ISSN: 2321-8169
131 – 136

An Improved Iris Recognition System with Template Security using CT and SVD

Shailesh Arrawatia
Department of Computer Science & Engineering
Apex Institute of Engineering & Technology
Jaipur, India
shailesh24790@gmail.com

Priyanka Mitra
Department of Computer Science & Engineering
Jaipur Engineering College & Research Centre
Jaipur, India
mitra.priyanka11@gmail.com

Mohit Saxena
Department of Computer Science & Engineering
Apex Institute of Engineering & Technology
Jaipur, India
apexmohit@gmail.com

Brij Kishore
Department of Computer Science & Engineering
Apex Institute of Engineering & Technology
Jaipur, India
akbrij@gmail.com

Abstract**—**The Iris biometric system is the most prominent method for identification of individual. Many researchers have been presented iris recognition methods from decade but a fully suitable solution for real world scenario is not implemented yet. The two major issues are responsible for it. First is no accurate method to operate on non-ideal iris images with high recognition rate. Second one is deployment of system with high security on the existing real world situations. In this Paper, the above mentioned problems are solved to an extent.

An accurate and secured iris template encoding method is used for generate highly secured encoded binary pattern for iris template. Contourlet transform and Singular Value decomposition is used for this purpose. Beside this security feature, the proposed method used best combinations of algorithm for provide high accuracy as compared to conventional system of iris recognition. In Our approach IIT Delhi iris database is used as input image. Iris region from eye image is extracted by canny edge detection and Hough transforms to achieve high recognition rate. Daugman's rubber sheet model is used for normalization. Security for normalized template is provided by Contourlet transform and Singular Value Decomposition. At last stage the combination of Hamming Distance and Normalized Correlation coefficient is used to achieve high recognition rate. So at each stage of iris recognition system all methods and algorithms are performed very well and provide higher accuracy as compared to existing iris recognition system.

Keywords*-Biometric system, Iris recognition system, Recognition rate, Canny edge detection, Hough transformation, Normalization, Daugman's rubber sheet model, Contourlet Transformation, Singular Value Decomposition, Hamming Distance, and Normalization Correlation Coefficient.*

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I. INTRODUCTION

Identity cards and security credentials are used by persons to verify their identity at the time of access to secured areas as airports, ATM, financial and corporate office etc. However, these methods of identification are not safe because they can theft or lost [1]. To eliminate this drawback, biometric methods for personal identification are highly adopted at large scale. Among all biometric methods as fingerprint, retina, iris and face texture, Iris recognition is the best suitable method because of its permanent and unique features which are responsible for achieving high recognition rate [2].

Iris anatomy:

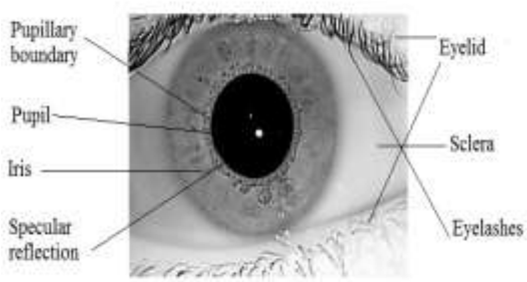


Figure 1. An eye image from IITD database [3].

Figure 1 shows the outer view of an eye image. In this image, the dark circular region at the center of image is the pupil which used to control the amount of light entering in eye. Outer region of this pupil is also a ring shaped structure which is known as Iris. This structure has unique features that are used to identify any individual with high accuracy. In the processing of iris recognition system the main task is to extract the iris region which is affected by the lower and upper eyelids and eyelashes. For this purpose inner and outer boundary of iris are identified by use of different segmentation techniques.

II. GENERAL FRAMEWORK OF IRIS RECOGNITION SYSTEM

The structure of iris recognition system is illustrated below in figure 2.

