

An Efficient Approach for Iris Recognition by Improving Iris Segmentation and Iris Image Compression

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Abstract The biometric person authentication technique based on the pattern of the human iris is well suited to be applied to any access control system requiring a high level of security. Commercial iris recognition systems are currently employed to allow passengers in some airports to be rapidly processed thru security, to allow access to secure areas, and for secure access to computer networks. With increasing need of the biometric systems the question arises naturally how to store and handle the acquired data. If required storage space is not adequate for these images, compression is an alternative. It allows a reduction in the space needed to store these iris images, although it may be at a cost in some amount of information loss in the process. This paper investigates the effects of image compression on iris recognition based on proposed algorithm and compression is performed using JPEG2000. The proposed technique is computationally effective as well as reliable in terms of recognition rates.

Keywords: Biometrics, Iris Recognition, JPEG2000.

1. Introduction

1.1 Overview

Today, biometric recognition is a common and reliable way to authenticate the identity of a person based on physiological or behavioral characteristics. A physiological characteristic is relatively stable physical characteristics, such as fingerprint, iris pattern, Genetic Analysis, Retina scan etc. This kind of measurement is basically unchanging and unalterable during life time. A behavioral characteristic is more a reflection of an individual's psychological state such as signature, speech pattern, or how one types at a keyboard. All physiology based biometrics don't offer satisfactory recognition rates (false acceptance and false reject rates are respectively referred as FAR and FRR). Iris detection is one of the most accurate and secure means of biometric identification - being least invasive, unique, stable, not easily captured and false accept probability can be estimated at 1 in 10^{31} . That's why iris recognition technology is becoming an important biometric solution for people identification in access control as networked access to computer application [K. N. Jariwala, U. D. Dalal, 2008-b]. Different parts of an eye image is shown in Fig. 1.

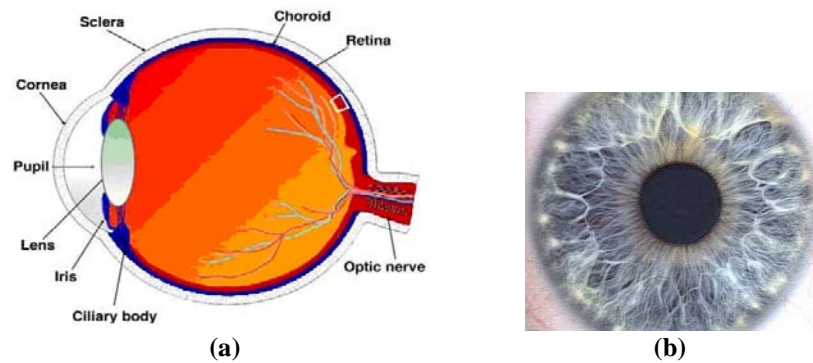


Figure 1 (a) Section through human eye. (b) A Human Iris

In order to use biometrics for identification, the biometric data must be collected by some means. This may be a costly and time-consuming process, and the data obtained is valuable and must be protected at the same time it requires large storage. One available option is compression. There are two types of compression lossless - without loss of information (such as monetary transaction) & lossy compression these algorithms can readily compress data further if some loss of information is tolerable. It is up to the user of the data to determine how much loss of information is acceptable.

For imagery, JPEG2000 and lossless-JPEG have demonstrated very good lossless compression performance with most types of imagery. However, lossless compression has a major drawback in that the reduction in file size is on the order of only 1.5:1 to 3:1 for many types of imagery. On the other hand, in this paper, we investigate the effects of lossy compression on the ability of an iris recognition system to accurately identify individuals. The performance is evaluated by means of the change in Hamming distances between IrisCodes using an iris recognition algorithm [K. N. Jariwala, U. D. Dalal, 2009]. A database for an iris recognition system does not contain actual iris images, but it stores a binary file that represents each processed iris, stored as 512 bytes per eye. However, we do not propose compressing this template data, but we propose the original images from which they were created because it is this data that is valuable and provides testing imagery for the development of new algorithms.

1.2 Outline

This paper is divided into five main parts. The Section 1 introduces what is the position of iris technology in personal authentication. In the Section 2, we sum up the state of the art in the domain of iris recognition. The Section 3 provides an overview of JPEG 2000. The Section 4 presents in details of our approach, and discusses the different issues we chose. The Section 5 provides test results and illustration of typical iris signature. At last conclusion is derived in Section 6, which tasks about the next considerations for the improvement of the proposed solution.

