

NOVEL APPROACH OF ACCURATE IRIS LOCALISATION FORM HIGH RESOLUTION EYE IMAGES SUITABLE FOR FAKE IRIS DETECTION

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High resolution images not only provide high recognition rate but also useful in safeguarding the iris recognition system from fake iris attack. To safeguard the iris recognition system against fake irises, one of the very popular technique is to detect the change in pupil size due to change in illumination. Many of existing methods assume that iris and pupil are circular or elliptical in nature, which is seldom true but they are actually of irregular shapes. Such methods fails in accurate iris segmentation from high resolution images. because these images shows low intensity gradient across the sclera-iris boundary and iris-pupil boundary. This paper presents a novel approach of accurate iris segmentation using two images captured at two different intensities. This method is completely robust for fake iris detection because it exploits the pupil dynamics for iris localisation. The success rate of accurate iris localisation from an high resolution image (UPOL database) is 99.45% and that from moderate resolution images (UBIRIS database) is 100%. Only occlusion-free images of UBIRIS database has been considered.

Keywords: Iris Segmentation, Fake Iris, Pupil Dynamics, Biometrics, Iris Localization

1. INTRODUCTION

Biometric based identification of people is getting more and more importance in the increasing network society [1]. Various types of biometrics include face, finger, iris, retina, hand geometry, palm print, ear, voice etc. In all of these characteristics, iris recognition is the gaining more attention because iris of every person is unique and it never changes during a person's lifetime[2-4]. Its complex pattern contains many distinctive features such as arching ligaments, furrows, ridges, crypts, rings, corona, freckles and zigzag collarette [2].

The acquired image of eye contains iris along with pupil and data derived from the surrounding eye region like sclera, eyelid and eyelashes. The acquired eye image has to be segmented to detect the iris, which is an annular portion between the pupil (inner boundary) and the sclera (outer boundary). The important steps involved are outer boundary (sclera along with eyelashes and eyelids) detection and inner boundary (pupil) detection.

Therefore, prior to calculating the features of iris and iris matching, it is very important to accurately segment and localize the iris from the acquired eye image because the overall performance of iris recognition system is decided firstly by the fact that how accurate iris is segmented and localized from an eye image and secondly by the resolution of an image.

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The reminder of this paper covers related work, motivation, proposed method, outer boundary detection, inner boundary detection, experimental results and conclusions in Sections 2, 3, 4, 5 and 6 respectively.

2. RELATED WORK

A generalised iris recognition system consists of: image acquisition, iris segmentation and localization (preprocessing), feature extraction and feature comparison (matching) stages. Biometric based personal identification using iris requires accurate iris segmentation and localization for successful identification/ recognition [3-11]. Several researchers have implemented various methods for segmentation and localising the iris. John Daugman [4-7] has proposed one of the most practical and robust methodologies, providing the groundwork of many functioning systems. He used integro-differential operator to find both the iris inner and outer boundaries for iris segmentation. A gradient-based binary edge map construction, as proposed by Wildes[8], with circular Hough transform used for iris segmentation. Several researchers have proposed several variants of these methods with minor modifications in their research schemes [9-14]. e.g. Narote et. al has proposed one of such modification to determine an automated threshold for binarization based on histogram [13]. All these methods are based on one or more assumptions as listed below:

- (i) Centre of iris is considered as centre of pupil.
- (ii) Pupil and iris are perfectly circular in shape.
- (iii) Iris (Outer Boundary) and Pupil (Inner boundary) are two concentric circles.

However, these are seldom true resulting into inaccurate iris segmentation and localization from an acquired image which leads to loss of important part (unique features) of iris near pupil and/or near outer boundary. The effect is more serious when iris is towards either left or right side of an eye.

