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# IRIS Recognition Using Neural Network

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**Abstract**: Biometric identification system employs physiological or behavioural characteristics to accurately identify each subject. The most reliable biometric system is the iris recognition due to richness and stability of iris texture. In this paper we proposed the cumulative sum based change analysis and neural network. The performance evaluation was measured in terms of false rejection rate and false acceptance rate. The experimental result gives the comparison between different methods and shows that neural network is a promising and effective approach in iris recognition.

**Keywords**: Iris recognition, Hough transforms, Neural Network

## I. INTRODUCTION

Now a day's every one possesses different types of cards for example- ATM card, Driving license, VISA card or student of college also possesses identity card, library card. For this every one need to remember number of passwords, also to carry proofs and cards. Only the reason behind is that, every wants to secure his data/information. The solution to this problem is that we need such a system which operates automatically and does not require to carry card like devices and also to remember password. All these requirements will be fulfil by biometric identification system. Biometric system provides automatic recognition of individual based on some fingerprints, facial features, voice, hand geometry, handwriting, the retina, and the one presented in paper is the iris. Biometric system work by first capturing a sample of the feature. The sample is then transformed using some sort of mathematical function into a biometric template. The biometric template will provide a normalized, efficient and highly discriminating representation of the feature, which can then be compared with other templates in order to determine identity. Many studies have been previously presented. [1] Proposed a phase demodulation method for iris feature extraction. An iris image is encoded into a compact sequence of multi scale quadrature 2-D Gabor wavelet coefficients, whose most significant bits compromise a 256-byte iris code. [2] Gives a zero crossing representation of one dimensional wavelet transform, calculated to characterise the texture of the iris. In [3], a texture analysis approach was proposed. A multi channel Gabor filtering was used to capture global and local details in an iris image. In [4] independent component analysis for iris pattern analysis has been used.

## II. IRIS RECOGNITION SYSTEM

The Iris is an externally visible and well protected organ whose unique epigenetic attractive pattern remains stable throughout the adult life. These characteristics make it very attractive for use as biometric identifying individuals. Image processing technique can be employed to extract the unique iris pattern from a digitized image of eye, and encode it in to biometric template contains an objective mathematical representation of unique information stored in iris, and allows comparison to be made between templates. When a subject wishes to be identified by iris recognition system, their eye is first photographed and then a template created for their iris region. This template is then compared with other templates stored in database until either a matching template is found and the subject is identified or no match is found and the subject remains undefined. Thus the basis of every biometric is to get the input signal/image apply some algorithm and extract the prominent feature for person identification /verification. In the identification case, the system is trained with the patterns of several persons. For each person, a template is calculated in training stage. A pattern that is going to be identified is matched against every known template. In the verification case, a person's identity is claimed. The pattern that is verified only is compared with the person's individual template. Most biometric systems allow two modes of operation, an enrolment mode for adding templates to database, and an identification mode,

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where a template is created for an individual and then a match is searched for in the database of pre-enrolled templates. An easy way to comply with the conference paper formatting requirements is to use this document as a template and simply type your text into it.

*A. System Development*

In general a biometric system consists of following components: pre-processing algorithms that remove artifacts from the digital output. These algorithms usually enhance, segment, normalize the digital images; a feature extractor that extracts significant features; a template generator that generates a biometric template which provides a discriminating representation of features; a storage component or the database that stores templates; and a classifier. A classifier compares the generated template with the other stored templates for recognition. The iris region can be approximated by two circles, one for the iris/sclera boundary and another, interior to first, for the iris/pupil boundary. The eyelids and eyelashes normally occlude the upper and lower parts of the iris region.