2. Previous Work

The French ophthalmologist Alphonse Bertillon seems to be the first to propose the use of iris pattern as a basis for personal identification [J. Daugman, 1993]. Daugman was the first one to give an algorithm for iris recognition who published his first promising results in 1992. Afterward many people worked in this area as it started gaining importance in secure access. Compression has been investigated and used in some biometric applications, such as the FBI standard for fingerprint compression [C. M. Brislawn, 1998; J. N. Bradley and C. M. Brislawn, 1992], or using MPEG compression [J. Daugman, 1997 H. Wang and S.F. Chang, 1997] for video that may be used in facial recognition applications, compression applied to IrisCodes, not iris images [U. von Seelen, 2004], and compression applied to iris image using masek algorithm [R. Ives, B. Bonney, D. Etter, 2005]. Here, we address the issue of compression applied to the iris imagery itself on the proposed algorithm [K. N. Jariwala, U. D. Dalal, 2009] for iris recognition in a faster way, without degrading the quality which will ultimately improve computational complexity and reliability in terms of recognition rates.

3. JPEG2000

JPEG2000 is the new compression standard published by the Joint Photographic Experts Group. It employs state-of-the-art compression techniques based on wavelet technology. Like the previous JPEG standard, it allows for both lossless and lossy compression of imagery. Lossy compression means that some information is lost in the process, and the amount of information lost is dependent on the algorithm used for compression, as well as the amount of compression desired (that is, the size of the compressed file).

JPEG2000 offers some advanced features, such as region-of-interest (ROI) coding, where the user could identify regions of the image that should be compressed to a higher quality than the surroundings. ROI coding might prove advantageous in iris image compression, since it would allow the iris itself to be compressed with less loss of information than other areas of the image that are not used in recognition [R. Ives, B. Bonney, D. Etter, 2005]. For this research, both lossless and lossy compression of iris images were tested using the default parameters and options for JPEG2000. JPEG2000 was implemented using Win32 executable code freely available from Kakadu Software [Kakadu Software].

Original image and its corresponding metadata are needed to view this picture.

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(a)

(b)

Fig. 2 (a) original iris image [CASIA database] (b) after compression to 20:1 using JPEG-2000.

Fig. 2 displays an original iris image before and after compression to 20:1 using JPEG-2000. The original image was collected using CASIA Iris Database [CASIA iris

image database]. Comparing the original and the compressed image, some noticeable differences lies primarily in the areas of high detail in the original image where compression or smoothing is noted. Statistically, the two images are not very different; the maximum difference between the two images is 26 gray levels, and the overall average difference is 0.056328 with a standard deviation of 2.951321. Overall, JPEG-2000 does a good job of maintaining the detail information even up to a compression of 20:1[R. Ives, B. Bonney, D. Etter , 2005].

4. Methodology

The images used in this research are from Chinese Academy of Sciences (CASIA) iris database. This is composed of images of 108 different eyes, with 7 images of each eye (totaling 756 iris images). These images are 320x280 8-bit bitmapped images, each occupying 92,160 bytes on storage. Performance was measured by observing the effect on fractional Hamming distances between the IrisCodes from the original and decompressed images, computed using the Iris Recognition algorithm [K. N. Jariwala, U. D. Dalal , 2009]. The fractional Hamming distance (F between irisCodes A and B is defined as:

$$HD = \frac{\|(code A \otimes code B) \cap mask A \cap mask B\|}{\|mask A \cap mask B\|} \quad \text{----- (1)}$$

The \otimes operator is the Boolean XOR operation to detect disagreement between the pairs of phase code bits in the two IrisCodes (code A and code B), and mask A and B identify the values in each IrisCode that are not corrupted by artifacts such as eyelids/eyelashes and specularities. The \cap operator is the Boolean AND operator. The $\| \|$ operator is used to sum the number of “1” bits within its argument. The denominator of (1) ensures that only the phase-code bits that matter are included in the calculation, after any artifacts are discounted. A value of $HID = 0$ indicates a perfect match between the IrisCodes, while typically a Hamming distance of ≤ 0.32 allows identification with high confidence and is here used as a threshold for recognition[R. Ives, B. Bonney, D. Etter , 2005].

