# Authentication and identification of individuals from the iris images

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***Abstract*— In this paper, we present an efficient method that allows us to authenticate and identify individuals by using iris images. In fact, the proposed method consists of three main steps. In the first step, we segment the image in order to define the upper and lower parts of the eyelids. We use two segments to exploit efficiently the region of interest of the iris and to extract only the interior half of the iris disc, which contains the most discriminate information. In the second step, the iris image is normalized by Daugman rubber sheet model, and then analyzed by bench of two 1D Log-Gabor filters to extract the texture characteristics. For the authentication and the similarity measurement between two irises, we use the Hamming distance with a threshold previously calculated. We then propose for the identification mode, a classification method based on the Multi-class SVM adopting the approach one against one. The proposed method has been tested on the Casia v1 database (756 iris images). For the authentication mode, we obtain very encouraging results: 1.39% for the global FAR, and 4.45% for the global FRR. For the identification mode, we obtain a rate recognition equals to 98.61%.**

***Keywords- Authentication; identification; recognition; iris; classification; Multiclass SVM.***

## I. INTRODUCTION

Identification by biometrics give us the possibility to recognize or check the identity of individuals, with a high degree of reliability. Currently, the use of the biometric systems such as recognition by the iris, face or by the fingerprints is of widespread interest in many environments of high security like the nuclear plants, the banks… etc.

The biometric systems that based on recognition of the face or the fingerprints are widely employed by the users; however, these systems cannot guarantee a very high security level comparing to a biometric system based on the iris. In addition, recognition by the iris characterizes by a very low error rate, where the probability to find two identical irises is 1/1078 proved by Dr. J. Daugman, and its stability is extended until death of the individuals. In fact, iris recognition system is one of the most successful systems that used for identifying individuals [1].

However, identification of individuals using the iris has several problems that are not completely resolved, such as, the localization of the iris in an iris image, the analysis and the characterization of the iris texture.

Currently, many researchers work on these problems, and the suggested methods are distinguishable from each other by the used techniques in the phases of segmentation, analysis and characterization of the iris. For iris segmentation, two methods are usually used: the intégro-differential operator [2] and Hough transform [3] [4] [5] [6] [7] [8]. For iris characterization, the most used methods are Gabor wavelet transform applied by Daugman, [3], Laplacian pyramid [4], packages wavelet transform [9] [10], multidimensional Hilbert transformation [5]. Recently, Khiari and Al [6] proposed another method based on the application of the directional pyramidal transformation.

In this paper, the key idea was inspired from the work of L. Masek [7], which developed iris authentication system that follows these main steps:

- Segmentation based on circular Hough transform to delineate iris and pupil circles, and linear Hough transform to define the high and low parts of the eyelids.
- Normalization step was applied to compensate the non- concentricity of the two borders and the varying size of the iris caused by the dilation/contraction of the pupil.
- A bench of two 1D Log-Gabor filters is used for extracting information from iris texture, and then the encoding was realized

with a phase of quantization developed by J. Daugman [11].

In fact, this work presents two main contributions related to iris segmentation phase. First, we define the upper and lower parts of the eyelids by two lines segment in order to exploit efficiently the region of interest of the iris. Second, we consider only the interior half of the iris disc that contains the most discriminate information, and it is less affected by noise. In addition, we develop an iris identification system by using a classification method based on the Multi-classes SVM relied on the approach one against one.

The remainder of this paper is organized as follows. The iris pre-processing and characterization is presented in section II. The authentication mode is devoted in section III. The identification mode is detailed in section IV. Finally, conclusions are drawn in section V.

## II. IRIS PRE-PROCESSING AND CHARACTERIZATION

### A. *Iris segmentation*

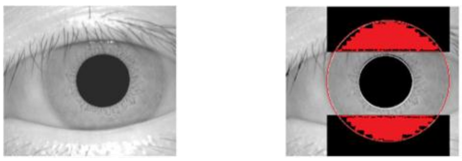
Iris segmentation consists in the extraction of the iris disc delimited by the circular borders of iris/sclera and iris/pupil.

Thus, detection of these boundaries in our system is based on circular Hough transform, which needs at the first time to the generation of an edge map. In this context, a modified version of Kovesi's Canny edge detection function [20] was applied, which allows the weighting of the gradients.

In our work, only vertical gradients are employed to detect the external circle of the iris disc, while vertical and horizontal gradients are both weighted to detect the points of the iris/pupil circle as proposed by Wildes [12].

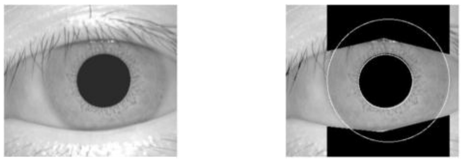
The detection of the external border of the iris/pupil is firstly performed by applying circular Hough transform only in the iris area, instead of the whole area of the eye. Afterthat, we obtain the rays, and the centers of the two circles delimiting the iris.

For separating the eyelids, we firstly used a simple thresholding technique. The analysis reveals that eyelashes are quite dark compared to the rest of the eye image. The obtained results show some anomalies that appear by the unexploited areas marked with red color, as illustrated in Figure. 1.



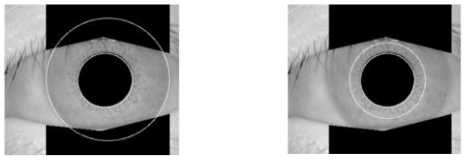
Original image. Segmented image (1).

To deal with such problem, we chose another technique for delimiting the high and low eyelids with two segments by using linear Houhg transform [13], as shown in Figure. 2.