*1) Iris Segmentation:*

In the pre-processing stage iris segmentation and normalization was done. During the segmentation iris region is isolated in an eye image by eliminating eyelids, eyelashes. The segmented iris region is normalized using Daugman's rubber sheet model in the normalization stage. In pupil detection, 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. Thus the first step to find or separate out the pupil apply histogram of input image from which we get threshold value for pupil, then apply edge detection, once edge of pupil find , then center coordinates and radius can be easily find out by following algorithm and code –

1. Find the largest and smallest values for both x and y axis.
2. Add the two x-axis value and divide them by two will gives x- center point.
3. Similarly add two y-axis values, divide it by two, gives y- center point.
4. Radius is calculated by subtracting minimum value from maximum and divides it by two gives the radius of pupil circle.

```
[Y,X] = find(edge_pupil1);
Cir_CenX =round((max(X) + min(X))/2);
Cir_CenY =round((max(Y) + min(Y))/2);
r_pupil1 =round((max(X) - min(X))/2);
r_pupil2 =round((max(Y) - min(Y))/2);
if r_pupil1 > r_pupil2
r_pupil =abs(r_pupil1);
else
r_pupil =abs(r_pupil2);
end
PupilCenterX1 =abs(Cir_CenX)
PupilCenterY1 =abs(Cir_CenY)
PupilR1 =abs(r_pupil)
```

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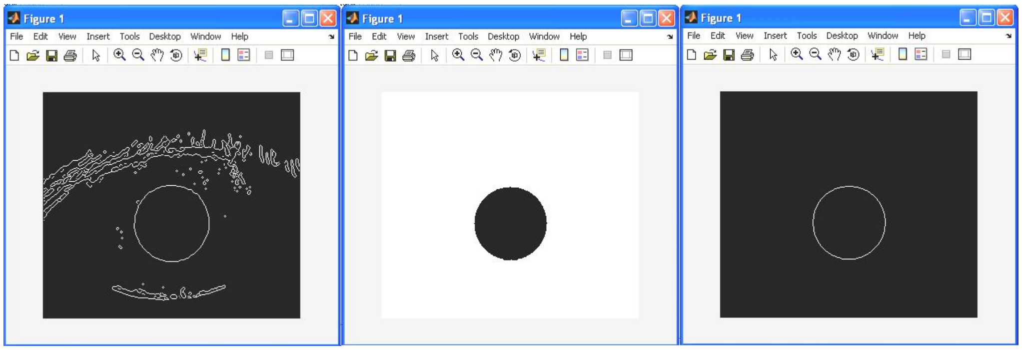


Fig 1 (a) Canny edge image (b) Only pupil (c) Pupil ring

Eyelash and eyelid always affects the performance of system. The eyelashes are treated as belonging to two types, separable eyelashes, which are isolated in the image, and multiple eyelashes, which are bunched together and overlap in the eye image. In this thesis iris circle diameter is assumed as two times pupil diameter and the noise, eyelash and eyelid, are avoided by considering lower 180 portion of iris circle.

*2) Iris Normalization*:

Once the iris region is localized in an eye image, the next stage is to normalize the circular iris region to a rectangular block so that it has fixed dimensions. For normalization of iris regions a technique based on Daugman's rubber sheet model was employed. A number of data points are selected along each radial line and this is defined as the radial resolution. The dimensional of the same iris inconsistencies between eye images are mainly due to the stretching of the iris caused by pupil dilation from varying levels of illumination. Other sources of inconsistency include, varying image distance, rotation of camera, head tilt, and rotation of eye within the eye socket. The normalization process will produce iris regions, which have the same constant dimensions, so that two photographs of same iris under different conditions will have characteristics features at the spatial location. The remapping of the iris region from (x, y) Cartesian coordinates to the normalized non-concentric polar representation is modelled as-

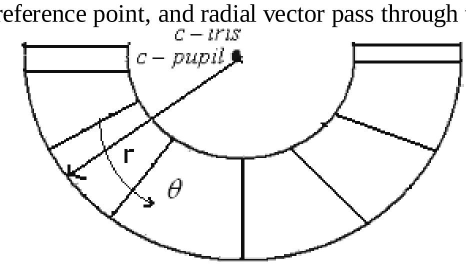
$$I(x(r,\theta), y(r,\theta)) \rightarrow I(r,\theta)$$

With

$$x(r,\theta) = (1-r)\, x_p(\theta) + r\, x_l(\theta)$$

$$y(r,\theta) = (1-r)\, y_p(\theta) + r\, y_l(\theta)$$

Another point of note is that the pupil region is not always concentric within the iris region, and usually slightly nasal. This must be taken into account if trying to normalize the doughnut shaped iris region to have constant radius. The centre of pupil is considered as the reference point, and radial vector pass through the iris region, as shown in fig.2.



