FAST AND EFFICIENT SEGMENTATION METHOD USING MODIFIED CIRCULAR FUZZY SEGMENTOR FOR IRIS RECOGNITION

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ABSTRACT

A novel approach is proposed in this paper is for iris segmentation and recognition in an iris based biometric system. We used the modified circular fuzzy segmentor (MCFS) model to segment the pupil and iris inner boundary. After accomplishing that, a binary encoder based feature extraction scheme Local Circular Encoder (LCE) is proposed to exactly extract the significant features to do the iris recognition process. Once feature extraction scheme is done by the LCE operator, the fuzzy logic classifier is used to achieve the recognition. For our experiment we used three databases CASIA, MMU and UBIRIS to analyze the increase of the error rates when the iris is inaccurately segmented. We selected 780 images of CASIA, MMU, UBIRIS databases to do the segmentation by our proposed segmentation algorithm to achieve the accurate segment. From the experimentation results, the proposed method of MCFS+LCE is outperformed than the existing methods.

***Keywords*- Iris Recognition; MCFS; fuzzy logic classifier; Local Circular Encoder (LCE) CASIA; MMU; UBIRIS**

I. INTRODUCTION

Today, security is one of the significant factors in the field of information, business, e-commerce, military and more [1]. For this motive, personal identification has turn out to be a considerable topic and some broadly employed methods of recognition such as PIN (Personal Identification Number), password, ID card and signatures have some disadvantages [2, 3, 4]. ID card or PIN can be stolen, password may be forgotten and signatures can be reproduced. In the modern society, biometrics, the technology of carrying out personal identification or authentication through an individual's physical attributes, is turning into an increasingly feasible solution for identity management, information protection, and homeland security [5]. In common, biometrics engages the employ of physiological and behavioural features. The physiological features contain the subsequent: face, fingerprint, iris pattern, retina, ear, thermogram, hand geometry, palm-vein pattern, and the behavioural features comprise the subsequent: gait, keystroke dynamics, smell, signature, and voice [6, 7, 8, 9]. It is commonly granted that iris recognition is the most precise of all the biometric technologies applied for human authentication today. Above all, iris recognition is generally more user friendly and the physical subsistence of the user can be assured [10]. The human iris has been found to hold highly distinct features distinctive to each individual, and, thus, offers a good substitute resource for personal identification [11]. The iris is a distinctive organ that is composed of pigmented vessels and ligaments forming unique linear marks, slight ridges, grooves, furrows, vasculature, and other related features and marks. Comparing more features of the iris raises the likelihood of uniqueness. Therefore, for recognizing an individual, iris is declared to be the most accurate and dependable and has received widespread attentions over the last decade [12, 13, 14, 15, 16].

In this paper, our intention consists in the analysis of the relationship between the accuracy of the segmentation process and the error rates of typical recognition systems. In order to achieve this, we perform the following experimental procedure:

- Selection of 780 images of the UBRIS (first version), CASIA and MMU databases. Manual verification that the used iris segmentation algorithm is able to accurately segment all the images.
- A segmentation algorithm namely modified circular fuzzy segmentor (MCFS) is proposed to extract the region of interest (ROC) like pupil and iris identification.
- Feature extraction on accurately segmented images: A binary texture feature called as local circular encoder (LCE) is proposed to extract significant iris features to do the recognition process.
- ***Recognition***: Recognition is done by the fuzzy logic classifier, which is divided the input iris image into whether recognize or not.

II. LITERATURE REVIEW

Using iris an abundant of researches has been suggested to attain personal identification and verification. A very few replicas utilize different iris segmentation algorithms for presenting more recognition among them. A robust iris recognition method has been offered by Y. Song et al [17] based on a sparse error correction model. In their method, all the training images are concatenated as a dictionary and the iris recognition task is cast to an optimization problem to look for a sparse representation of the test sample in terms of the dictionary. However, the overall complexities of their proposed algorithm become high. Moreover, an algorithm for iris recognition has been offered by K. Miyazawa et al [18] using phase-based image matching technique by means of phase components in 2D discrete Fourier transforms (DFTs) of specified images. But, it suffers to handle noisy conditions in illumination and camera to-face distances.