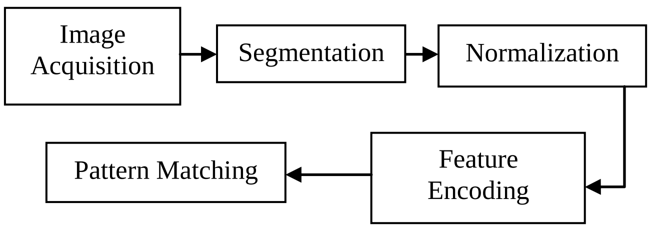


Figure 2. Iris recognition system

A. Image Acquisition

In image acquisition stage iris images are captured by using specially designed digital cameras. Generally pupil radius lies between 0.1 to 0.8 times of radius of iris [4]. The main concern of iris image acquisition is to extract iris image part from whole image of eye with maintaining the iris image quality so reliable and desired result can be calculated [5].

B. Iris Segmentation

Actual iris region is defined by its inner and outer boundary. These boundaries are identified by iris segmentation. Importance of this step is shown by the concept that further processing of iris recognition system is performed on the iris image which was obtained by iris segmentation method [6].

C. Normalization

In normalization phase a fixed dimension iris image is created by remapping image coordinates. The image is remapped by transforming coordinates Cartesian to polar [7]. Pupil size may vary according to the amount of light entering in eye. So, multiple eye images of same person may show difference in pupil size. This variation occurs due to difference in environment conditions in which image is captured. This situation creates degradation in matching result. It is highly required to remove these types of problems. Daugman's rubber sheet model is used to solve this problem and perform normalization in well manner.

D. Feature Encoding

The most important phase of iris recognition process is feature Encoding because it determines the exact pattern, feature and characteristics of iris image that are used to distinguish and identify iris images [7]. This step involve the encoding part in which normalized template is encoded. Gabor filter, Contourlet transformation and other encoding method are commonly used.

E. Template Matching

The final phase of iris biometric recognition system contains a comparison between captured iris featured templates to the stored iris template [7]. This comparison is performed by the use of hamming distance algorithm, Euclidean distance and Normalization coefficient method. This step provides information about the processed template that they are same or not.

III. Objective

The main objective of our research work to develop the new approach for iris recognition to provide better security in iris template encoding and better recognition rate with fast computation. These objectives are:

- Improvement in the segmentation stage to detect iris region accurately so better recognition rate is achieved.
- To perfume feature encoding in more efficient manner to provide highly secure iris template of minimum size.
- Use the best combination of techniques in segmentation, normalization and feature encoding with pattern matching to obtain overall high performance system with minimum error rate.

IV. Proposed Method

The input database of iris images is provided by IITD. Which has iris images of 224 persons and size of image is 320x240 pixels. In the proposed algorithm Hough transformation is used for iris localization and canny edge detection method is used for edge detection in the area which is affected by eyelids and eyelashes. When the segmentation process is performed then daugman's rubber sheet model is used for normalization which converts the Cartesian coordinate into polar coordinates. As studied in literature survey, feature encoding was performed by wavelet transform that has some disadvantage that they cannot extract features related to directionality and anisotropy. To remove these limitations we used contourlet transformation that extract directional information also and help to generate better encoded template which provide much better recognition rate. Template security features are enhanced by the use of SVD in encoding process. so feature extraction is done by the combining the strength of Gabor filter, contourlet transform and single value decomposition. Which provide feature vector and template protection by encoding the normalized template. At last stage hamming distance algorithm is applied for pattern matching. Our algorithm for iris recognition is presented here:

Iris recognition Algorithm:

Input: Iris image1 I(x,y) and Iris image W(m,n)

Output: Iris matched/Unmatched status

Step 1: Input the iris image I with size of x * y from IITD Iris database where x and y represents the rows and column of the Iris image.

Step 2: canny edge detection method is applied to generate an edge map of iris image.

Step 3: Hough transform is performed on the edge map to produce the segmented Iris image by locating Iris inner and outer boundary.

Step 4: Normalization is performed on the segmented iris image to convert the angular coordinates of iris into the polar coordinates. This procedure is done by daugman's rubber sheet model which creates a resultant rectangular shaped iris template.

Step 5: Next step is feature encoding in which 1D log Gabor filter is applied on normalized iris image and generate filter value as a coefficients.