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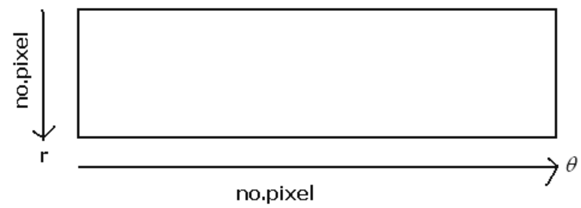


Fig 2. Normalization Pattern of Iris

The normalization process proved to be successful and some results are shown in Fig.3 However, the normalization process was not able to perfectly reconstruct the same pattern from images with varying amounts of pupil dilation. Since deformation of the iris results in small changes of its surface pattern.

Fig 3. Normalized iris part

*3) Feature Extraction*:

In order to provide accurate recognition of individuals, the most discriminating information present in an iris pattern must be extracted. Only the significant features of iris must be encoded so that comparisons between templates can be made. The template that is generated in the feature encoding process will also need a corresponding matching metric, which gives a measure of similarity between two iris templates. This metric should give one range of values when comparing templates generated from same eye, known as inter-class comparisons, and another range of values when comparing templates created from different irises, known as inter-class comparisons. The decision can be made with high confidence as to whether two templates are from the same iris, or from two different irises. The feature extraction in this paper is implemented with the help cumulative sum changed analysis method, Circular and Radial Feature extraction and neural network.

A cumulative-sum-based analysis method given by Jong-Gook Ko et al. [14] is used to extract features from the iris templates. In this method, the normalized iris template is divided into cells for calculating cumulative sums. An average grey value of the cell is used to represent each cell.

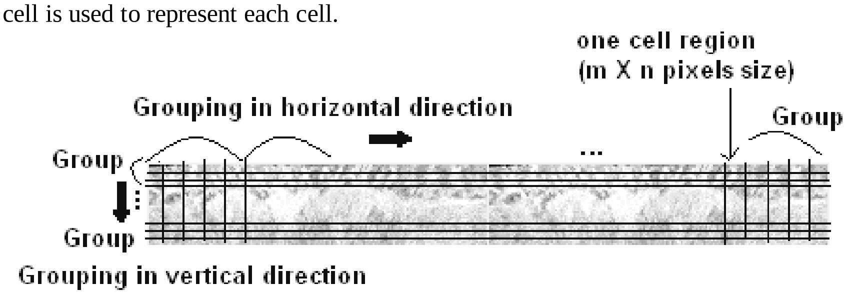


Fig.4 Division of normalized iris image into cell and grouping of cell region

The following steps are applied to extract features horizontally and vertically -

Features are extracted [Horizontally] as follows-

Step 1. Fixed out the dimension of the normalized image.

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Step 2. Divide normalized iris image into basic cell region. One cell region equals to 3(row) X 10 (column) pixel size.

Step 3. Represent each cell by their average grey value as a representative of respective cell.

Step 4. Make the group of average values obtained [1X5].

Step 5. Calculate cumulative sums over each group.
Features are extracted [Vertically] as follows-

Step1. Take the transpose of normalized image matrix which becomes 150(rows) X 36(columns) pixel size.

Step2. Divide normalized image matrix into basic cell region. One cell region equals to10 (row) X 3 (column) pixel size.

Step3. Represent each cell by their average grey value as a representative of respective cell.

Step 4. Make the group of average values obtained [1X3].

Step 5. Calculate cumulative sums over each group.