A method known as An Optimized Wavelength Band Selection for Heavily Pigmented Iris Recognition has been brought in by Y. Gong et al [17]. Commercial iris recognition systems usually obtain images of the eye in 850-nm band of the electromagnetic spectrum. The greatly pigmented iris images are incarcerated at 12 wavelengths, from 420 to 940 nm in their work. Their experimental effects proposed that there exists a most appropriate wavelength band for heavily pigmented iris recognition when employing a single band of wavelength as illumination. A possibility fuzzy matching approach with invariant properties has been suggested by C. C. Tsai et al [19], which can offer a robust and efficient matching scheme for two sets of iris feature points. In addition, they suggested an efficient iris segmentation method to process the identified inner and outer boundaries to soft curves. Nevertheless, the complexities of their iris pupil identification become high

In addition, a perturbation-enhanced feature correlation filter (PFCF) has been suggested by M. Zhang et al [20] for robust iris matching. In addition, accordingly as the gallery templates a set of further correlation filters are improved. The decision is found out by the fusion result of multiple correlation filters. In their system, the inner pupil boundary accurately for most samples from the database but fails to localize the outer iris boundary. In addition, a method for the recognition of iris patterns has been suggested by H. Rai et al [21] using the mixture of support vector machine and Hamming distance. Their approach as well employed parabola detection and trimmed median filter for the intention of eyelid and eyelash detection and removal, correspondingly. They showed that their method is computationally efficient and dependable. A weighted co-occurrence phase histogram (WCPH) has been offered by P. Lia et al [22] for symbolizing the local features of texture pattern and employs it to iris recognition. They assessed the performance of their technique on the UBIRIS.v2 database and assessed the vigor to noise of iris encoding and matching methods on the UBIRIS.v2 database. Nevertheless, their approach still suffers due to localization errors increase for the noisy for UBIRIS databases.

III. PROPOSED METHOD

An Intelligent Framework for Iris Recognition system is as shown in Fig.1.

❖The system starts with the segmentation stage, followed by feature extraction and lastly, recognition. First, pupil and irises are segmented and segmentations are evaluated.

❖Secondly, they are normalized by rubber sheet model to convert the rectangular conversion process. Then, a feature set is constructed based on LCE algorithm, which is newly designed operator for code generation process.

❖After getting the texture features, at last, fuzzy logic classifier is used for accurately and inaccurately segmented irises separately for recognition.

3.1 Segmentation through Modified Circular Fuzzy Segmentor (MCFS)

The proposed method of modified circular fuzzy segmentation (MCFCS) is explained with the following steps:

Step1: Binarization

At first, the input iris image is converted into binary image, which means it converts an image of up to 256 gray levels to a black and white image. The input image is given with a threshold value of 0.5. Threshold is selected based on the image contrast, apply the condition as in (1).

$$B_{Binary}(k,y) = \begin{cases} 0, & if\ B_{grey}(k,y) =< Threshold \\ 1, & Otherwise \end{cases} \quad \ldots..(1)$$

Step2: Compute the horizontal & vertical run length quantization

- After converting to binary image, the run length encoding (RLE) is applied for code representation as a pair representation based on its histogram. For example, if *V*=[1,1,1,1,0,0,1,1,1,1,1,1,1,1] is a vector to be encoded, then the run length encoding of *V* is *H(V)*=[(1,4),(0,2)(1,8)].
- Subsequently, run length quantization is applied here as a procedure to replace all ones within a binary image with the corresponding run length coefficients re-quantized in unsigned 8-bit integer domain by some custom quantization function as follows:
- $rqf(V(n)) = \min(255, \max(1, round(255 * V(n) / \max(V(n)))))$.(2)
- Where, *V* is the vector to be quantized and *n* is the index of its non-zero components. Above process is done by two directions like vertical and horizontal and corresponding quantized image is obtained.

Step 3: Modified Fast k-Means Image Quantization

Thereafter, modified Fast k-Means Image Quantization (MFKMQ) is applied on the horizontal and vertical run length quantized image to obtain pupil region. Commonly, Fast k-Means Image Quantization (FKMQ) is a variant of k-means algorithm designed for fast chromatic clustering in uint8 domain. It transforms the input image in an equipotential chromatic map [20] with k-levels by replacing each chromatic value with the closest centroid. A suboptimal (incomplete) variant of FKMQ [25] can be easily derived by imposing termination in a small number of iterations while resetting the first centroid to the minimum available value (or to zero). In this way, the input image is forced to reveal its own range of darkness (numerical meaning of darkness according to the image histogram) and to return a handler to that area covered by lower chromatic values. Due to the modification in the FKMQ, the pupil region is accurately extracted, which improves the performance of the FKMQ. This is particularly useful in detecting the pupil location.