Step 6: Contourlet transformation is applied to this Iris image and decomposed the iris images in frequency

ISSN: 2321-8169
131 – 136

sub bands with the help of Laplacian Pyramid and Directional filter bank. LP is used to divide input iris image in low pass and band pass image. The band pass image will be the input of directional filter bank which convert it in high pass image. Generally the iris image size or the normalized template size is small and has multi-direction content with smooth edge information. Contourlet transformation is most suitable for this type of iris images because the information is represented in less number of coefficients in contourlet transformation as compared to other transformations.

Step 7: Then each partitioned iris image is multiply by the value of log Gabor coefficient.

Step 8: as the multiplication of each row of image with coefficient is completed then SVD is calculated for this iris region.

Step 9: The matrix M of SVD is again multiply with the coefficient to produced more secured encoded pattern.

Step 10: Apply inverse SVD then inverse contourlet is applied to obtain the actual iris image.

Step 11: Generate the binary string from this encoded iris pattern.

Step 12: Calculate Hamming distance of these iris pattern and make the decision if the two iris are of same person or not.to analyze the similarity between two iris template or to make the decision whether two iris templates are same or not a threshold value of hamming distance is decided. If the value of hamming distance is below threshold value then two templates are of same eye otherwise they are form different eyes.

Step 13: Calculate Normalized correlation coefficient which is used to find the similarity between two images. If the two images are exactly same then NCC should be 1 or if both are completely different then it should be 0. The threshold on these similarity values provides the decision whether the two iris images are of same iris or not.

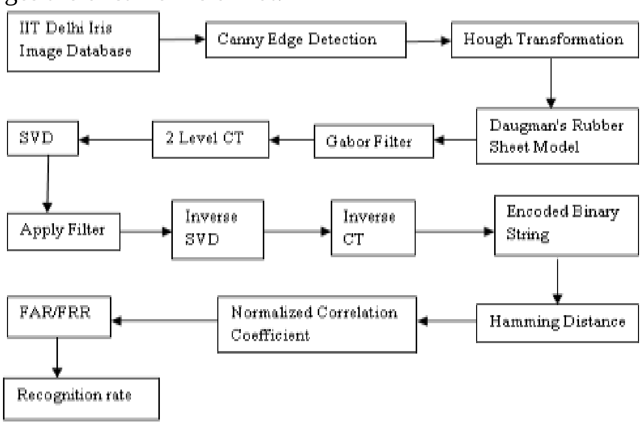


Figure 3. Flow Chart of Proposed algorithm

V. Result and Discussion

A. Introduction

The proposed technique entitled as "An Improved Iris Recognition System with Template Security using CT and SVD" has been proposed in previous section. Now this section shows the results and analysis of system accuracy with its performance. we have executed iris recognition system many times to evaluate the performance of proposed scheme and here the summarized result is presented and evaluates the efficiency and robustness of proposed iris recognition system by comparing its performance related parameters with the existing system parameters.

B. Database

In our experiment IITD iris database is used. This database contains all type of images some of them are heterogeneous images, some are having different level of noise and some have other artifacts. This database has ideal and non-ideal images and these images are captured in less constrained capturing environment. So these situations are suitable for our experiment because it gives the real time testing condition for our experiment.

C. Evaluation Metrics

It is common that the main evaluation parameter of iris recognition system is Recognition Rate. Recognition rate is calculated with the help of False Accept rate, False Reject rate, Hamming distance and Normalized Correlation. These parameter are discussed here

1) HammingDistance

$$HD = \frac{1}{N}\sum_{j=1}^{N} X_J XOR Y_J$$

Hamming distance performs a bit comparison between two binary template using XOR operation and produce a result which declare that both templates are same or not [7]. If the value of Hamming Distance is low it means both template are from same eye image and if it is high then two binary templates are from different eyes.

2) NormalizedCorrelation(NC)

Wildes et al. make use of normalized correlation to recognize the similarity feature between two iris templates [8]. This is represented as

$$\frac{\sum_{m=1}^{x}\sum_{n=1}^{y}[I(m.n)I'(m,n)]}{\sqrt{\sum_{m=1}^{x}\sum_{n=1}^{y}[I(m,n)]\ \ [I'(m,n)]}}$$

Where I(m,n) and I'(m,n) are two iris images which are to be matched. The value of coordinates (m,n) will be 1 to x and 1 to y respectively.NC will be lies between 0 and 1. if the value of NC is equal to 1 then it means two templates are exactly same. If it is zero means both templates are exactly opposite. So the value of NC is as near to 1 indicate the more similarity between iris templates.