This will gives the two matrixes in which each element indicates cumulative sum value. For horizontal process 12 X 15 and for vertical process 15 X 12 matrixes will obtain. The procedure to calculate cumulative sum is described as follows-suppose that X1, X2, X3, X4, X5 are five representative values of each cell region within the first group located on the left top corner of figure 3.10. Then cumulative sums are calculated in the following way.
Step 1. Calculate the average Xm=(X1+X2+X3+X4+X5))/5

Step 2. Calculate cumulative sum from 0:S0 = 0

Step 3.Calculate the other cumulative sums by adding the difference between the current value and the average to the previous sum:

$$Si = Si\text{-}1 + ( Xi – X) \quad \text{for } i= 1,2,3,4,5$$

The next step is to generate the code which is generated by using simple algorithm given below-
Step 1. First calculate the maximum and minimum value from the obtained group cumulative sum.
Step 2. If Si located between MAX and MIN index and if Si is on upward slope set cell's iris code to 1 and if Si is on downward slope set cell's iris code to 2.
Step 3. If Si is not located in between MAX and MIN set the iris code to 0.
This algorithm generates iris codes by analyzing cumulative sums which describe the variations in the grey values of iris patterns. An upward slope of cumulative sums means that the iris pattern may change from darkness to brightness. A downward slope of cumulative sums means the opposite. An example of iris code generation is shown in fig.5. Each cell has two iris codes: one for horizontal direction, the other for vertical.

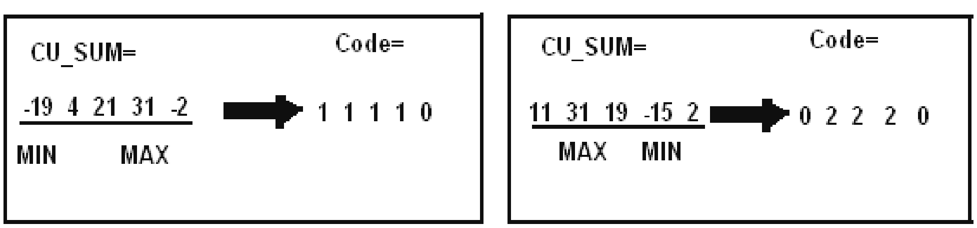


Fig 5. Example of iris code generation

The second approach circular and radial feature extraction is based on edge detection .Edges are detected in input image using canny edge detector. After edge detection image is changed to binary format in which white pixels are present on edges and black pixels elsewhere. The number of white pixels in radial direction and on circle of different radius gives important information [15].

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(a) Radial features:

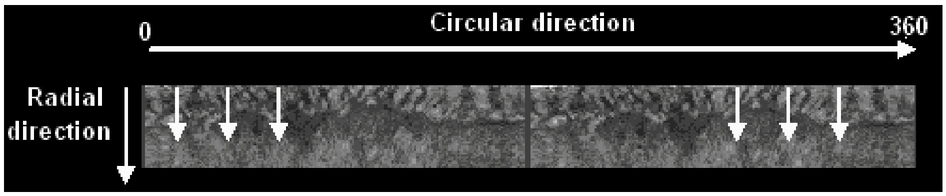


Fig 7: Feature extractions in radial direction

In iris image value of radial feature at particular angle will be number of white pixels along the radial direction.

If

$$S_{r,\theta} = 1 \;\; iris\_polar\_image[r][\theta] == WHITE$$
$$= 0 \;\; iris\_polar\_image[r][\theta] == BLACK$$

Feature at angle θ will be

$$F_\theta = \sum_{r=1}^{N} S_{r,\theta}$$

(b) Circular features

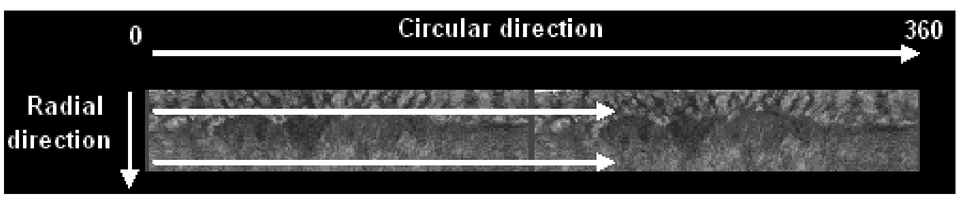


Fig.7 Feature extraction in circular direction

In iris image value of circular feature at particular radius will be considered as sum of white pixels along the circle of that radius. Keeping the $S_{r,\theta}$ meaning of same .The feature of particular radius r will be given as following.