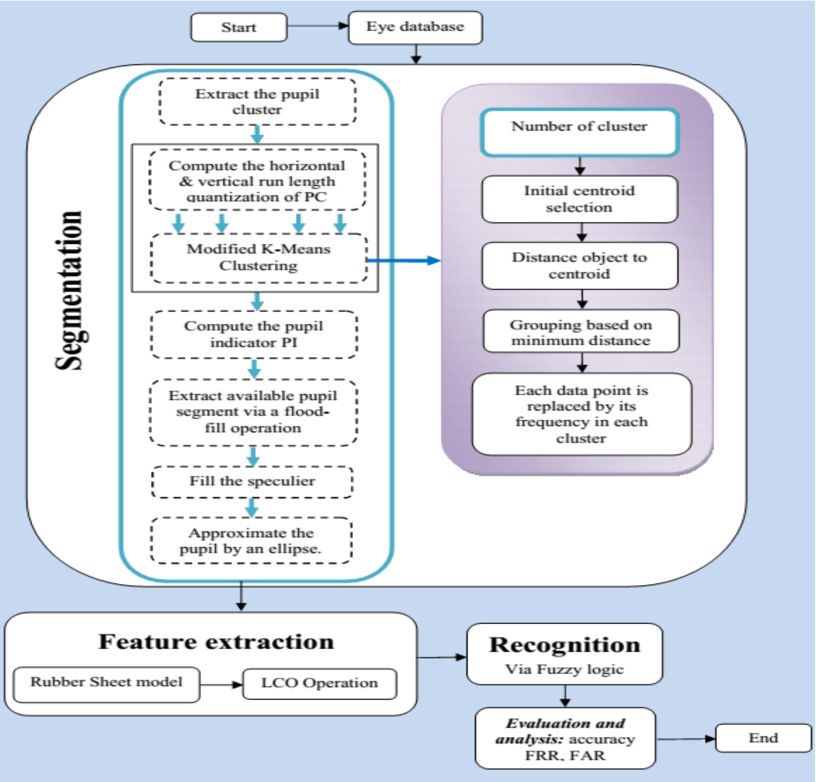


Fig.1: Intelligent framework for iris recognition system

Step 4: Pupil identification

Based on the vertical and horizontal pupil quantized image, the common region is selected and this region is named as pupil cluster.

Step 5: Iris segmentation

Finally, a circle is drawn named as iris region using the pupil circle.

3.2 Iris Normalization

Daugman's Rubber Sheet Model is used to convert circular to rectangular conversion (CTRC) operation. The main task of it is to generate a rectangular strip from segmented iris to form a rectangular matrix with a consistent value. Here, the iris area i.e. polar coordinate is converted Cartesian coordinates. Therefore, iris area is obtained as a normalized strip with regard to iris boundaries and pupillary center. The homogenous rubber sheet model is devised by Daugman in 1993 used for normalization process

Daugman's Rubber Sheet Model

Once the iris image is efficiently localized, then the next step is to transform it into the rectangular sized fixed image. The transformation process is carried out using the Daugman's Rubber Sheet Model [29] and is shown in Fig. 2.

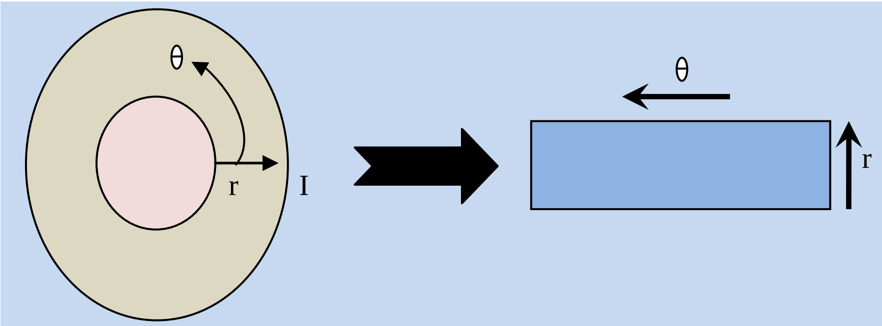


Fig.2: Daugman's Rubber Sheet Model

For every pixel in the iris, an equivalent position is found out on polar axes. The process comprises of two resolutions: Radial resolution, which is the number of data points in the radial direction and Angular resolution, which is the number of radial lines generated around iris region. Using the following equation, the iris region is transformed to a 2D array with horizontal dimensions of angular resolution and vertical dimension of radial resolution.

