Iris Image Enhancement for Biometric Personal Identification

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ABSTRACT**:** *Obtaining an iris image under uncontrolled and facing non friendly users, the chances of acquiring non ideal images is very high due to poor focus, off-angle, noise, and motion blur, occlusion of eyelashes and eyelids and wearing glasses. In order to improve the quality of these images, we propose a method which improves the quality of degraded iris images and ultimately improve the recognition accuracy. In the first step the iris image is localized, and then normalized the iris image to get the fixed size. In the second step, the valid region (iris region) is extracted from the segmented iris image so that to get only the iris region. In order to get well distributed texture image, bilinear interpolation is used to the segmented valid iris gray image. The low contrast of the resulted interpolated image is enhanced by histogram equalization. The 1D Gabor filter is applied to the gray image channels and gray texture information is extracted by 1D Gabor filter. And, the Hamming distance is chosen as a metric for recognition. The NICE-II training dataset taken from UBRIS.v2 was used for the experiment. The proposed method shows more enhanced performance in the aspect of FAR (False Acceptance Rate), FRR (False Rejection Rate) and EER (Equal Error Rate).*

Keywords: Iris Boundary, Bilinear Interpolation, Image Enhancement

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1. Introduction

Many methods for user identification are based on what a person possesses like physical key or ID card etc., or what a person knows like a secret password etc. All these methods have some problems that key may be lost, card may be forged and password may be forgotten. In recent days, there have been some growing interests on biometric user identification from both academia and industry [l]. And, most of all iris recognition systems available for user identification require near-infrared illumination. Since near-infrared illumination measurement is non-friendly to users, it also requires user's cooperation to capture an iris image with good quality. And it exerts as an additional burden for the user to participate in actively for the recognition of his/her ID. Therefore, there are some research issues to reduce this burden of users as much as possible by the improvement of performance of iris recognition even in the semi- or un-constrained environment [2].

Figure1 shows examples of noisy iris images, each affected by various factors such as low illumination, blurring, rotation, occlusion by eyelids and eyelashes, off-angle, and noises by Typical machine learning based approaches to text categorization are *K* Nearest Neighbor, Naïve Bayes, Support Vector Machine, and Neural Network. They are used not only for text categorization, but also for any pattern classification problem, such as image classification, protein classification, and character recognition.

Although there are other approaches than the named approaches, the four approaches are most typical and popular. In section II, we will present previous cases of applying the three approaches, namely *K* Nearest Neighbor, Naïve Bayes, and Support Vector Machine to text categorization.

glasses. These factors reduced the performance of iris recognition drastically. So it is necessary to eliminate these noises [3] and enhance the normalized iris image after localization. In this paper an efficient method to enhance the quality of normalized iris image is proposed which is composed of five steps as shown in fig.2. In first step the iris image is captured by the system, and then iris image is preprocessed in order to localize the pure iris and be normalized to the scale. And the localized and normalized iris image is enhanced by bilinear interpolation and histogram equalization. After extracting the features representing iris patterns, patterns are matched up with the previously stored database. Finally, the decision is made by the corresponding matching results.

(a) (b) (c) (d)

(e) (f) (g) (h)

Figure 1. The noisy iris images (NICE.II Training dataset) (a) Off-angle. (b) Low illumination (c) Occlusion by eyelashes (d) Occlusion by eyelids (e) Blurring (f) Rotation (g) Occlusion by ghost region (h) Occlusion by ghost region

2. Image Acquisition

The eye image to be analyzed must be acquired in digital form which is suitable for analysis. In further implementation we will be using NICE-II (Noisy Iris Challenge Evaluation - Part II) database from UBIRIS developed within the SOCIA Lab. (Soft Computing and Image Analysis Group) of the University of Beira Interior (Portugal) [4].

3. Preprocessing

The acquired image always contains not only the valuable parts i.e. the iris part, but also some irrelevant parts like eyelids, pupil etc. in some conditions, the iris image is in low contrast and brightness is not uniformly distributed. In addition, different distances from eye to camera may result in different image sizes of the same person eye. In order for analysis, the original image required preprocessing, which composed of three steps.

3.1 Iris Localization

The segmented iris image is provided by the NICE.II dataset as shown in figure 2 (b), but the pupil and iris pixel positions are not provided. To find the accurate centers, the iris center is calculating first by the geometric center of the black pixels. The radius of the iris region is calculated based on half of the difference between left and rightmost position of the pixels in the black region these values we select the left and right most position at which the gray value changes 255 to 0 and 0 to 255 respectively.

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(a) (b) (c)

Figure 2. Detection of pupil and iris boundaries (a) Original image (b) Segmented image provided by NICE-II (c) Result of pupil and iris boundaries

Now while detecting the pupil radius and center we are using the white pixels inside the black pixels as shown in figure 2. Considering the region where detected the rough position of iris center is considered as pupil area, we used component labeling algorithm [11] in this area, the accurate pupil center is calculated. Like iris radius based on the leftmost and rightmost position of the current pupil area, the exact pupil radius is obtained.

