International Journal of Computer Information Systems and Industrial Management Applications (IJCISIM)
ISSN: 2150-7988 Vol.2 (2010), pp.163-173
http://www.mirlabs.org/ijcisim

Dynamic Iris Localisation: A Novel Approach suitable for Fake Iris Detection

Rajesh Bodade [1], Dr Sanjay Talbar [2]

[1] Military College of Telecommunication Engineering, Mhow-453441, INDIA

[2] S.G.G.S. Institute if Engineering and Technology, Nanded, INDIA

rajeshbodade@gmail.com, sntalbar@sggs.ac.in

Abstract

High resolution images not only provide high recognition rate but are 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. They are actually of irregular shapes. Such methods fail in accurate iris segmentation from high resolution images. because these images show 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 localization. The success rate of accurate iris localization from 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 have been considered. The FAR and FRR values of the composite method of fake iris detection are 0.625% and 0.625% respectively.

***KEYWORDS*:** Fake iris detection, Fake Iris , Pupil Dynamics, Biometrics, Iris Localization

1. Introduction

Biometric based identification of people is getting more and more importance in the increasing networked 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 gaining greater 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 how accurate iris is segmented and localized from an eye image and secondly by the resolution of an image.

The remainder of this paper covers related work, motivation, proposed method, fake iris detection, experimental results and conclusions in Sections 2, 3, 4, 5, 6 and 7 respectively.

2. Related work

A generalized 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 localizing 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 have proposed one 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 in 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 vey 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 localization technique which is capable on segmenting and localizing the exact iris boundary very accurately.

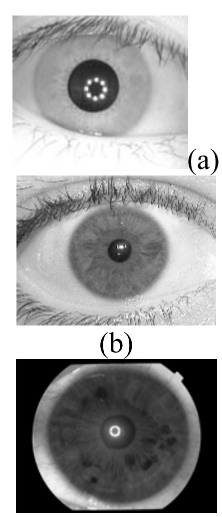

(a) (b) (c)

Fig. 1 Sample images of (a) CASIA database, (b) UBIRIS database and (c) Phonix database

4. Proposed Method

The authors have 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.

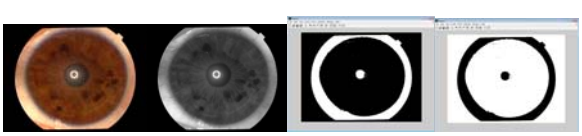
The proposed method uses two or more images of same subject acquired at different intensities and/or different wavelengths of light to detect the changes in size of pupil (Pupil dynamics) and changes in light reflectance ratio of iris and sclera (Reflectance ratio) so that iris of exact shape is accurately 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 normalization.

4.1 Preprocessing

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



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

Fig 3 (a) Original eye image (b) Grayscale image (c) Binary image (d) Inverted binary image