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

Where, $I(x,y)$ is the iris region, (x,y) and (r,θ) are the Cartesian and normalized polar coordinates respectively. The range of θ is $[0\ 2\pi]$ and r is $[0\ 1]$. $x(r,\theta)$ and $y(r,\theta)$ are defined as linear combinations set of pupil boundary points. The formulas given in the following equations perform the transformation,

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

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

$$x_p(\theta) = x_{p0}(\theta) + r_p Cos(\theta)$$

$$y_p(\theta) = y_{p0}(\theta) + r_p Sin(\theta)$$

$$x_i(\theta) = x_{i0}(\theta) + r_i Cos(\theta)$$

$$y_i(\theta) = y_{i0}(\theta) + r_i Sin(\theta)$$

Where, (x_p, y_p) and (x_i, y_i) are the coordinates on the pupil and iris boundaries along the θ direction. (x_{p0}, y_{p0}), (x_{i0}, y_{i0}) are the coordinates of pupil and iris centers [27].

IV. FEATURE EXTRACTION

Once the iris segmentation is over, eyelid and eyelash pixels are identified using MCFS method and then the feature extraction is performed using Local Circular Encoder (LCE) algorithm. To start this method, Daugman's Rubber Sheet Model is used to convert circular to rectangular conversion (CTRC) operation. The main task of it is to generate a rectangular strip from segmented iris to form a rectangular matrix with a consistent value. Here, the iris area i.e. polar coordinate is converted Cartesian coordinates. Therefore, iris area is obtained as a normalized strip with regard to iris boundaries and pupillary centre. The homogenous rubber sheet model is devised by Daugman in 1993 used for normalization process. Then, the rectangular iris image is applied for the code generation process using LCE method. Once the rectangular conversion is over, the code generation is done through the Local Circular Encoder (LCE). In order to design, weighted-based neighbor computation process is presented to remove or process that corrupted iris parts based on the quality assumption. The weighted-based neighbor computation is done by three domain information like spatial, Gabor and wavelet. The detailed process of the LCE method described step by step:

Step1: Let the spatial domain image (rectangular array) be denoted as $I(i, j)$, the wavelet domain image (via LL band) be denoted as $I_w(i, j)$ and the Gabor domain image (using Gabor filter $I_w(i, j)$) be denoted as $I_g(i, j)$, the resultant binary code through wavelet domain $I_w(i, j)$ be denoted as $code_A$, the resultant binary code through Gabor domain $I_g(i, j)$ be denoted as $code_B$, the resultant binary code through the original rectangular array $I(i, j)$ be denoted as $code_C$, the obtained single binary 8-bit code via OR operation can be denoted as B_s.

Step2: Partition the rectangular array $I(i, j)$ into 3*3 sub blocks with centre block X_C.

Step3: Apply a Gabor filter to the resultant rectangular array image $I(i, j)$ (original) to extract texture information. Therefore, the texture of iris is encoded by 2D multi-directional Gabor filter. Typically, an input array $I(i, j), (i, j) \in \Omega$ (Ω - set of image points), is convolved with a 2-D Gabor function $g(i, j), (i, j) \in \Omega$ to obtain a Gabor feature image $r(i, j)$ and the resultant binary code as follows:

$$r(i, j) = \iint_{\Omega} I(\xi, \eta) g(i - \xi, j - \eta)\, d\xi\, d\eta$$

Finally, $Code_A \leftarrow [r(i, j)]_{3\times3}$

Step4: On other hand, a wavelet transform is applied to extract low and high band information. Following that, it decomposes four sub bands like LL, LH, HL and HH. In this study, LL band is used to computation process. According to this, binary code is generated from each 3*3 block in LL sub band.

$$Code_B \leftarrow [I_w(i, j)]_{3\times3}$$

Step5: In addition, the resultant binary code is obtained through the original rectangular array $I(i, j)$ (spatial domain). Mathematically, this transformation can be represented as

$$Code_C \quad \leftarrow \quad [I(i, j)]_{3\times3}$$

By combining these three domain information (i), (ii) and (iii) using OR operation, we obtain single 8-bit binary code, it can be represented as follows

$$B_s = OR(Code_A, Code_B, Code_C)$$

Step6: The 8-bit binary code B_s is converted as equal decimal number D_s and it is replaced in same position of $I(i, j)$. This process is repeated for all 3*3 blocks to obtain $I_{out}(i, j)$.