To find out the accurate iris center and radius we are using the detected rough center position and radius center. The circular edge detector is using to detect the accurate iris center and radius [5]. The following integro-differential operations is using for finding out the accurate center and radius of iris region.

$$\max_{(x_0, y_0), r} \left[\frac{\partial}{\partial r} \left(\int_{-\frac{\pi}{4}}^{\frac{\pi}{6}} \frac{I(x,y)}{5\pi r/12} ds + \int_{\frac{5\pi}{4}}^{\frac{5\pi}{6}} \frac{I(x,y)}{5\pi r/12} ds \right) \right] \quad (1)$$

Where 'r' is the radius of iris region, (x0,y0) is the center position if iris region. We are performing two integrodifferential operations in the range of –450 to 300 on the right side and 1500 to 2250 on the left side. The reason of selecting these two regions is only because other regions can be hidden by eyelids which can produce errors. Figure 2(c) shows the accurate boundaries of iris and pupil regions.

3.2 Normalization

The human irises from different people may be captured in different size, and even irises from the same person maybe different. The size may change, because due to variation in illuminations and variations of inner boundary is due to the dilation and contraction of pupil region. In order to reduce these variations and obtained a normalized iris images, the lengths of the inner and outer iris boundaries is adjusted in order to achieve more accurate recognition results.

The detected iris region shown in figure 4(b) is in Cartesian coordinates is transformed into that of polar coordinates shown in figure 3.3(c). The polar coordinates of iris image are divided into 8 tracks and 256 sectors [12].

In each track and sector the pixel values are averaged in vertical direction based on 1-D Gaussian kernel. As a result a normalized iris image of $256 * 8$ pixels is produced which reduce the errors, which arises while segmenting the iris image [10].

3.3 Iris Enhancement

After segmentation and localization of the iris image, it still has non uniform illuminations caused by the position of light, low contrast and noises, which will affect the recognition performance. The image enhance, which reduce the effect of non-uniform illumination and low contrast by using the following steps.

- Convert both the colored original image and segmented iris image to gray.
- Extract the valid region i.e. only the gray pixels from the segmented image by separating the gray pixels from white pixels.
- To enlarge the width and height to three times of both segmented and original image and set the iris radius to 125, because the iris diameter is from 200 to 250 pixels.