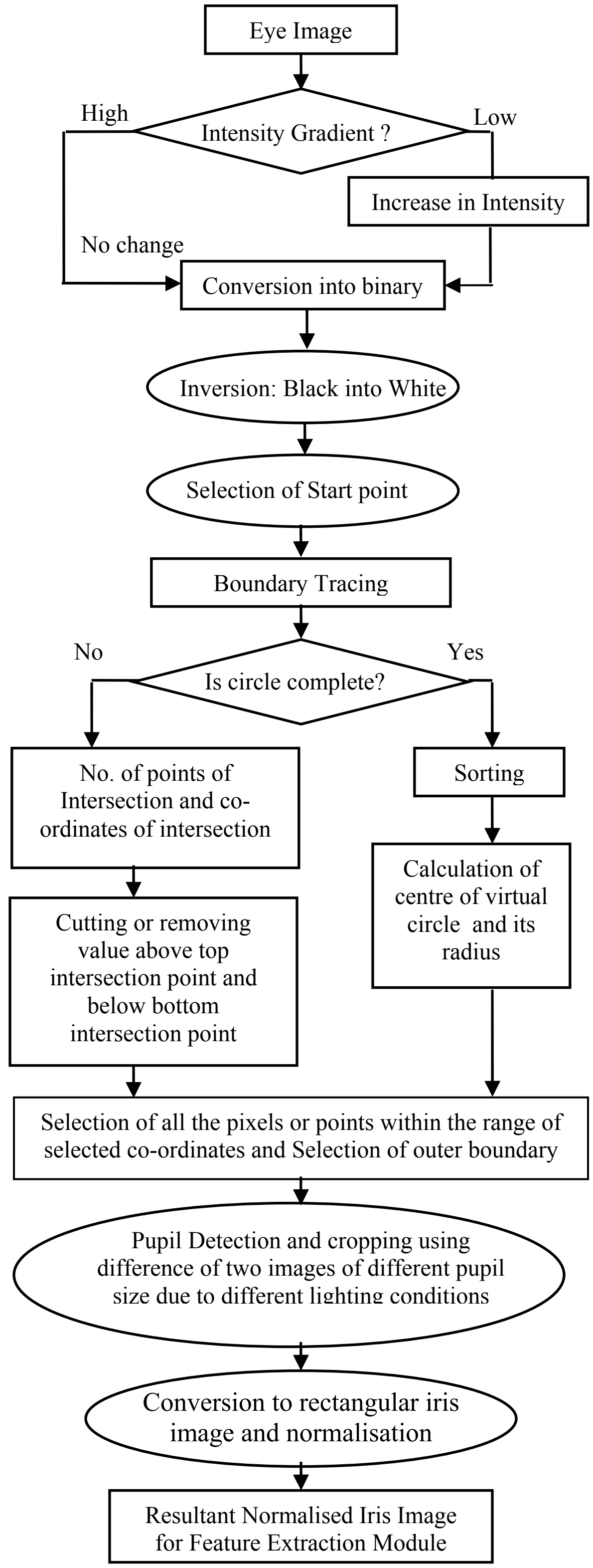


Fig 2. Flowchart of the proposed method

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 in the 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
.

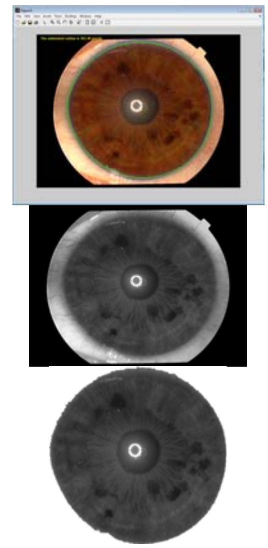


Fig 4(a) Tracing of outer iris boundary and cropping of iris for Complete circle

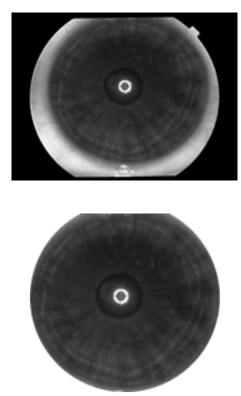
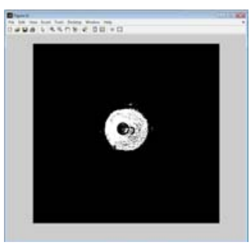
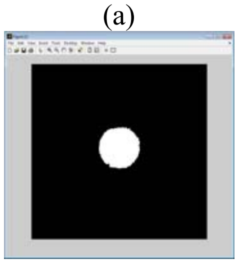
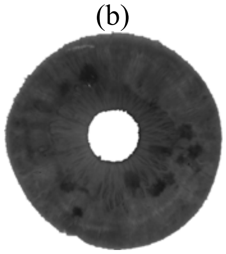


Fig 4(b) Tracing of outer iris boundary and cropping of iris for Incomplete circle

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).


(a)

(b)

(c)
Fig 5 Steps of 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).