V. MATCHING OR RECOGNITION VIA FUZZY LOGIC SYSTEM

The testing iris image N is given to the fuzzy logic system, where the test iris data is converted to the fuzzified value based on the fuzzy membership function. Then, the fuzzified input is matched with the fuzzy rules defined in the rule base. Here, the rule inference procedure is used to obtain the linguistic value that is then converted to the fuzzy score using the average weighted method. From the fuzzy score obtained, the decision is generated whether the test iris image belongs to the recognition or not.

VI. RESULTS AND DISSCUSSION

Proposed results are carried on MATLAB-2013b version- 8.1.0.604, using three dataset CASIA, MMU and UBIRIS. Performance evaluation is based on the parameter Accuracy, FAR and FRR.

6.1 Effectiveness of the segmentation performance

The accuracy of iris recognition highly depends on the accuracy of segmenting the iris and pupil or region of interest. Fig.3 illustrates the segmentation performance of the proposed against existing approach namely circular fuzzy segmentation (CFS) [28].

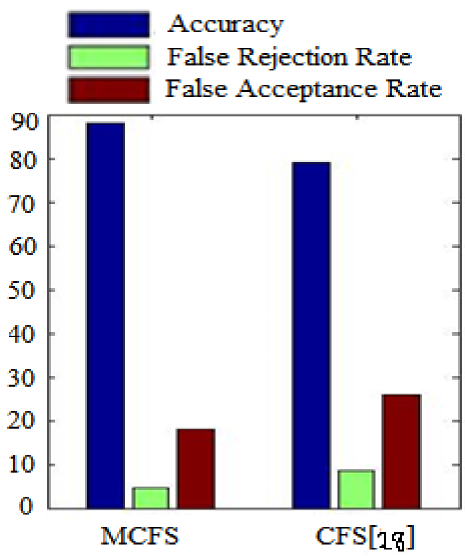


Fig.3 : Segmentation performance of the proposed against existing system [28]

The Fig.3 indicate that the proposed segmentation method of MCFS performs better accuracy than the CFS [28] method. From the Fig.3, our MCFS method achieves better accuracy value of 88%, which is higher than the CFS algorithm (78%). Overall, the given method reports a fact: some of the irises could not be segmented accurately using CFS algorithm. However, our proposed method of MCFS was segmented maximum number of iris images than the CFS algorithm.

6.2 Effectiveness of the recognition performance

The methods proposed by PBIM approach [27], SURF approach [28] are the best known among existing systems for iris recognition. In [27], phase based iris recognition is proposed using Fourier Phase Code (FPC) for representing iris information. A major problem of their approach is that the 2D FPC does not contain amplitude spectrum and the actual iris image cannot be reconstructed from the 2D FPC. In [28], the authors have developed an iris recognition system. However, their system is developed to localize the inner pupil boundary accurately for most samples from the CASIAV3 database but fails to localize the outer iris boundary. However, errors due to localization increase for the noisy and low resolution and UBIRIS databases. The proposed method of MCFS-LCE is performed on three benchmark datasets like CASIA, MMU and UBIRIS. Hybridization of modified k-means and fuzzy logic classifier is well suited to improve the recognition process. The performance of the proposed recognition method is analyzed by accuracy, false acceptance rate (FAR) and false rejection rate (FRR) and presented in Figures 3, 4 and 5. As seen in the figures, the proposed method of MCFC-LCE had the highest accuracy, FAR and FRR rate for all iris images compared to the existing methods. For example (for UBIRIS database), the proposed method (MCFC-LCE) gave 99.14% of accuracy and 0.0076 of FAR and 0.0051 of FRR, the PBIM approach [15] which gave 87% of accuracy and 45% of FAR and 7% of FRR, followed by the SURF approach [16] which gave 94% of accuracy and 39% of FAR and 6% of FRR. Overall, the proposed method of MCFC gives the better recognition results than the existing algorithms.