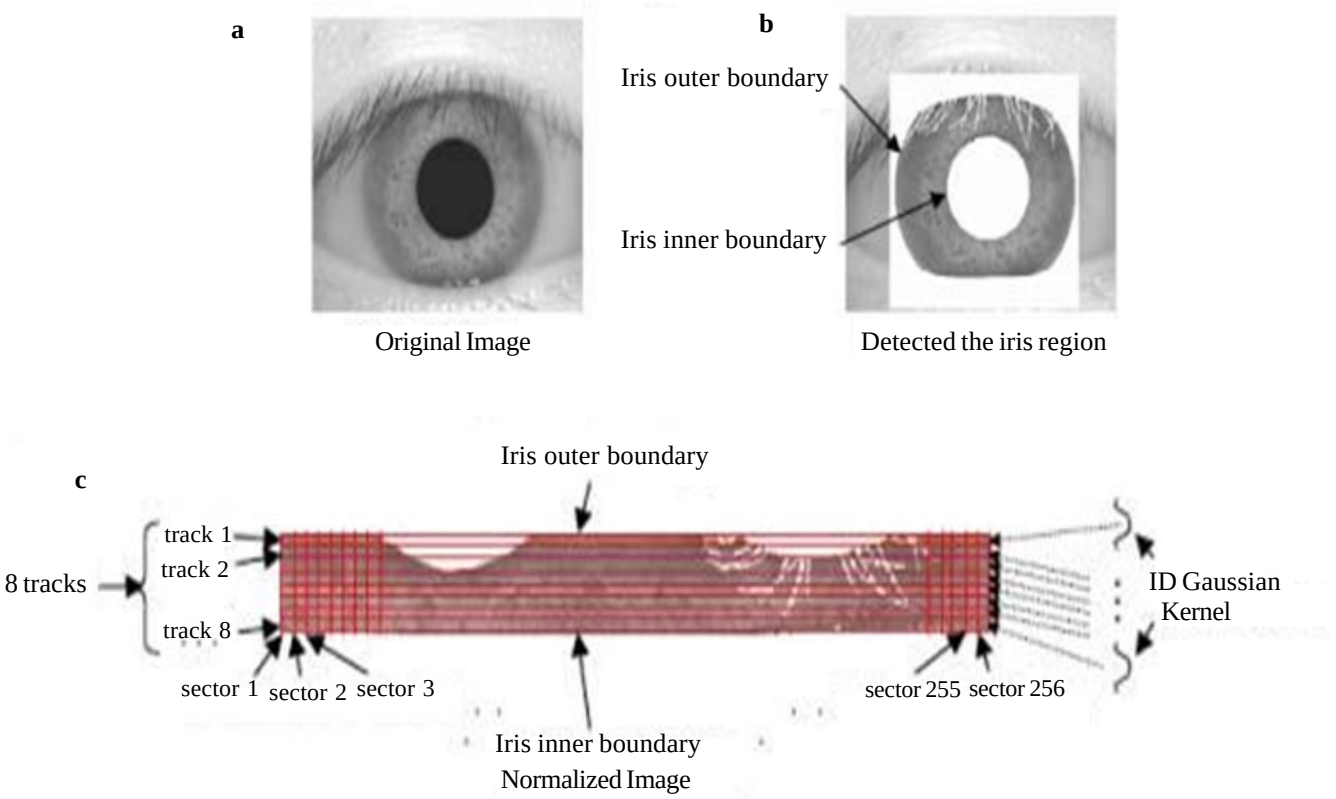

Figure 3. Normalization steps (a) Original image (b) Iris inner and outer boundary (c) Normalized image of 256 ∗ 8

- Interpolate the new segmented iris region by Nearest Neighbor interpolation and the original image by Bi- Linear interpolation.
- In order to get well distributed texture image we overlap the segmented iris region with the original image and got the result image of iris region.
- The low contrast of the resulted image of the previous image is enhanced by the histogram equalization method.

3.4 Feature Extraction and Matching

In order to extract the iris binary code, we are using 1D Gabor wavelet filter with the normalized iris image [6]. If the iris image has rich texture information of high contrast then the Gabor filter giving better performance. In order to get recognition accuracy, we select the possible optimal size and frequency by experiments. As we have eight tracks in normalized iris image, so using 1D Gabor filter the convolution of intensity is preformed in each track in horizontal direction. As shown in figure 4 (C) the width of normalized iris image consist of 256 pixels, so the convolution is performed at each pixel position of the entire width of each track of the normalized iris image.

As a result we obtained the magnitude value of 256 pixels of each track by using 1D Gabor filter [5]. The value obtained from the Gabor filter calculation is checking for positive or negative value. If the magnitude value is less than zero, the magnitude value would be zero. And else, the value would be 1. As a result we got 256 bits in each track and as each normalized image consist of 8 tracks so total 2048 bits (256 ∗ 8) [5]. All noisy iris region and iris regions which are occluded by eyelids, eyelashes is considered to be unreliable and not taking part for iris code matching.

For matching, the Hamming distance was chosen as a metric for recognition, since bitwise comparisons were necessary. The Hamming distance algorithm employed also incorporates noise masking, so that only significant bits are used in calculating the Hamming distance between two iris templates.

Methods	FAR	FRR	EER
Gray image from RGB	25.6830	25.7173	25.70
Histogram Equalization	24.5233	23.9633	24.2433
Un-Sharp Masking	24.8783	25.5218	25.2001
Histogram Stretching	25.1220	24.4921	24.8071
Bilinear Interpolation	23.4776	23.6014	23.5395
Combined Bilinear interpolation and UnSharp Masking	24.0126	23.7963	23.9044
Combined bilinear and histogram stretching using iris radius and valid iris region	**22.9626**	**23.5180**	**23.2403**