$$F_r = \sum_{\theta=0}^{2\pi} S_{r,\theta}$$

Iris code will be considered as sequence of radial and circular features. In this method number of white pixel on radial and circular direction is measured which then indicates code for that particular eye image. It is obtained by following steps-

1. Image in polar form is converted into binary form.

Fig 8.Normalized image converted into binary

2. Number of white pixels in radial and circular direction is measured

White pixels [counts] = 1059
Black pixels [x] = 7041

3. Total numbers of white pixels are stored.
4. Similar steps from 1 to 3 are followed for both the query and data base image.

For matching compare the two images by using subtraction of white pixels available in database image from number of white pixels available in query image.

The third approach for the feature extraction used is Neural network. A NN is developed with a systematic step-by-step procedure which optimizes a criterion commonly known as the learning rule. The input/output training data is fundamental for these networks as it conveys information which is necessary to discover the optimal operating point. Basically, NN is system. A system is a structure that receives an input, process the data, and provides an output. Neural network is used to classify the extracted vectors. We use Learning Vector Quantization ((LVQ) model due to its low complexity and high learning capability. The LVQ is simple and faster than the error back- propogation algorithm, which is most popular neural network model. However, the learning speed and classification performance of the LVQ are sensitive to the initial weight vectors. A simple method of initializing the weight vectors is to take the first m training vectors and use them as a initial weight vectors, and remaining weight vectors are then used for updating the vectors [21]. The proposed algorithm is follows-

Step 1- Among training vectors of each class take the first vector & use it as a weight vector for the class. The values of the remaining weight vectors for the classes are set to zero.

$$W_l^k = X_l^k \quad \text{for } k - 1,2,\ldots\ldots K,\ldots\ldots M$$

Where $X_l^k$ is the first training pattern of the k-th class, $W_l^k$ is the first weight vector for the k-th class, and M is the total number of classes.

Step 2- Feed a new training vector as an input vector into the network.

Step 3- Compute the distance between input vectors and weight vectors.

Where Xi is the element of input vector, $W_{i,j}^k$ is the ith element of the jth weight vector for the kth class, and N is the dimension of the input vector.

Step-4- Determine whether the class represented by the weight vector with minimum distance is the same with the class of the input vector. Only if two classes are different, the input vector is assigned as a new weight for the class of the input.

Step-5- Repeat steps 2-4 until all the training vectors are processed.

## III. MATCHING

In order to provide accurate recognition of individuals, the most discriminating information present in an iris pattern must be extracted. Only the significant features of the iris must be encoded so that comparisons between templates can be made. The template that is generated in the feature encoding process will also need a corresponding matching metric, which gives a measure of similarity between two iris templates. This metric should give one range of values when comparing templates generated from the same eye, known as intra-class comparisons, and another range of values when comparing templates created from different irises, known as inter-class comparisons. The two metrics that is used are explained in brief below.

### A. *Hamming distance* :

The Hamming Distance gives a measure of how many bits are the same between two bit patterns . Using the Hamming Distance of two bit patterns, a decision can be made as to whether the two patterns were generated from different irises or from the same one. In comparing the bit patterns X and Y, the Hamming Distance, HD, is defined as the sum of disagreeing bits (sum of the exclusive-OR between X and Y) over N, the total number of the bit pattern.

### A. *Euclidean distance (ED):*

The Euclidean Distance (ED) can be used to compare two templates, especially if the template is composed of integer values. The weighting Euclidean distance gives a measure of how similar a collection of values are between two

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templates. The Euclidean distance metric is a classically used means of measuring the distance between 2 vectors of n elements.