3. MOTIVATION

The visual and empirical study of CASIA[15], UBIRIS[16] and Phoenix[17] iris image databases is carried out and following facts are observed:

- (i) CASIA images are low resolution, UBIRIS images and Phonics images are high resolution.
- (ii) Gradient of intensity across sclera-iris boundary and across-pupil is very high in CASIA images, moderate in UBIRIS images and high in Phonics images. It is high for high resolution images as compared to low resolution images.
- (iii) In practice, use of high resolution images is obvious for better recognition rate with the availability of high resolution cameras and large memory devices at lower cost.
- (iv) Reflectance of flash light is observed in pupil region of CASIA and Phonics database images.
- (v) Effect of eyelid and eyelashes is more in CASIA as compared to other database but sufficient successful techniques[3][11] have been proposed to overcome this problem.
- (vi) The assumption that an iris and a pupil are circular in nature, which is seldom true but they are actually in form of irregular shapes.

Sample image of each database is shown in Fig (1). From the study, it is very clear that pupil detection and outer boundary detection in Phonics database is most challenging because it has high resolution, low intensity gradients and reflection of flash light in a pupil. Therefore, it results into failure of many segmentation techniques for such type of images. These studies have motivated the authors to propose new robust iris segmentation and localisation technique which is capable to segment and localise the exact iris boundary very accurately.

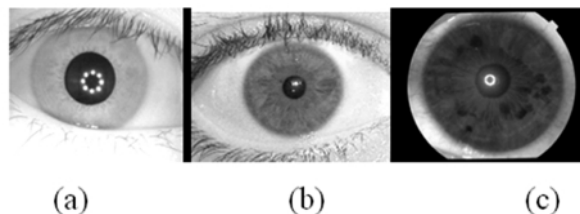


Fig. 1: Sample Images of (a) CASIA Database, (b) UBIRIS Database and (c) Phonix Database

4. PROPOSED METHOD

Authors proposed a novel approach of iris segmentation and localisation based on comparison of two images for complete and accurate segmentation of iris without loss of iris features, dynamically.

The proposed method uses two or more images of same subject acquired at different intensities and/or different wavelengths of light to detect the changes in size of pupil (Pupil dynamics) and changes in light reflectance ratio of iris and sclera (Reflectance ratio) so that iris of exact shape is accurately segmented and localized. As Pupil dynamics and Reflectance ratio is also used for Fake Iris Detection for an automated iris recognition systems[7][18-23], this method is inherently capable of detection of fake iris.

The proposed algorithm is implemented in MATLAB7.0, on PIV-3Ghz, Intel processor with 512MB RAM and tested on Phoenix database[17].

The complete overview of the proposed system is represented by a flowchart as shown in Fig (2). The system mainly consists of: preprocessing, outer boundary (sclera-iris) detection, inner boundary (iris-pupil) detection and normalisation.

4.1. Preprocessing

Firstly, an eye image is converted to grayscale image. Grayscale image is checked for intensity gradients corrective action is initiated to improve it. For selection of outer and inner boundaries, grey scale image is converted into binary image. Fig. 3(a-c) shows an original eye image, its grayscale, binary and inverted binary image respectively.

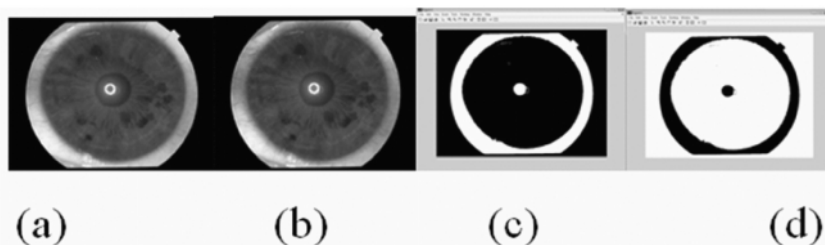


Fig. 3: (a) Original Eye Image (b) Grayscale Image (c) Binary Image (d) Inverted Binary Image

