1;0 0 0;1 2 1}

$C_{horizontal}$ ={-1 0 1;-2 0 2;-1 0 1} (3)

The absolute value of the gradient images along the vertical and horizontal direction is obtained to form an absolute gradient image using the equation

$$G_{abs} = G_{vertical} + G_{horizontal} \quad (4)$$

where $G_{vertical}$ is the convolution of image with $C_{vertical}$ and $G_{horizontal}$ is the convolution of image with $C_{horizontal}$. The absolute gradient image is used to find edges using Canny edge detection [5]. The edge image is scanned for pixel (P) having true value and the center is determined with the help of the following equations

$$xc = x - r\cos(\theta)$$

$$yc = y - r\sin(\theta) \quad (5)$$

where x, y are the coordinates at pixel P and r is the possible range of radius values, θ ranges from [0:π]

For a particular value of r, the values of xc and yc are obtained and stored in an accumlator and the accumulator counter is incremented every time the values of xc and yc satisfy image dimension criteria. The maximum value of accumulator counter gives the centre of the pupil along with the radius. Figure. 4(b)(edge detection image of eye) shows the results of performing Canny edge detection on an eye image as pre processing output. As it could be observed, pupillary boundary is almost completely detected as shown in Figure 4(b) and Figure. 4(c) shows iris inner boundary localization which has been achieved via circular hough transform method

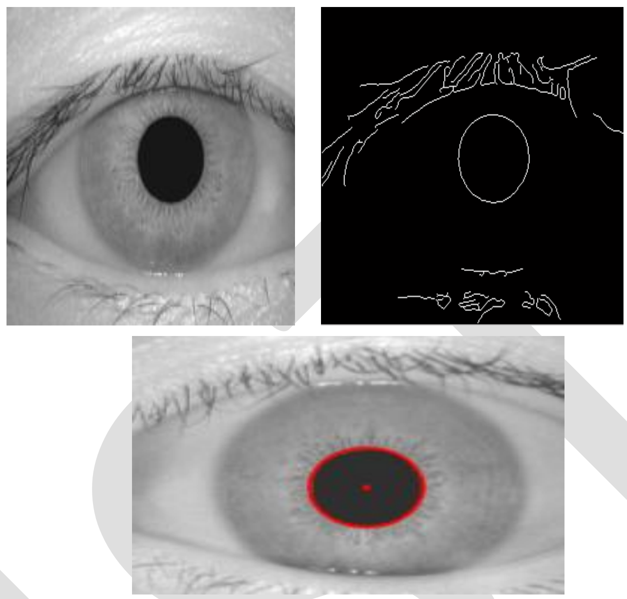


Figure 4(a,b,c) Steps involved in detection of inner pupil boundary

3.2.2. CIRCULAR HOUGH TRANSFORM

The Hough transform can be described as a transformation of a point in the x,y-plane to the parameter space. The parameter space is defined according to the shape of the object of interest A straight line passing through the points (x1, y1) and (x2,y2) can in the x,y-plane be described by:

$$y = ax + b \qquad (6)$$

This is the equation for a straight line in the Cartesian coordinate system, where a and b represent the parameters of the line.The circle is actually simpler to represent in parameter space, compared to the line, since the parameters of the circle can be directly transfer to the parameter space. The equation of a circle is

$$r^2 = (x - a)^2 + (y - b)^2 \qquad (7)$$

As it can be seen the circle got three parameters, r, a and b. Where a and b are the center of the circle in the x and y direction respectively and where r is the radius.The parametric representation of the circle is

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

$$y = b + r\sin(\theta) \qquad (8)$$

Thus the parameter space for a circle will belong to R^3 whereas the line only belonged to R^2

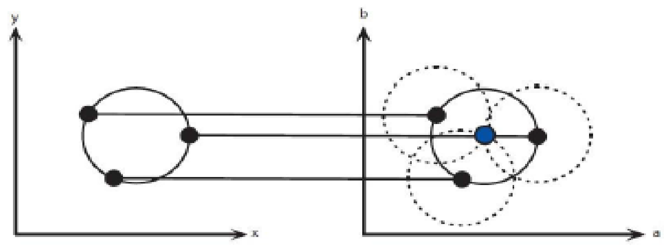


Figure.5 A Circular HT from the x,y-space (left) to the parameter space (right), for a constant radius

Following is detail description of Hough transforms Algorithm

1.Pre-processing image, get edge image by, using edge extracting arithmetic operators