3) False Reject Rate (FRR)

FRR is the false reject rate that is the rate on which iris templates of same iris image are unmatched. FRR is calculated among intraclass comparison of iris image.

$$\text{FRR}(\%)=\frac{\text{Number of false rejected}}{\text{total number of authentic attempts}}\text{x}100$$

4) False Accept Rate(FAR)

FAR is the false acceptance rate which shows the number of wrongly matched iris template of different eyes. FAR is calculated in interclass comparison of eye image.

$$\text{FAR }(\%)=\frac{\text{Number of false accepted}}{\text{total number of imposter attempts}}\text{x}100$$

5) Equal Error Rate(EER)

EER is the threshold value which is use to evaluate the system performance. It is calculated by finding the midpoint where FAR and FRR meet in ROC plot. The robustness of system against the impostor attempt can be checked by EER.

6) Receiver Operating Characteristics (ROC)

ROC curve is a graphical representation of the relationship of False Reject rate and False Accept rate. It also used to view the summarize format of system performance by generating value of EER.

7) Recognition Rate(RR):

Iris recognition rate or accuracy of system is defined as the number of successful recognition of iris biometric over the total attempt of template matching. If the recognition rate is high then system recognize iris very efficiently.

$$\text{Recognition Rate}=\frac{\text{total number of correct matching}}{\text{total number of matching}}\text{x}100$$

D. Experimental Setup

In our experiment the iris recognition technique is performed on two eye images. The iris regions of these two iris images are compared with each other and if it is matched then it shows that these two images are of same eye otherwise they are from different eyes. The tool MATLAB 14a (8.3.0.532) is used to implement this proposed work. As discussed above IITD iris database is used as input image and segmentation is performed by canny edge detection and Hough transformation due to their high efficiency in segmentation process. Then Daugman's rubber sheet model is used in normalization to convert angular coordinates of iris region into polar coordinates system. Feature encoding provide security feature to protect normalized template by applying CT and SVD. When CT is applied in both DFB decomposition and LP decomposition, 'pkva' filters are exploited . The number of pyramidal levels chosen are two (1,2). At each pyramidal level, the number of directional sub bands is set to 2, 4 and 8 respectively. after singular value decomposition is performed of feature vector of iris region. these steps are performed for both eye images. in last stage hamming distance is calculated of resulting vector of to iris images.

Further our experiment calculate the similarity score of two iris template by calculating Normalized Correlation coefficient (NCC). by applying different threshold values of hamming distance and NCC our experiment shows its performance on differnt parameter in section 5.5.

E. Simulation Results

The IITD database provides good segmentation result. Because these eye image are captured for iris recognition research work so pupil boundary and sclera boundary are clearly identified. In our experiment 660 combinations are used in which 155 combination rate intraclass comparison as 505 are interclass comparisons. As our calculation, this method gives 99.54 percentage recognition rate which is higher than existing systems.

TABLE I.

RECOGNITION RATE AT DIFFERENT THRESHOLD OF HAMMING DISTANCE WHEN NCC IS .9955

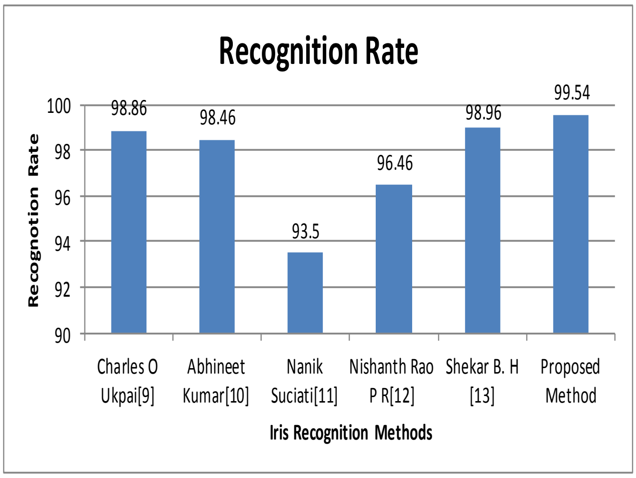
Hamming Distance Threshold Values	Recognition Rate in %
0.3	99.54545455
0.32	99.24242424
0.34	98.93939394
0.36	97.42424242
0.38	95.75757576

TABLE II.