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

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

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 form 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

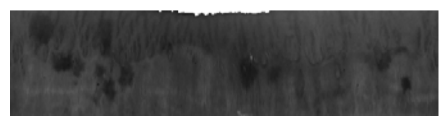


Fig 6 (b) Normalised rectangular iris

5. Fake Iris and it’s Detection Methods

It has been reported that iris recognition systems have also been deceived by fake biometrics which is called fake iris. For instance, L. Thalheim and J. Krissler captured user's eye images with a camera used in a commercial iris recognition system and printed the images on matte paper. They then cut off a hole in the pupil and succeeded in deceiving the commercial iris recognition system with this printed fake iris.

Fake irises can be of five types, namely eye print out, eye movie, rubber eye, printed eye lens and, dead eye. There is a need for the iris counterfeit classification as well as for a systematic approach to subterfuge prevention. Some issues regarding the iris aliveness were already addressed by Daugman [20]. Here classification of a few variants of iris counterfeits detection into several groups, characterized by the increasing level of the methods sophistication have been done.

5.1 Frequency Spectrum Analysis based Fake Iris Detection Method

The first group – passive measurements - relies on characteristics of the living eye as opposed to artificial objects. These may include a smoothness of the frequency spectrum typically obtained for images of live organ. The same frequency analysis reveals dominating frequencies, which may indicate that the iris image was altered in a regular way, e.g. by printing using a raster device. Frequency spectrum seems to be a straightforward source of information concerning the existence of regular artefacts within the image. The concept of artificial frequencies localization prior to the iris recognition was already suggested in the literature [20], however no automatic methodology was proposed to materialize the ideas existing for years. Frequency spectrum methodology has an important advantage, namely, it requires no additional hardware, since the same static image as used in the iris recognition may be analyzed. On the other hand, the method has a serious drawback, originating from Shanon's theory. It is that the method fails once the resolution of the printing device, used for counterfeit preparation is more than twice the resolution of the analysis camera [24]. Fig 7 shows the real and printed irises along with their spectra.

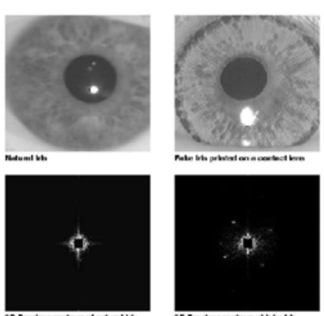


Fig7 Spectrum of real and printed iris

5.2 Wavelength Reflectance based Fake Iris Detection Method

The second group of countermeasures to iris spoofing includes the methods examining the internal eye structure. Two Daugman's propositions may be classified into this countermeasure class, namely the analysis of the eye tissue at different wavelengths and analysis of the so called Purkinje reflections [20]. Since the melanin pigment responsible for the eye colour has a specific infrared light absorption profile, this may be used to distinguish between a live tissue enriched with melanin and e.g. the glassy eye imitation free from organic elements. On the other hand, the Purkinje reflections are difficult to be observed, and typically only two out of four are clearly visible. This is difficult to observe and calculate. Figure 8 shows the distribution of the P_{850}/P_{750} values of the live and fake irises.

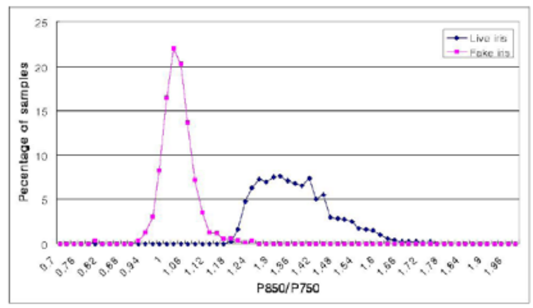


Fig 8 Distribution of the P_{850}/P_{750} values of the live and fake irises

5.3 Pupil Dynamics based Fake Iris Detection Method

The third group of possible antispoofing mechanisms is based on dynamic (i.e. behavioural) eye features. It was suggested in literature that the human pupil oscillates constantly with the approximate frequency of 0.5 Hz, even in a uniform lighting conditions. This phenomenon, called the hippus, is relatively easy to be passively measured if it is observed for an eye. However, our tests disclosed that not all eyes reveal a sufficient hippus signal that might be unmistakably distinguished from the noise using the same measuring equipment as that used for iris recognition.