2. Initialize Hough transformation matrix, let A(x,y,r)=0;

3. For every edge-points, let r varies from r_{min} to r_{max} , calculating every points satisfied equation (7).
let A (x, y, r) = A(x,y,r)+1

4. Make a decision of seeking for circle depending on vote from A

In Hough space, the parameters of max(A) will be responding to the best circle of image space. Many experiments have shown that Hough transform has high accuracy and Hough transform is a good method to detect objects edge. But the quantity of data needed to calculate is very large, with image size increasing, the quantity of data cause it difficult to be used in real-time

3.2.3. IRIS OUTER BOUNDARY LOCALIZATION

External noise is removed by blurring the intensity image. But too much blurring may dilate the boundaries of the edge or may make it difficult to detect the outer iris boundary, separating the eyeball and sclera. Thus a special smoothing filter such as the median filter is used on the original intensity image. This type of filtering eliminates sparse noise while preserving image boundaries. After filtering, the contrast of image is enhanced to have sharp variation at image boundaries using histogram equalization as shown in Figure 6(a). This contrast enhanced image is used for finding the outer iris boundary by drawing concentric circles, as shown in Figure 6(b), of different radii from the pupil center and the intensities lying over the perimeter of the circle are summed up. Among the candidate iris circles, the circle having a maximum change in intensity with respect to the previous drawn circle is the iris outer boundary. Figure 6(c) shows an example of localized iris image.

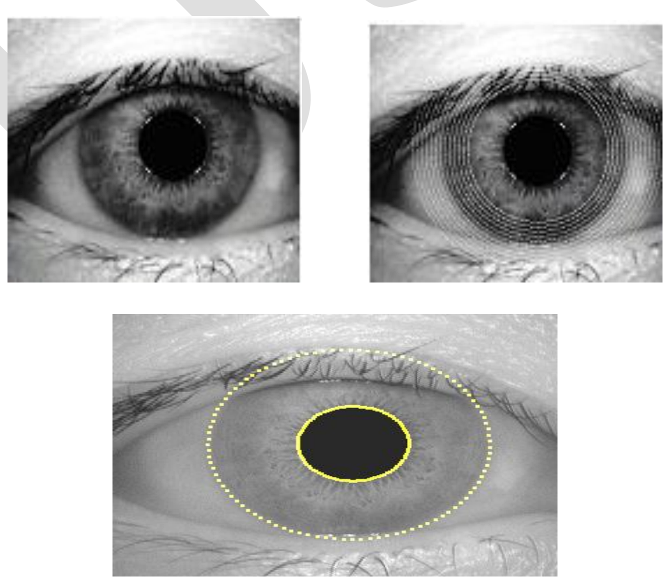


Figure **6**(a) Contrast enhanced image (b) Concentric circles of different radii (c) Localized Iris image

3.3 NORMALIZATION

After iris localization, we have to normalize it in order to enable the generation of the feature vector and their comparisons. There are many variations in the image of the eye, like optical size of the iris, position of pupil in the iris, varying imaging distance, rotation of the camera, head tilt and rotation of the eye within the eye socket. Also the iris orientation changes from person to person. Hence it is required to normalize the iris image so that the representation is common to all, with similar dimensions. Therefore, this normalization process will produce irises with same fixed dimensions so that two photographs for the same iris under different lighting conditions will have the same characteristic features

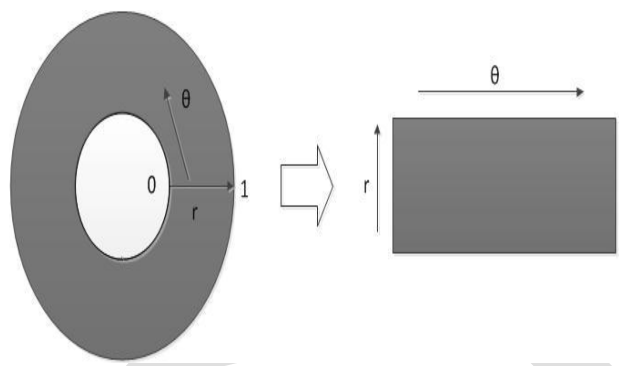


Figure 7.Normalization method

In normalization stage, an approach based on Daugman's method is used. Figure. 7 shows transforming iris area from Cartesian to polar coordinates. Therefore, iris area is obtained as a normalized strip with regard to iris boundaries and pupillary center. The iris area is illustrated on a rectangular strip of 8*512 [5, 8].The concept of rubber sheet modal suggested by Daugman takes into consideration the possibility of pupil dilation and appearing of different size in different images. For this purpose, the coordinate system is changed by unwrapping the iris and mapping all the points within the boundary of the iris into their polar equivalent as shown in Figure 7. This model remaps 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 angle $[0,2\pi]$.Figure 8.1 below shows the normalized iris image.