## IV .PERFORMANCE ANALYSIS

The most commonly used metric for matching the two bit strings generated by query image and template stored in database is the Hamming Distance. It is a simple XOR operation where result equal to zero when both said a string has same bit string. Euclidean distance is especially useful for comparing matching whole word object elements of two vectors. It measures only distance between two iris code vectors. The figure 9 to 11 shows the obtained result -

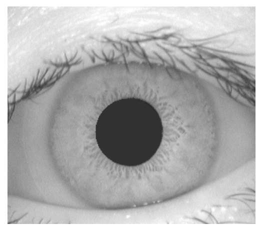

Fig.9 Query Image (3.bmp)

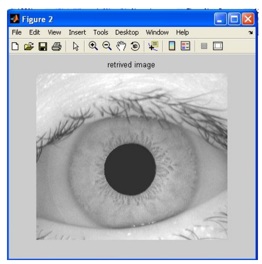


Fig.10 Retrieved Image (3.bmp)

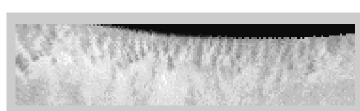

Fig.11 Normalized image

### A. *Experimental Results:*

*Results for Cumulative Sums Based Change Analysis Method*

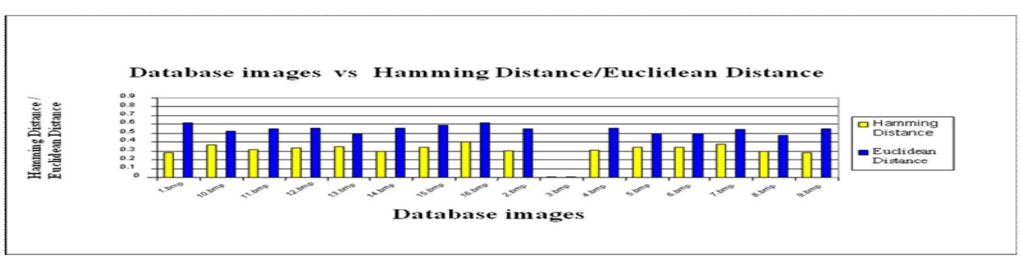


Fig 12. Database images vs Hamming Distance/Euclidean Distance for Cumulative sum based change analysis

*Results for Radial and Circular Feature Encoding Method:*

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The graph shows Database images vs. Hamming distance. The plot shows that the minimum hamming distance and Euclidean distance occurs for the 3.bmp image. an absolute difference is calculated, zero absolute difference between query image template and database image template indicate the template of authorized person also for authentic person a minimum Euclidean distance value is obtained.