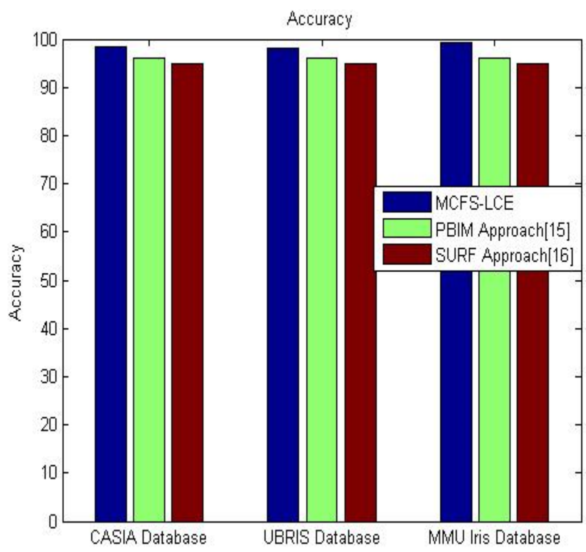


Fig. 4: Recognition performance of the proposed against existing systems [27] and [28] based Accuracy measure

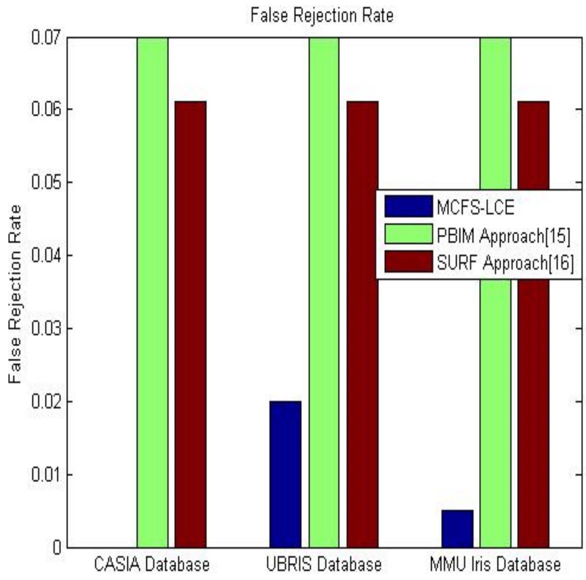


Fig. 5: Recognition performance of the proposed against existing systems [27] and [28] based FRR