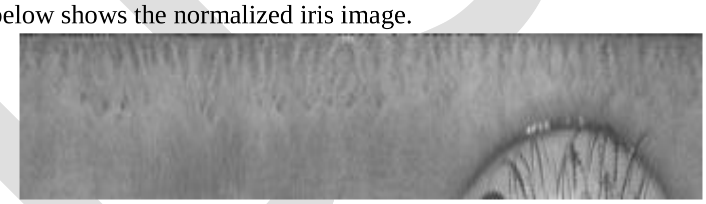


Figure 8.1.-normalized iris image

If the neccesary constituents or the patterns of iris texture are not clearly identifiable, then enhancement process is employed to improve the resultant of normalization process .And, in order to increase the matching rate, only certain portion of the normalized image is taken ,since the portion nearer to pupil will be containing much distinctive information and doing so reduces much of the lashes portion which is shown in figure 8.2 below

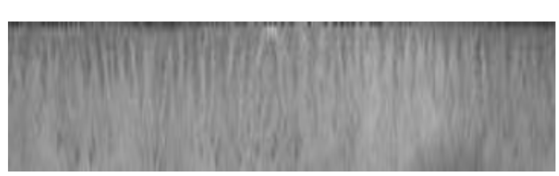


Figure 8.2-cropped normalized image

3.4 FEATURE EXTRACTION

Ordinal Measure of DCT Coefficient

Ordinal measures is also referred to as ordinal features. In this paper these two terms will be used interchangeably. An approach to obtain ordinal measure of DCT coefficient can be summarized as follows [9].

i. Let an image denoted by I(normalized image).
ii. Histogram equalization is applied in order to enhance the patterns
iii. Divide the given image into 8x8 blocks
iv. Apply the dct transform for each of the individual blocks.
v. Let the DCT coefficients calculated from the whole image denoted by Ic.

Figure 9 shows selection manner of AC part of DCT coefficients. In the figure, there is 8 rows and columns .The AC coefficient was selected similar to the zig-zag scanning used in JPEG standard. However, the size of the block under consideration was not specified as 8x8 as in JPEG standard. The numerical 1 indicates the DC component. The zig-zag scanning was started at row 2, column 1 (first location of AC) .i.e the numerical 2 indicates the first AC component. Here the coefficients are more selectively scanned, depending on their magnitudes.Ordinal measure was obtained by ordering the absolute value of AC coefficient of Ic.

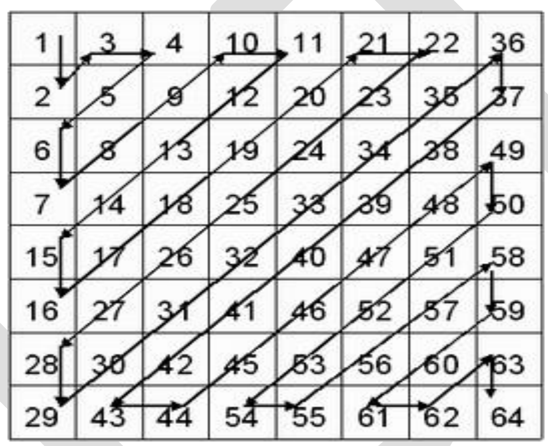


Figure 9 The method followed to extract features from these low-frequency DCT coefficients is a ziq-zaq scanning

Figure10 shows the application of the DCT on one of the Normalized iris image .Figure 10(a) displays the normalized image, and Figure 10(b) displays the result of applying the DCT on the normalized iris image, and it is possible to verify that most of the image's energy is concentrated in the upper left corner. This is the region that represents the DCT lowest frequency coefficients.

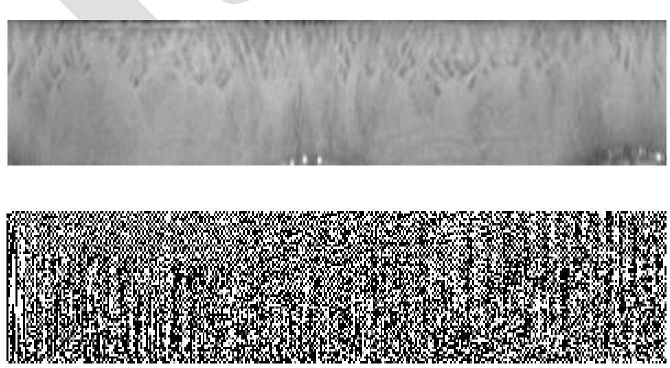


Figure 10(a) An example showing the normalized iris image (b)corresponding DCT transformed image.