We compressed 54 images from database using lossy JPEG-2000 to compression ratios of 4:1, 6:1, 8:1, 10:1, then 11:1, 12:1, etc. up to 20:1 and their IrisCodes were created. As mentioned in Section II, when using JPEG-2000, the default compression parameters were selected; the only option chosen was the compression ratio. For each original iris image, there were 14 compressed versions, which populated each database with 810 images (54 x 15). To derive the performance results, each original iris image was compared against every other image in the database. This means that a total of 43,686 comparisons were made (809 x 54), of which 756 comparisons (54 x 14) were enrollee attempts (the irises should match) and 42,930 (54 x 53 x 15) were imposter attempts (the irises should not match).

5. Results

To form a baseline regarding compression of iris images, JPEG-2000 was used first to compress the iris images without loss of information. Lossless compression allows

exact reproduction of the original image from the compressed file. Depending on the algorithm used, the size of the compressed file will vary. In addition, different images will result in different compression attainable when using the same algorithm.

5.1. Performance evaluation of the proposed method

In a first study, we tested successfully the proposed algorithm [K. N. Jariwala, U. D. Dalal, 2009] on a CASIA database to detect iris. In Fig. 3(a)-(d), some degraded sample images from CASIA eye image database are shown. Our approach successfully detect iris boundary though light reflection present at iris boundary (Fig. 3(a)), non uniform illumination in eye image (Fig. 3(b)), iris is occluded by eye lashes (Fig. 3(c)). and when eye is not properly opened (Fig. 3(d)). Figure 3(e)-(h) show the detected iris boundary using our proposed method [K. N. Jariwala, U. D. Dalal, 2009] corresponding to the images in Figures 3(a)-(d).

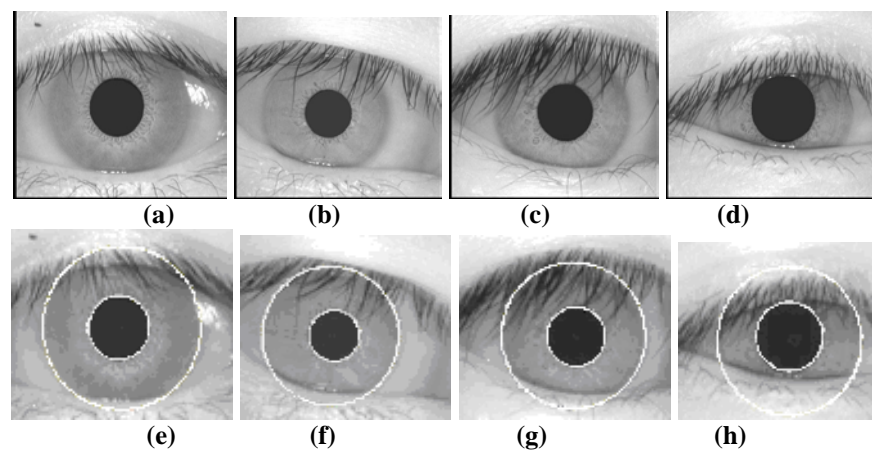


Figure 3. Successfully detected iris boundary: (a) Eye image with light reflection, (b) Non uniform illumination eye image, (c) Eye image occluded by eyelash (d) Not properly open eye image, (e)-(h) Detected iris boundary corresponding to images in (a)-(d)

In a second experimentation, we estimated the False Acceptance Rate (FAR) and the False Reject Rate (FRR) of our system. Lossy compression effects on recognition performance were evaluated using the False Acceptance Rate (EAR) and False Rejection Rate (ERR), with results summarized in Table 2. Fixing the criterion of decision $HID \leq 0.32$ implies optimum FAR and FRR as shown in fig.4.

Table 2 – False accept and false reject rates for the ‘CASIA-a’ data set with different separation points using the optimum parameters.

Threshold	FAR (%)	FRR (%)
0.16	0.00	90.14
0.20	0.00	72.88
0.24	0.00	28.88
0.28	0.00	3.98
0.32	0.01	1.12
0.36	3.24	0.04
0.40	26.49	0.00