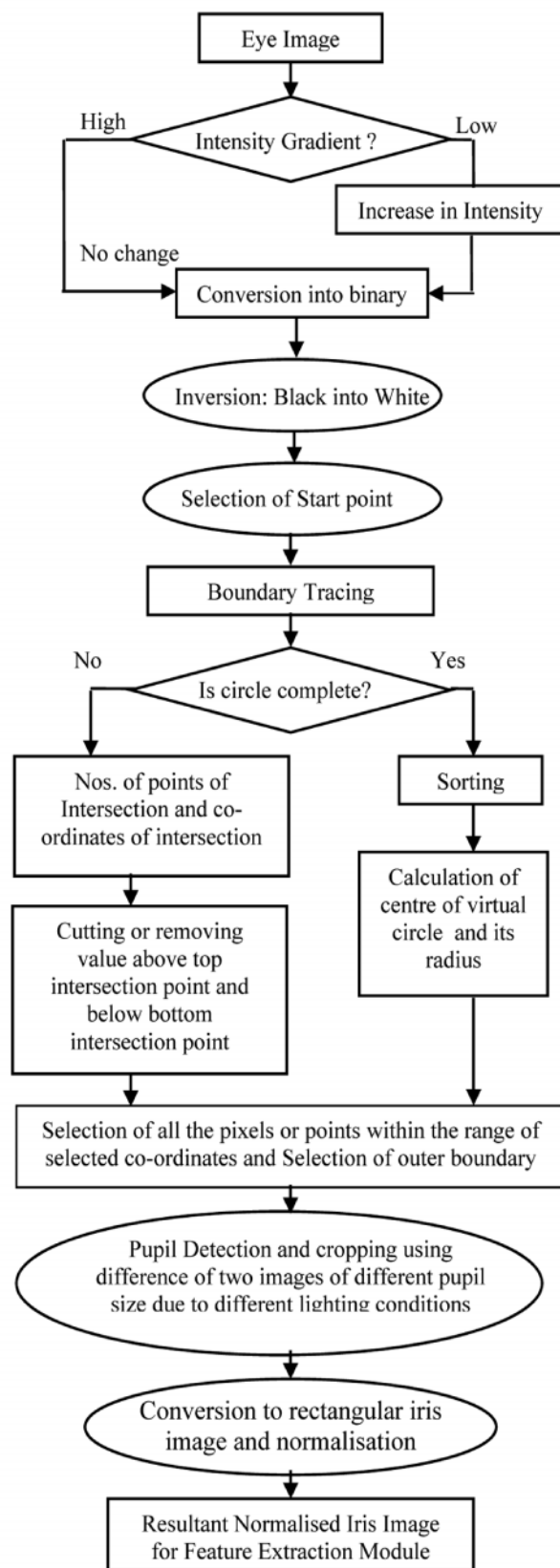


Fig. 2: Flowchart of the Proposed Method

4.2. Outer Boundary Detection

Existing algorithms assume iris images as exactly circular in nature, which is seldom true but such assumption results into failure in certain high resolution images where intensity gradients across sclera-iris and iris-pupil is low. When high resolution images where intensity gradients across sclera-iris and iris-pupil is low are converted into binary images, resultant images are not in form of circular objects but they are actually in form of irregular shapes. In this algorithm, binary image is traced and pixels are classified based upon values of their intensities i.e. one group with intensity values of 255 (White, Level 1) and other with intensity of 0 (Black, Level 0) as shown in Fig. 3(c). Then, binary image is inverted as shown in Fig 3(d).

Boundary is traced for all points with binary value as 1 in all direction starting from selected point that is the first point that has value as 0 coming from top to bottom in any one quarter of image. Thus, complete boundary is traced for a complete iris without any intersection.

For images with intersection with upper or lower eyelids as shown in Fig (4-b) may not result into a complete one object (closed circular path), for such cases, point of intersection is calculated and all points above point of intersection in case of intersection with upper eyelid and points below in case of intersection with lower eyelids are removed. The traced boundary of iris is shown with green colour and a virtual circle is drawn using all these traced points with blue colour as shown in Fig (4). In case of complete iris, area under the traced circle (green colour) boundary is selected and in case of intersection, area within virtual circle (blue colour) boundary is selected. This selected area is cropped from rest of the image and copied to new image which is used for pupil detection stage. Similar technique is used for second image of the same subject. Two different images of same subject will have differences, especially, in the size of pupils. Therefore, these images are used for test of pupil dynamics to detect fake iris from real one. The authors are also working on development of robust fake iris detection algorithm.