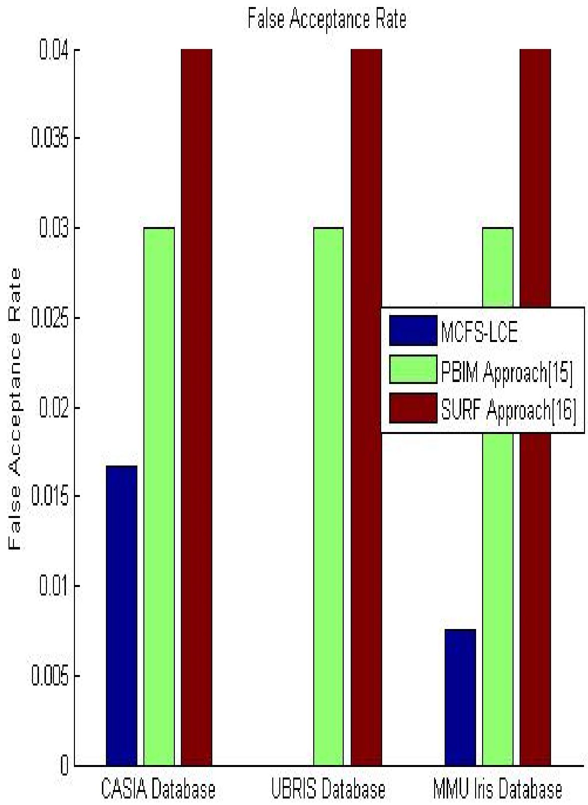
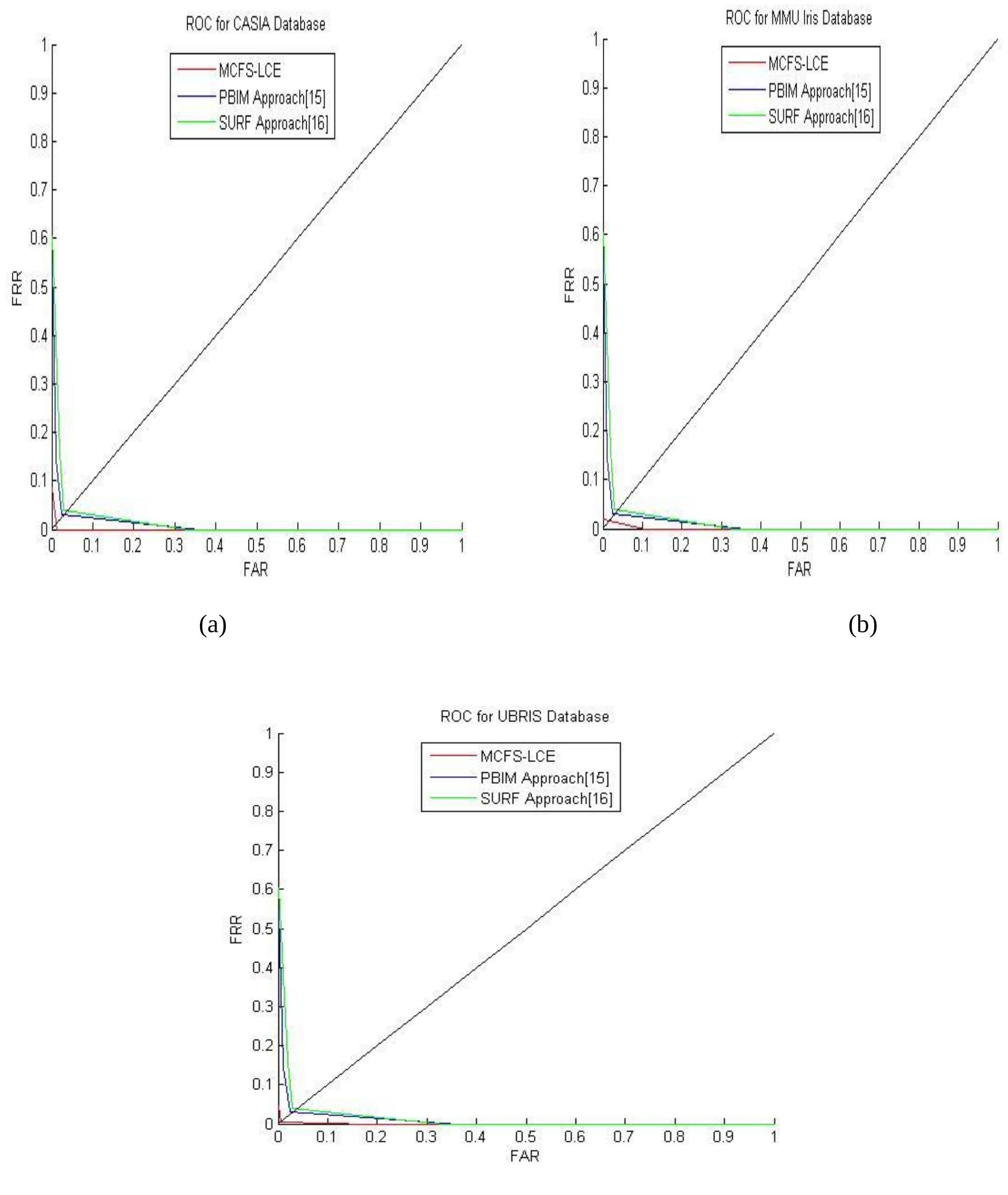


Fig. 6: Recognition performance of the proposed against existing systems [27] and [28] based FAR measure

❖ ***Detection Error Tradeoff (DET) performance***

Fig.7 explains the Detection Error Tradeoff (DET) performance of three iris datasets. It contains the DET curves obtained with proposed method (red lines) and PBIM approach [15] (blue lines) and SURF approach [16] (green lines). Overall, the performance of the proposed method achieves better performance than the existing approaches.



(a) (b) (c)

Fig. 7: Detection Error Tradeoff (DET) curves obtained for the CASIA, MMU and UBRIS databases

VII. CONCLUSION

Accuracy and robustness to the system is achieved with our iris segmentation and recognition method called as modified circular fuzzy segmentor (MCFS) model, which is perfectly segmenting the pupil and iris inner boundary. After segmenting, a binary encoder based feature extraction scheme named as LCE is proposed to extract all the significant features to do the iris recognition process. After completing the feature extraction scheme after applying the LCE operator, the fuzzy logic classifier is used to do the Iris recognition. Our tests has proven that on more challenging iris images databases set, CASIA, MMU, UBIRIS, confirmed that our method of segmentation is robust and achieved the gain in performance results. Our experimental results shown that, the proposed method of MCFS+LCE is outperformed than the existing methods. Our future work includes how to improve the robustness to segmentation error with different types of real-time and benchmark datasets found throughout the world.

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