It seems that the dynamic features of the eye observed within certain time horizon should be a result of a certain interaction between the user and the machine. This makes the measurement active. The human-machine interaction may be twofold. The first, command driven reaction, is the consequence of the system request to perform some action by the user requesting to be authenticated. This may include blinks or eye movement forced by an object tracking. However, this kind of interaction may be uncomfortable to the user, since a supplementary training is required besides the one offered prior to the iris biometrics usage. Moreover, this kind of anti-spoofing mechanism is difficult to implement in negative identification systems, i.e. systems aiming at recognizing criminals. Figure 9 shows the variation in pupil size due to change in intensity of light.

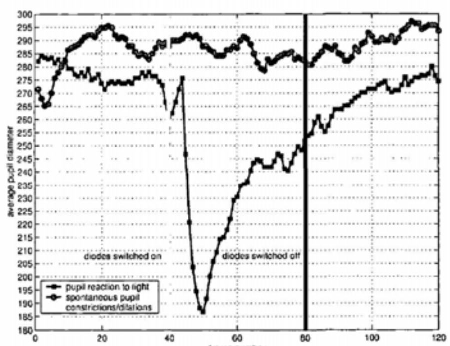


Fig 9 Variation of pupil size due to change in intensity of light

Almost ideal situation is to actively measure those stimulus driven eye dynamic features which are independent of our consciousness, and are not interfering with typical iris recognition process. One such feature is the pupil dynamics. Primarily, the pupil constriction and dilation partially influences the human eye accommodation process and is classified in psychology as the conditional response. There was a lot of research referring to this phenomenon. Since early 60's there is a research aiming at modeling the pupil reflex as a control system. In 1967 Clynes and Cohn proposed [21] a model of human pupil response to step luminescence changes.

Each person looked into the camera lens, identically as during the iris enrolment or verification procedures. The system waits for 4 seconds to guarantee a stabilization of pupil just after the accommodation process. The LED is then lit-up and the acquisition starts. Report recorded 25 frames per second (i.e. a frame comes every 40 ms) and the acquisition time was set experimentally to 4 seconds. This is sufficient to observe the entire pupil reaction to light changes.

This method requires two images at two intensities to compare the pupil dynamics which is also exploited for accurate iris localization from the eye images. Thus, Fake iris detection is inherently done in the iris localization algorithm.

Fake iris detection methods based on passive measures (first two methods) have been researched much more than active or dynamic measures (third method) , due to the ease of applicability. All the methods have their own advantages and drawbacks.

5.4 Possible outcome of Fake Iris Detection

Each kind of fake iris has few peculiar characteristics. On this basis it can be predicted which of the active and passive methods will be able to detect a particular type of fake iris. Active methods concentrate on change in the area of the iris and pupil inversely, i.e. as the pupil contracts, area of iris will increase and as the pupil dilates the area of the iris decreases. Passive methods don't require any change in the image. They analyze the characteristics of the image itself. Wavelength reflectance method and analysis of the frequency spectrum are used to detect fake iris based on expected aberrations in the image of a fake iris. Table 1 summarizes the possible outcomes of passive and active method.

Table 1 Fake iris detection by active and passive methods

Type of fake iris | method	Active method	Passive method
Eye print out	Contentious	Detect
Eye movie	Not detect	Detect
Rubber eye	Detect	Contentious
Printed eye lens	Detect	Contentious
Dead eye	Detect	Not detect

Therefore, we have developed a composite method for robust fake iris detection employing multiple methods. However, the method based on pupil dynamics is inherently carried out during the accurate iris localization algorithm as explained in section 4 above.