4.3. Pupil Detection

Once the iris has been separated from the rest of the eye, next step is to remove the pupil. Pupil is the darkest portion near the center of the eye. So the middle portion of the eye within the limits defined is scanned for pixels with intensity less than 60. This particular threshold is an approximation based on the analysis of the iris database and its variation may give different and incorrect results. Therefore, to avoid such variation, two image reference method is used.

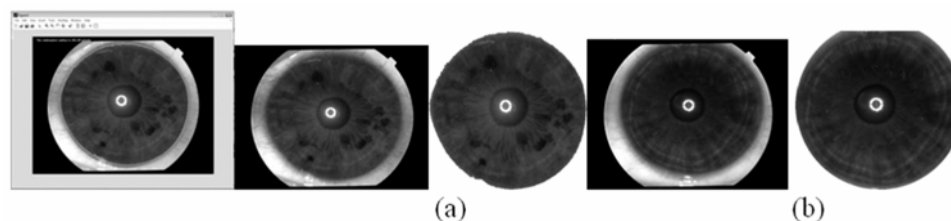


Fig. 4: Tracing of Outer Iris Boundary and Cropping of Iris for (a) Complete Circle and (b) Incomplete Circle

In this method, it is assumed that, two images of same subject are acquired in a small interval of time (one after another) under different light intensities. These images are first converted to binary images then binary images are compared / subtracted to detect the variation in size of pupil. As iris part of two images is same, result of subtraction will give 0 value and only place where non zero values are obtained is the region of pupil due to variation in size of pupil.

The nature of pupil within iris is very complex, and due to flash lights and other room lights it produces lots of variation in intensities of iris and bright light spots in pupil as shown in Fig. 5. Therefore, above test may result into number of small parts (regions) of pupils as noise or unwanted information instead of one complete pupil as shown in Fig. 5(a). These small parts (regions) of pupil need to be removed. This is achieved by tracing an image for any region of less than 30 pixels. If such region is detected then this is removed considering the fact that size of pupil is certainly much larger than 30 pixels. This results into removal of extra unwanted information and detection of complete pupil from iris as shown in Fig 5(b).

Tracing this inner boundary and selecting region outside inner boundary and below outer boundary will give exact iris with minimum losses as shown in Fig 5(c).

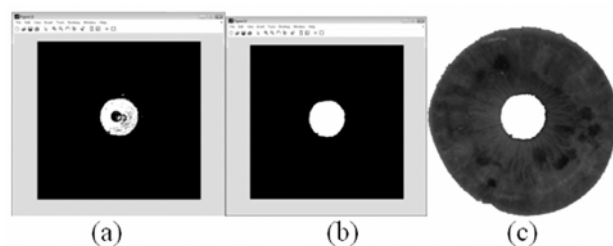


Fig. 5: Pupil Detection

For detection of dynamics in pupil, variation in size of pupils of two images of same subject is detected. If variation is in the range of 5 to 15%, then it may be considered as real eye, else fake eye.

Finally, completely detected iris is converted to rectangular image using normalization Equation (1) and (2) as shown in Fig 6(b).

$$x_1 = x + r * \cos(\Phi) \quad (1)$$

$$y_1 = y + r * \sin(\Phi) \quad (2)$$

where, (x, y) are the coordinates of center of the ring,

(x_1, y_1) are the coordinates of pixel of rectangular image, r is a radius of iris ring that varies from inner to outer boundary of iris image and Φ is an angle of that varies from 0 to 360 degree.