COMPARISON OF RECOGNITION RATE WITH CONVENTIONAL ALGORITHMS AND PROPOSED ALGORITHM

Researcher	Recognition Rate
Charles O Ukpai[9]	98.86
Abhineet Kumar[10]	98.46
NanikSuciati[11]	93.5
NishanthRao P R[12]	96.46
Shekar B. H [13]	98.96
Proposed Method	99.54

 ISSN: 2321-8169
131 – 136



Comparison of Iris Recognition rate with Conventional Algorithms and Proposed algorithm

TABLE III.

COMPARISON OF FAR AND FRR OF CONVENTIONAL METHODS WITH PROPOSED METHOD

Researcher	FAR	FRR
Tisse[14]	1.84	3.00
Li Ma[15]	0.02	1.98
Daugman[16]	0.01	0.09
HamedRanjzad[17]	1.6	2
FebusReikdj G. Cruz[18]	2.22	4.44
Proposed method	0.00	1.93

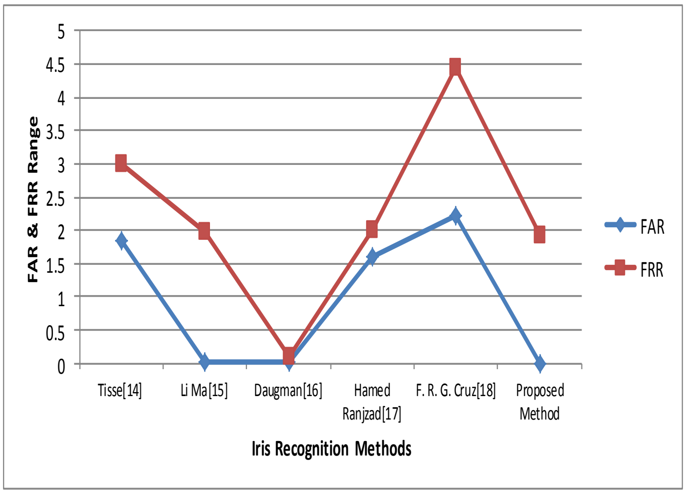


Figure 4. Comparison of FAR and FRR of Conventiinal Methods with Proposed Method

VI. CONCLUSION AND FUTURE SCOPE

Iris recognition is the highly attractive research area over last decade due to increased requirement of security features in iris template and increment in accuracy. The rich and unique feature of iris pattern makes it highly acceptable biometric based authentication system. Yet the use of low quality iris images and security of iris templates are still challenging task in this area.

In this report the security problem of iris template is solved and improvement in recognition rate is performed very well by proposed approach. Few issues and challenges discussed in first chapter are being undertaken in the proposed work which affects overall performance of iris recognition system. Segmentation, normalization and feature encoding are some steps which are discussed in the proposed method and implemented in a new way which provide better results. In this thesis we focused on all these three steps but our main task is to encode normalized iris template and provide better recognition rate. Template encoding is performed by CT and SVD very well and achieve recognition rate up to 99.54 percentages. Pattern matching is also most important part of any biometric identification system. Here for pattern matching the combination of Hamming distance and Normalized coefficient threshold is used to identify the correct iris template match. The result section provides validation of implementation of proposed work by showing encouraging performance as compared to other iris recognition systems.

The proposed iris recognition system work very well with high accuracy and recognition rate. it also enhance the iris template security but still there are some issues and challenges which are need to be solve. average recognition rate still 99.54 it may be reach to 100 percent and provide accurate result. processing of real time captured image with high accuracy is still challenging task. So these are some area in which further research is required to overcome these issues.

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