Thus, the proposed method of iris localization not only localizes and segments the iris accurately from an eye image but checks the fakeness of the iris using pupil dynamics.

6. Results

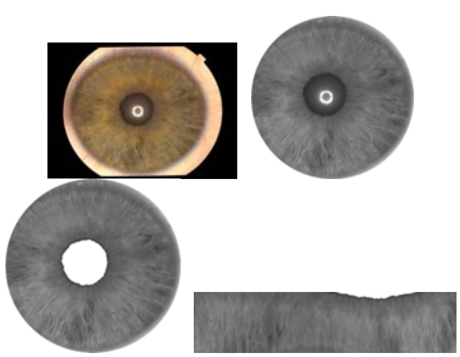
The algorithm is tested using high resolution images of UPOL database and occlusion free, moderate resolution images of UBIRIS database.

The UBIRIS database [16] consists of 2400 iris images of 240 subjects in two distinct sessions. The UPOL database contains 3 x 128 = 384 iris images (i.e. 3 x 64 left and 3 x 64 right). The images are: 24 bit - RGB, 576 x768 pixels, file format: PNG. The irises were scanned by TOPCON TRC50IA 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 both the databases.

The success rate of accurate iris localization from a 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 have been considered.

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

Fig 10 shows the output of various stages of algorithm for sample images of database.



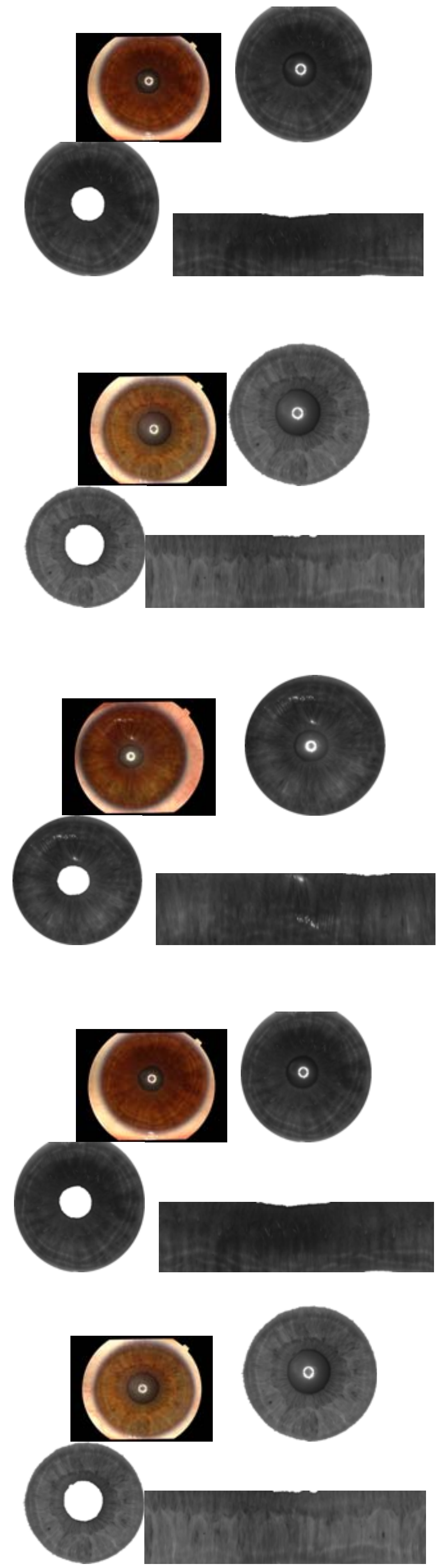


Fig 10 Output of four stages of accurate iris localization for the sample eye images

The segmentation accuracy and timing analysis of the algorithm and its comparison with existing algorithms is given in Table 2.

Table 2. 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

For implemented *active method*, obtained FAR and FRR values are 24.3% and 0.625%, respectively which are shown in Fig 11.