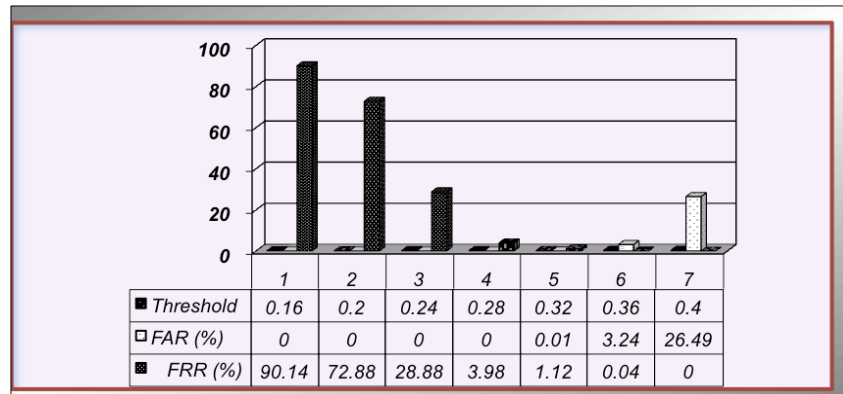


Figure 4 : Fixing the criterion of decision to 0.32 implies optimum FAR and FRR.

With the ‘CASIA-a’ data set perfect recognition is not possible due to the overlapping distributions. With a separation point of 0.32 a false accept rate and false reject rate of 0.01% and 1.12% respectively is achieved, which still allows for accurate recognition as shown in table 2.

5.2. Comparison for various compression ratio

Typical HD results using the CASIA database are illustrated in table 3, Here for an iris image referred to as “ Iris-01 ”. The left column shows the compression ratio applied to test images to which the original image is compared. The middle column displays the Hamming distance computed when the IrisCode for the original image was compared against itself and also against compressed versions of itself. The right column was derived by comparing the original image IrisCode with an uncompressed image of a different eye referred to as “Iris-02”, as well as compressed versions of Iris-02.

Table 3 : CASIA database Hamming Distance (HD ≤ 0.32 determines recognition)

Compression Ratio	Iris - 01 (same eye)	Iris - 02 (different eye)
None	0	0.47088
4:1	0.04188	0.46833
6:1	0.12422	0.46333
8:1	0.12480	0.46335
10:1	0.13675	0.46501
11:1	0.09675	0.47102
12:1	0.09791	0.46888
13:1	0.12636	0.46982
14:1	0.12996	0.46989
15:1	0.13344	0.47024
16:1	0.10959	0.46947
17:1	0.11263	0.46850
18:1	0.11480	0.46664
19:1	0.15685	0.46530
20:1	0.19679	0.46987

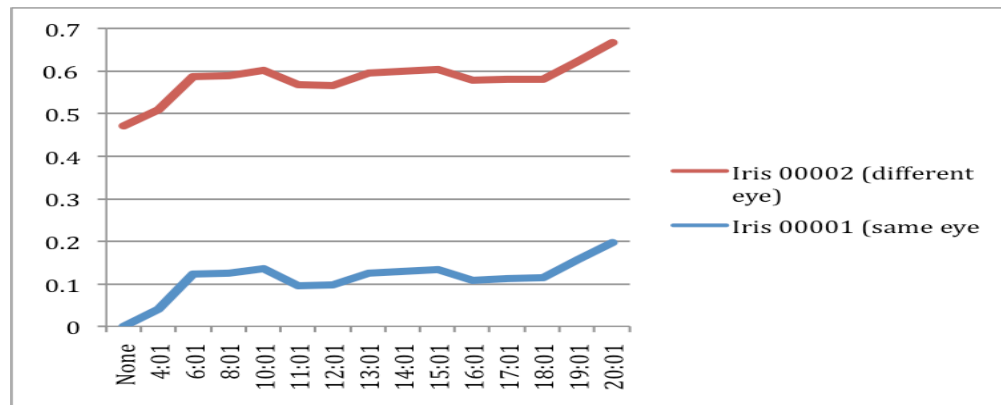


Figure 5 : Compression ratio & Hamming distance for same eye & different eye.

6. Discussion

From these results, JPBG-2000 has proven to be a very capable lossy compressor for iris imagery that iris database storage could be reduced in size, possibly by a factor of 20 or even higher and have a very minor affect on system performance. As a state-of-the-art lossless compressor, compression of these iris images using lossless JPBG-2000 could reduce the required storage for a database to approximately 1/2 of its original size. This may be sufficient in some cases, but significant improvement can be achieved with lossy compression.

Next step should be the utilization of one feature of JPEG-2000 is the use of regions of interest. A priori knowledge of a region of interest (pupil location) should be preserved with less information loss should improve these results. In addition, other options of JPBG-2000, such as choice of wavelet filters can also be examined. Further analysis of how these results scale to a larger database can be analysed. In view of these evaluations, our system achieves high confidence identity verification based on iris texture using innovative approach.

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