3.5. MATCHING ALGORITHM

After successful normalization process. In the normalised iris image, Each of those frequency sub-bands is divided into 8x8 non-overlapping blocks and DCT is applied to each block. Unique iris features are obtained by comparing the energies containing in corresponding DCT blocks of both the sub-bands. These features extracted i.e the features in the form of DCT coefficients are used to generate a matching distance. The matching distance is calculated for each of the individual blocks , for this minkowsky distance metrics is used . From the obtained block distance value based upon the threshold fixed, decision is made such that the image belong to a particular category or recognized.The Minkowsky distance is defined as

$$MD = \sum_{i=1}^{n} (Xi - Yi)$$

here, X (and Y) is a set of DCT coefficients in a form of column vector, and Xi (and Yi) is the ith DCT coefficients of X(and Y).

4. EXPERIMENTAL RESULTS

The threshold value used is the average distance measure of top seven signatures as they belong to different eye images of same person's eye. Three images are taken in first session and four are taken in second session. The threshold thus set is used to compute False Acceptance Rate (FAR) and False Rejection Rate (FRR). The performance of the proposed method is evaluated in terms of the following metrics .

4.1 False Acceptance Rate:

The false acceptance rate, or FAR, is the measure of the likelihood that the biometric security system will incorrectly accept an access attempt by an unauthorized user. A system's FAR typically is stated as the ratio of the number of false acceptances divided by the number of identification attempts.

4.2 False Rejection Rate:

The false rejection rate, or FRR, is the measure of the likelihood that the biometric security system will incorrectly reject an access attempt by an authorized user. A system's FRR typically is stated as the ratio of the number of false rejections divided by the number of identification attempts. In a practical scenario a low FAR & a high FRR would ensure that any unauthorized person will not be allowed access. In this case a threshold value of 0.6906 shows a low FAR and high FRR. Thus a correlation value of 0.6906 have been set to authenticate the identity of an individual

4.3 Equal Error Rate:

A biometric system determines the threshold values for its FAR and FRR and when both the rates are equal it is referred to as Equal Error Rate. In this paper an equal error rate of 13% have been attained which gives an accuracy of 87% of the system.

4.4Average Accuracy Rate

This gives the average accuracy of the recognition system. It is given by Equation (9).

$$Accuracy = 100 - \frac{FAR + FRR}{2} \quad (9)$$

Where, FAR is the False Acceptance Rate and FRR is the False Rejection Rate

ERROR RATE

We have investigated the optimum number of DCT block required for matching process Figure 11shows the error rate as a function of the number of DCT blocks. It is understood from the plot, the error rate is constant from the block 12 onwards which implies that the sufficient and minimum number of blocks to be considered for matching the iris images is 12 blocks .

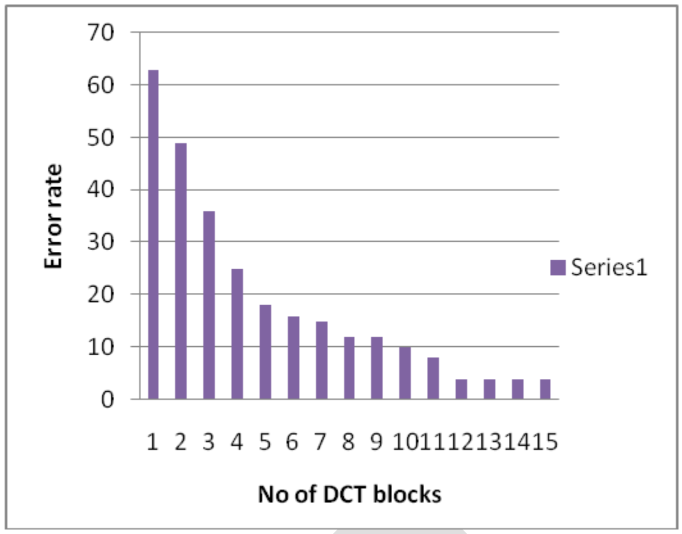


Figure. 11: Percentage error rate Vs number of DCT blocks

User	FAR%	FRR%
1-10	0.3	0.6
11-20	0	0.5
21-30	0	0.8
31-40	0.1	0
41-50	0.3	0.8
51-60	0.1	0.8
61-70	0.1	0.7
71-80	0.1	0.8

Table 1 shows representation of the false acceptance and false rejection for category of 10 individuals.