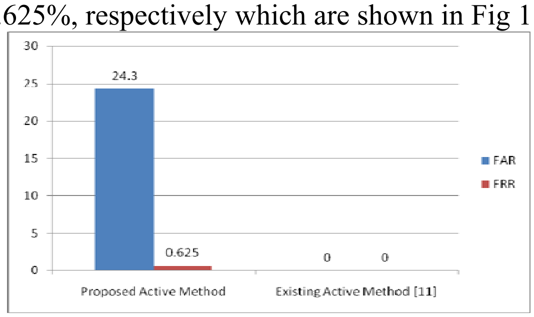


Fig 11 Comparison of proposed active method to existing active method

For implemented *passive methods*, FAR and FRR are 23.75% and 1.25%, respectively are obtained as shown in Figure12.

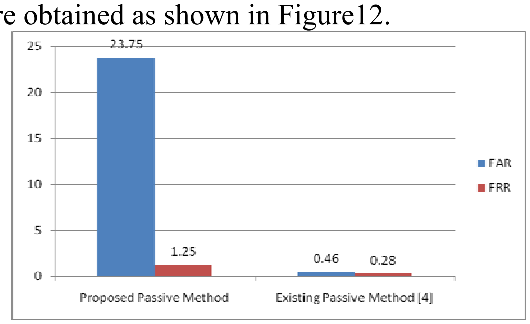


Fig 12 Comparison of proposed passive method to existing passive method

The large FAR values can be attributed to wide scope of database used to simulate fake irises. The FAR and FRR values of the *composite method* are 0.625% and 0.625% respectively.

7. 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 is not based on the above stated assumptions which are seldom true but that 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 [18-24].

References

[1] Biometrics: Personal Identification in a Networked Society, A. Jain, R. Bolle and S. Pankanti, eds. Kluwer,1999.

[2]R. Johnson, "Can Iris Patterns Be Used to Identify People?"Chemical and Laser Sciences Division, LANL, Calif., 1991.

[3] W. Kong, D. Zhang, "Accurate iris segmentation based on novel reflection and eyelash detection model," Proceedings of 2001 International Symposium on Intelligent Multimedia, Video and Speech Processing, Hong Kong, pp. 263–266, May 2001.

[4] J. Daugman , "How iris recognition works," IEEE Transactions on Circuits and Systems for Video Technology, vol. 14, pp. 21–30,January 2004.

[5] J. Daugman, "High Confidence Visual Recognition of Persons by a Test of Statistical Independence," IEEE Trans. PAMI, vol. 15, no. 11, pp. 1148-1161, Nov. 1993.