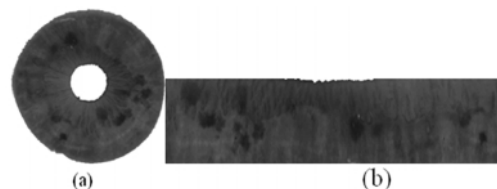


Fig. 6: (a) Segmented iris (b) Normalised rectangular iris

5. RESULTS

The algorithm is tested high resolution images of UPOL database and occlusion free, moderate resolution images of UBIRIS database.

The Phonics database contains $3 \times 128 = 384$ iris images (i.e. 3×64 left and 3×64 right). The images are: 24 bit - RGB, 576×768 pixels, file format: PNG. The irises were scanned by TOPCON TRC501A optical device connected with SONYDXC-950P3 CCD camera[17]. The proposed algorithm is implemented in MATLAB7.0, on PIV-3Ghz, Intel processor with 512MB RAM and tested on Phoenix database[17].

The success rate of accurate iris localisation from an high resolution image (UPOL database) is 99.45% and that from moderate resolution images (UBIRIS database) is 100%. Only occlusion-free images of UBIRIS database has been considered.

Moreover, extracted irises showed very minimal loss of iris texture features as compared to existing methods. specially for high contrast iris images where many existing methods underperform.

Fig 7 shows the output of various stages of algorithm for sample images of database.

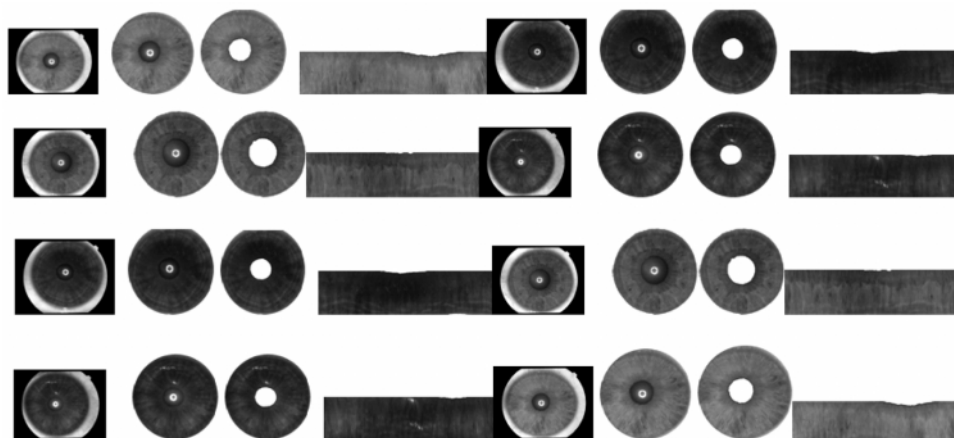


Fig. 7: Accurate Iris Segmentation Output for Sample Eye Images

The segmentation accuracy and timing analysis of the algorithm and its comparison with existing algorithms is given in Table 1.

Table 1
Result of Segmentation Accuracy and Timing Analysis

| Methodology | Accuracy | Time in Seconds |
|-------------|---|-----------------|
| Proposed | 99.45 % (UPOL database) 100 % (UBIRIS database) | 1.39 |
| Daugman[4] | 67.23% | 1.03 |
| Wildes[3] | 88.49% | 1.3 |
| Masek[12] | 83.97% | 7.8 |
| Narote[13] | 91.33% | 1.21 |

6. CONCLUSIONS

The proposed method not only showed the very high accuracy rate of iris segmentation at comparable timing cost but also very accurate segmentation of iris with minimal loss of features.

The strength of the method is that it does not based on the above stated assumptions which are seldom true but it uses a very practical approach which is based on the comparison of two iris images at different light intensities to detect the change in the size of pupil.

Thus, this is a very promising technique for making iris recognition systems more robust against fake-iris-based spoofing attempts[18]. This makes this method more useful than any other methods.

We are extending the use of this method for fake iris detection / aliveness detection of iris for full-proof iris recognition system using Shift Invariant Iris Feature Extraction Using Rotated Complex Wavelet and Complex Wavelet for Iris Recognition System[14] for good recognition rate with inherent anti-spoofing mechanism[18-23].

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