Table 1. The FAR, FRR and EER

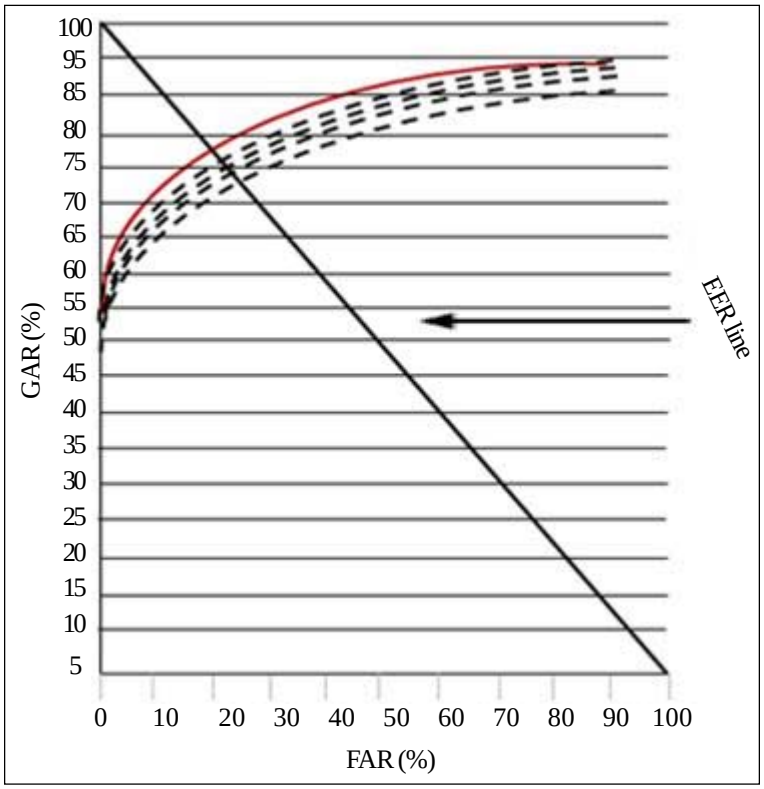

Figure 4. ROC curve of proposed method and existed simple methods

4. Experimental Results

The NICE.II dataset taken from UBIRIS.v2 databases is used for experiments. The NICE.II database consists of 1,000 images including 171 different classes. All images in RGB color and the image is 400 by 300 in resolutions. While doing the experiment the number of authentic test was 3,593 and the number of imposter test was 495,907.

In our experiment we tested FAR (False Accepting Rate), the error rate of accepting a genuine user as imposter and FRR (False Rejecting Rate), the error rate of accepting an imposter as genuine user and EER (Equal Error Rate) [8]. The EER is the error rate

when the FAR is the same as that of FRR. In conventional biometric have converse relationship, because if the FAR becomes greater FRR would be smaller and vice versa.

4.1 Comparing with Existing Methods

Several enhancement methods have been proposed for the improving of iris recognition. In order to compare our method with the previous methods, we used the algorithm of histogram equalization used in [7] and [9], histogram stretching used in [8], low pass un-sharp filter, only Gray image used in [10] and interpolation methods.

Table-1 shows that the FAR, FRR and EER of the proposed methods are lower than the previous methods used in simple way. The figure 4 below shows the Receiver Operational Characteristic (ROC) curves with the genuine acceptance rate (GAR), the GAR is an overall accuracy measurement of a biometric system; it is calculated by the formula given below [6].

$$\textit{Genuine Acceptance Rate}\ (GAR) = (100 - FRR\ (\%))$$

The higher the GAR rate the higher would be recognition accuracy. As shown in figure 5 the recognition accuracy of the proposed method is higher than that of the previous methods.

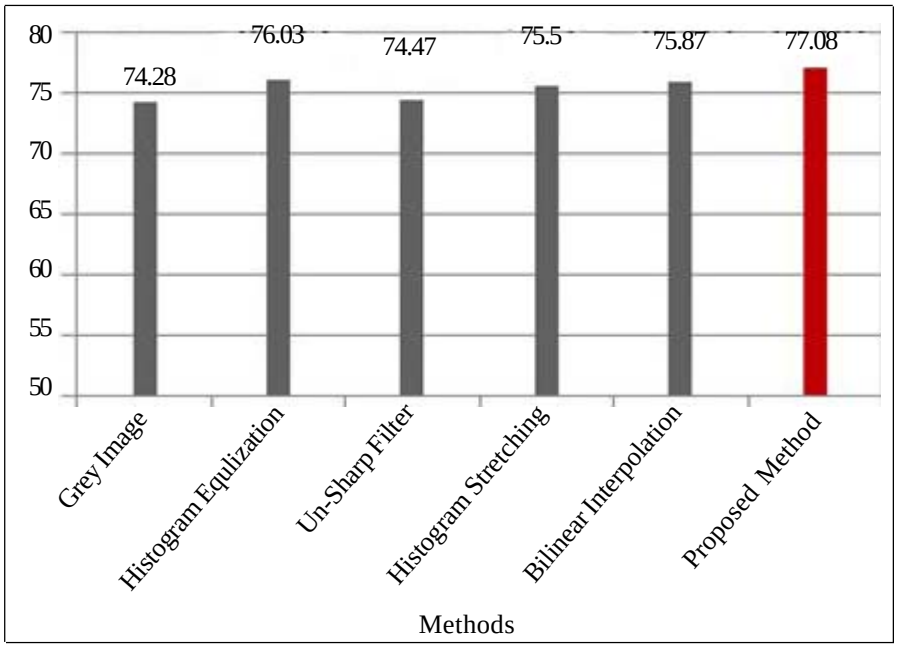

Figure 5. Recognition Accuracy in the form of Genuine Acceptance Rate (GAR)

5. Conclusions

In this paper, a simple and effective algorithm is proposed for the iris image enhancement. The ultimate goal was to improve the performance of iris recognition even when the image is degraded or noisy input is occurred. Experimental results show that the proposed method can show better results compared with the previous simple methods. And these results can be used to make a personalized service system in the special environment such as the personalized interactive theater where the user gazes in the specific direction most of all time.

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