[6] J. Daugman, Biometric Personal Identification System Based on Iris Analysis, United States Patent, no. 5291560, 1994.
[7] John Daugman, "Anti-spoofing Liveness Detection", available on-line at http://www.cl.cam.ac.uk/users/igdl000/countermeasures.pdf
[8] R. Wildes, "Iris Recognition: An Emerging Biometric Technology," Proc. IEEE, vol. 85, pp. 1348-1363, 1997.
[9] W. Boles and B. Boashash, "A Human Identification Technique Using Images of the Iris and Wavelet Transform," IEEE Trans. Signal Processing, vol. 46, no.4, pp. 1185-1188, 1998.
[10] C. Sanchez-Avila and R. Sanchez-Reillo, "Iris-Based Biometric Recognition Using Dyadic Wavelet Transform," IEEE Aerospace and Electronic Systems Magazine, pp. 3-6, Oct. 2002.
[11] L. Ma, Y. Wang, and T. Tan, "Personal Identification Based on Iris Texture Analysis," IEEE Trans. On PAMI, vol. 25, No. 12, pp. 414-417, Dec 2003.
[12] Masek L, Kovesi P (2003), "MATLAB source code for a Biometric Identification System Based on Iris Paterns", The school of Computer Science and Software Engineering, The University of Western Austrilia.
[13] S. P. Narote, A. S. Narote, L. M. Waghmare, "An automated Segmentation Method for Iris Recognition," proceedings of International IEEE Conference TENCON-2006.
[14] Bodade, Rajesh M. Talbar, Sanjay N., "Shift Invariant Iris Feature Extraction Using Rotated Complex Wavelet and Complex Wavelet for Iris Recognition System," proceedings of Advances in Pattern Recognition, 2009. ICAPR '09. Seventh International Conference on, pp. 449-452, 4-6 Feb 2009.
[15] Chinese Academy of Sciences Institute of Automation, Database of 756 Grayscale Eye Images, http://www.sinobiometrics.com.
[16] Hugo Proenc¸a and Lu´ıs A. Alexandre. UBIRIS: iris image database, 2004. http://iris.di.ubi.pt
[17] High contrast Iris image database downloaded from: http://phoenix.inf.upol.cz/iris/download/
[18] Lisa Thalheim, Jan Krissler, and Peter-Michael Ziegler, "Biometric Access Protection Devices and their Programs Put to the Test", c't 11/2002, page 114 – Biometric
[19] S. Lee ,Kang Ryoung Park, Jaihie Kim " A Study on Fake Iris Detection based on the Reflectance of the Iris to the Sclera for Iris Recognition" , ITCCSCC 2005, pp. 15551556, Jeju Island, South Korea, July 4-7, 2005
[20] J. Daugman, "Iris Recognition and Anti-Spoofing Countermeasures", 7th International Biometrics Conference, 2004, London.
[21] Manfred Clynes and Michael Cohn, "Color dynamics of the pupil", Annuals of N.Y., Academy of Science.
[22] Andrzej Pacut, Adam Czajka, and Przemek, Strzelczyk, "Aliveness Detection for Iris Biometrics" IEEE Conf, ICCST-2004
[23] S. Lee. " Fake Iris Detection Method based on Reflectance Ratio between Iris and Sclera as Wavelength Variation, Thesis for Masters in Science, Yonsei University, Seoul, South Korea, 2006.
[24] T. Matsumoto., "Impact of Artificial Gummy Fingers on Fingerprint Systems", Proc. SPIE, Vol.4677, pp. 275289. 2002.

Rajesh Bodade received a B.E. degree from Shri Guru Gobind Singhaji Institute of Engineering and Technology, India, in 1992, a M.E. degree from Swami Ramanand Tirtha Marathwada University, Maharashtra, India in 1999. He is pursuing Ph.D. degree from SGGS Institute of Engineering and Technology, Nanded, India. He is currently working as Associate Professor in Faculty of Communication Engineering at Military College of Telecommunication Engineering, Mhow, India, a premier technical institute of Indian Army. His research interests include Pattern Recognition and Machine Intelligence, Biometrics , Audio signal processing and multimedia, Steganography and steganoanalysis etc. He has published /presented research papers in the area of interest. He is a Life member of Institution of Engineers, IETE and ISTE. He is reviewer of research journals and worked on TPC of IEEE conferences.

Sanjay Talbar is a Professor in Electronics and Telecommunications Engineering dept at SGGS

Institute of Engineering and Technology in Nanded, Maharashtra, India. He received BE and ME degrees in electronics engineering from the Marathwada University, India , in 1985 and in 1990, respectively and Ph.D from S.R.T. Marathwada University, Nanded in May 2000. He worked at various levels in several academic, research and professional organizations. He received the Young Scientist Award by URSI, Italy in 2003. He has been part of collaborative research programme at Cardiff University Wales, UK. He is an author of several books. He published many research papers in reputed journal and conferences. He guided several M.Tech and PhD thesis. Dr. Talbars's area of interest includes Image processing, Embedded system and design, Internet communications, Pattern Recognition and Machine Intelligence, Biometrics and communication security, Texture Analysis etc. He is a member of several professional societies including IEEE.