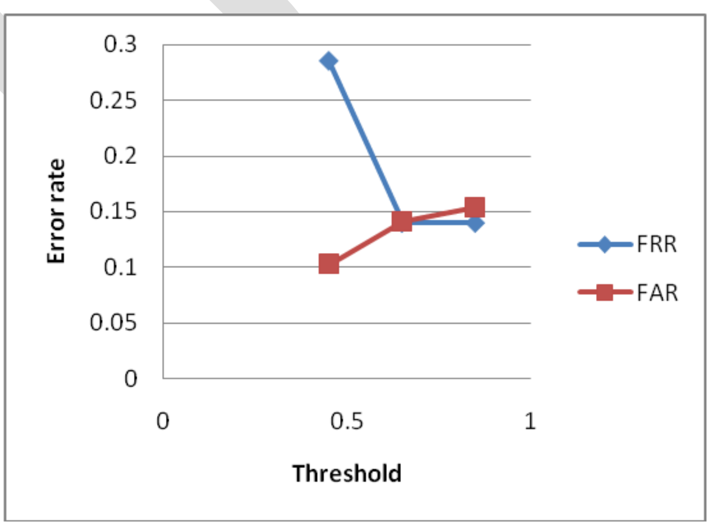


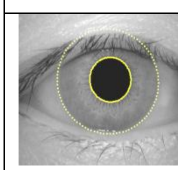
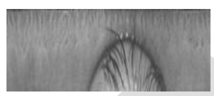
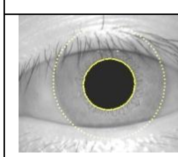
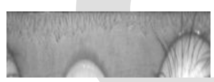
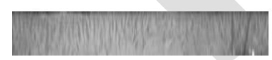
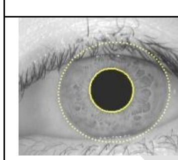
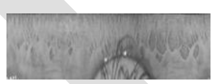
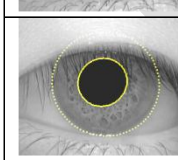
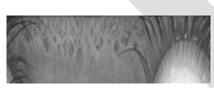
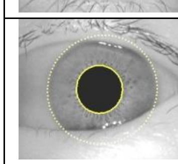
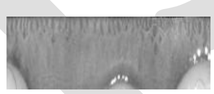
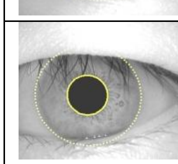
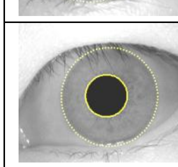
Figure 12 Graphical representation of FAR and FRR

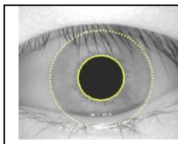
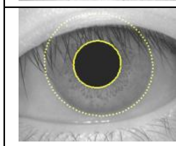
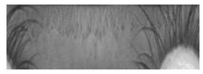
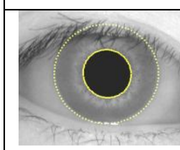
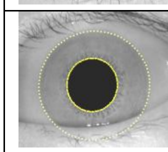
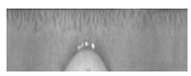
Table 2 shows representation of the false acceptance and false rejection for various threshold values

Threshold	FAR%	FRR%
0.45	0.1025	0.2857
0.65	0.1410	0.142
0.85	0.1538	0.142

Table2.Error rate

. The proposed method was implemented using MATLAB v7.9. Figure 13 below shows a set of database images where the corresponding segmentation, normalization and cropping is done, in order to increase the matching rate, only certain portion of the normalized image is taken ,since the portion nearer to pupil will be containing much distinctive information.

Segmentation	Normalized	Cropped normalized image
		
		
		
		
		
		
		

5. CONCLUSION

Analysis of the developed iris recognition system has revealed a number of interesting conclusions.Segmentation is the critical stage of iris recognition,since areas that are wrongly identified as iris regions will corrupt biometric feature generated resulting in very poor recognition.In this paper with the CASIA database version1, 85% of images managed to segment successfully.and got a reduced FAR and FRR rate of about 0.120 and 0.142 respectively. And has achieved a over all accuracy of 87%.

- **Future Work**

The above implementation is carried out for CASIA data bases of various versions.I .It is required to work with all available data bases and with non co-operative iris images. It is also required to develop embedded system with iris recognition, the most time consuming part of iris recognition can be implemented using verilog HDL. Matching part of iris recognition algorithm can be implemented on low cost Spartan 3AN FPGA
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