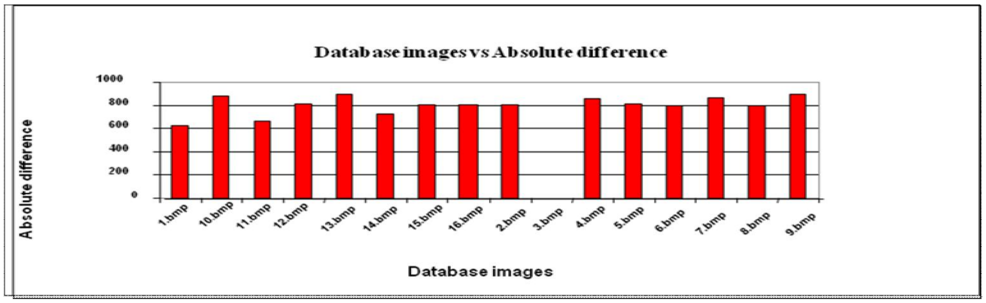


Fig 13. Database images vs. Absolute difference for Circular and Radial method

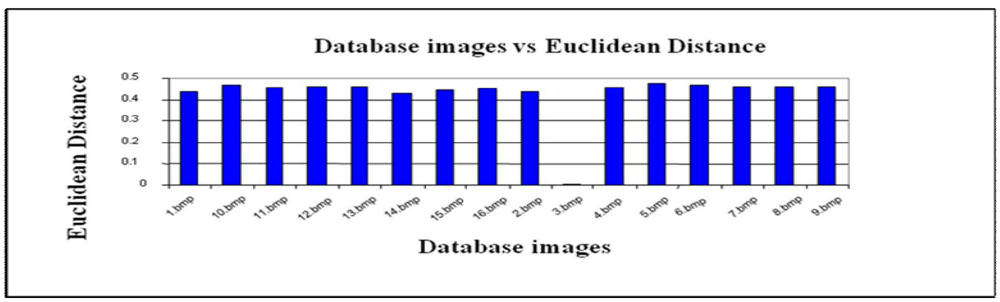


Fig 14. Database images vs Euclidean distance for Circular and Radial method

The performance of iris recognition is done using the following parameters-
False Acceptance Rate (FAR):
The fraction of the number of accepted client patterns divided by the total number of client patterns is called False Rejection Rate (FAR). The calculation of FAR shows that FAR is the area when the hamming distance of the inter class distributions is less than the set threshold. For the above method it is 12.5%.The graph of FAR is as shown below. The results show that the two persons are falsely accepted by the system

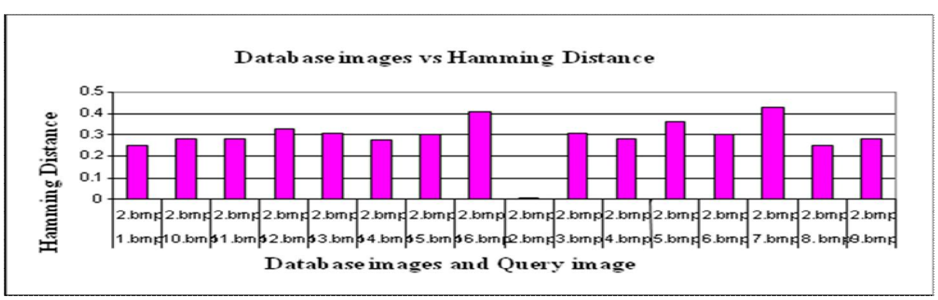


Fig.15 Graph of FAR

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False Rejection Rate (FRR):

The fraction of the number of rejected client patterns divided by the total number of client patterns is called False Rejection Rate (FRR). According to the FAR, its value lies in between zero and one. FRR is the area when the hamming distance of intra class distributions is greater than the set threshold. The calculation of FRR shows that FRR is the area when the hamming distance of intra class distributions is greater than the set threshold. For the above method it is 13.88%.

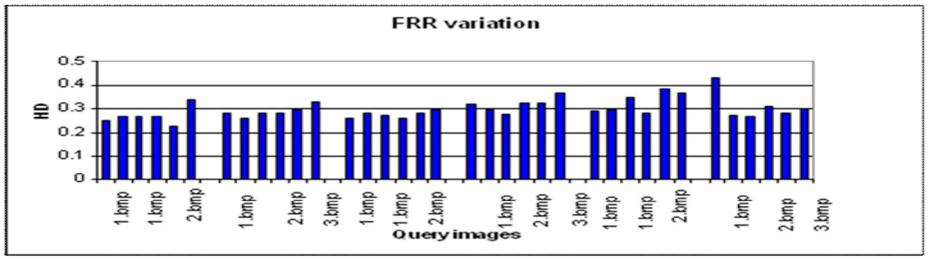


Fig.16 Graph of FRR calculations

Decidability and Equal Error Rate:

If hamming distances between two templates is less than a separation point than two iris templates are said to be matched. The separation between inter – class and intra-class hamming distance distributions can be measured by metric 'decidability'. The performance of biometric system is decided by value of decidability. Higher the value of decidability better is the performance of system. Actually it decides the separation of FAR and FRR. If 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 called the Equal Error Rate (EER) and in above graphs it, is obtained for image 3.bmp where HD is same for FAR and FRR(0.32778).

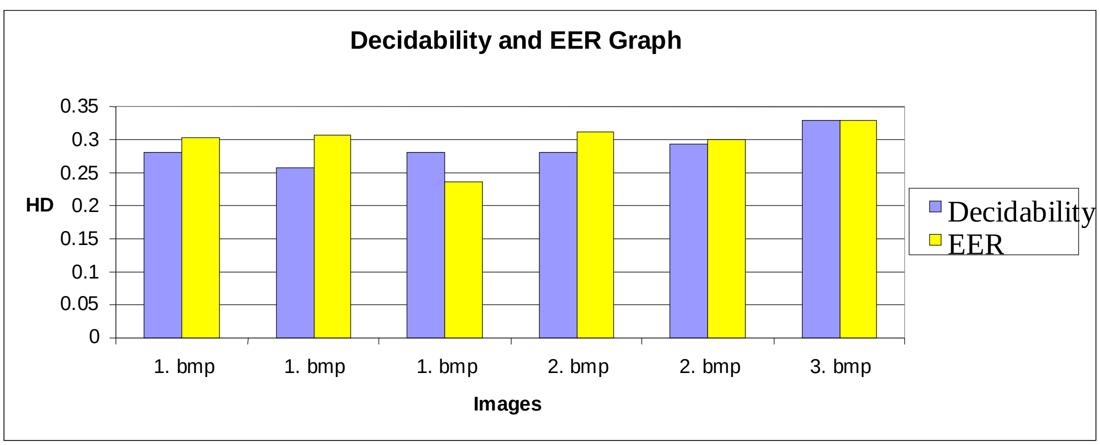


Fig. 17 Graph of Decidability

The recognition rate for cumulative sum based change analysis is 86.61% and the time required for feature extraction is 14.27s. Among the three methods, the third method neural network gave better recognition rate of 96.8% and consumes less time i.e. 0.014s for feature extraction. This recognition rate and speed is obtained for the 60% trained images. The below table shows the result of all methods-

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Department of CIVIL, CE, ETC, MECHNICAL, MECHNICAL SAND, IT Engg. Of Vishwabharati Academy's College of engineering, Ahmednagar, Maharastra, India

Table I Recognition of performance comparing with existing methods

| Sr.No | Methods | Recognition Rate |
|---|---|---|
| 1 | Daughman | 99.37% |
| 2 | Boles | 92.61% |
| 3 | Li ma | 94.33% |
| 4 | Neural Network | 96.8% |
| 5 | Cumulative sum based change analysis | 86.61% |

## V. CONCLUSIONS and FUTURE SCOPE

In the Cumulative sum based change analysis feature extraction method, a normalized iris image is divided into cells and codes generated for these cells by the proposed code generation algorithm. The method is relatively simple and efficient compared to other existing methods. The recognition rate for cumulative sum based change analysis is 86.61% and the time required for feature extraction is 14.27s. In the next method the features are extracted by using Radial and Circular feature extraction method. The Performance of this algorithm is not encouraging. As the inter-class hamming distance distribution is almost overlapping with intra-class hamming distance distribution. It is very hard to find good separation point for this algorithm. Also this algorithm is based on result of edge detection and edge detection algorithms are not efficient for illumination in images. Some edges cannot be detected if image is taken in low illumination condition. This algorithm did not give better verification results. The neural network is another method which is used for personal iris recognition system. Using this method, iris segmentation is performed in short time. The located iris after pre-processing is represented by a feature vector. Using this vector as input signal the neural network is used to recognize the iris patterns. Among the three methods, the third method neural network gave better recognition rate of 96.8% and consumes less time i.e. 0.014s for feature extraction. Hamming distance is chosen as a classifier, which calculates the similarity between two iris codes. A lower hamming distance indicates higher similarity and the two templates were deemed to be generated from the same iris. The image 3.bmp has obtained the minimum Hamming distance and Euclidean distance. The Hamming distance for 3.bmp is 0.05 and Euclidean distance is 0.011.Therefore the test image belongs to the 3rd person. From all the future extraction method it is observed that the neural network gave the better result and the feature execution time is very less. So, among the three methods neural network is one of the better recognition systems.

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