Original image. Segmented image

information, which is represented by the structural variations of the iris texture (high gradient areas), we preferred to exploit only the internal half of the iris disc, because it contains the most discriminating information and it is less affected by the noise (eyelids), as shown in Figure. 3. Indeed, the proposed technique decreases the complexity and the computation load without losing information.



Segmented iris (2) Segmented iris (3)

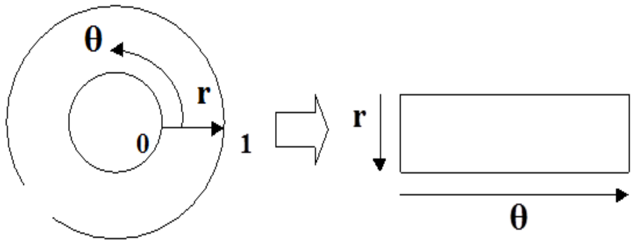
Figure 3. Location of the structural change of the iris texture.

### B. *Iris normlization*

The iris disc does not always have the same dimension, even for eye images of the same person; this is due to various problems as follows:

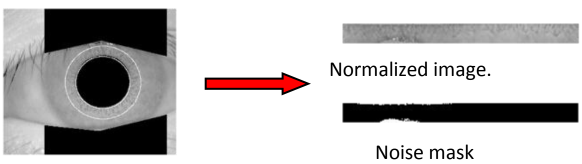
- Different acquisitions conditions of the eye images.
- Dilation and contraction of the pupil due to the variation of the illumination level.
- The pupil region is not always concentric within the iris.

In order to overcome these problems and to compare between different segmented iris images, a stage of normalization is applied. It consists in transforming the region of the iris disc to rectify the dimensions of all the iris discs, by using the homogenous rubber sheet model proposed by Daugman [11]. It transforms each point in the iris area to the polar coordinates (r, θ), where *r* is on the interval [0,1] and θ is angle [0,2π], as illustrated in Figure.4.




Daugman rubber sheet model [11].

ır system, we use (20*240) points, but only ) points corresponding to the internal half s disc that are retained for the next steps of essing, as shown in Figure. 5.



Normalized image.

Noise mask

Segmented image (3).

Figure 5. Normalization of the segmented iris.

The remapping of the iris region from (x,y) Cartesian coordinates to the normalized non-concentric polar representation is obtained by the equation (1).

$$x(r,\theta) = (1-r)\times x_p(\theta) + r\times x_i(\theta)$$
$$y(r,\theta) = (1-r)\times y_p(\theta) + r\times y_i(\theta) \quad (1)$$

Where (x,y) are the original Cartesian coordinates, (r,θ) are the corresponding normalized polar coordinates, $(x_p,y_p)$ and $(x_i,y_i)$ are the coordinates of the pupil and iris boundaries along the θ direction.

*C. Iris Extraction parameters and encoding*

Once the segmentation and normalization process are achieved, the next step is the extraction of the most discriminating information present in the iris region. For this reason, we apply the following steps:

- We first applied for each line of the normalized matrix image the Fast Fourier Transform (FFT to 1D signal).
- We then applied the Inverse Fast Fourier Transform IFFT on the multiplication FFT (1D signal) by a 1D Log-Gabor Filter.

The frequency response of a 1D Log-Gabor filter is given by:

$$G(f) = \exp\left(-\frac{(\log(f/f_0))^2}{2\times(\log(\sigma/f_0))^2}\right) \quad (2)$$

Parameters setting :

- We used a bench of two 1D Log-Gabor filters.
- The bandwidth of the 1D Log-Gabor wavelet is given by $\sigma/f_0 = 2$.
- Center frequency of the 1D Log-Gabor wavelet is given by $f_0 = 18$ pixels.
- One of the disadvantage of Gabor filter is that the even symmetric, filter will have a DC component whenever the bandwidth is larger than one octave [14]. However, zero DC component can be obtained for any bandwidth by using a Gabor filter, which is Gaussian on a logarithmic scale; this is known as the Log-Gabor filter, as shown in Figure. 6.

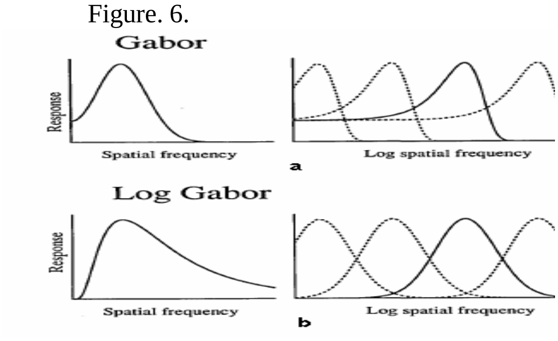



Figure 6. Comparison of the Gabor and Log-Gabor function [15].

Indeed, the phase of the multi-resolution analysis is more informative than its amplitudes, which are very sensitive to the illumination problems. In this way, the phase of filtred image was quantized using four-quadrants of J. Daugman [11], when going from one quadrant to an adjacent quadrant one bit is changed as shown in Figure. 7.

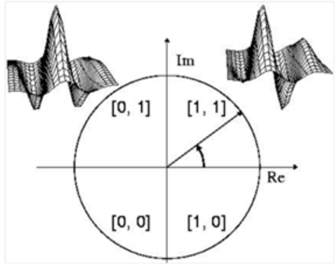



Figure 7. Quantization Phase [11].

The encoding process produces a bitwise template containing a number of bits of information (as shown in Figure. 8 (a)), and a corresponding noise mask which corresponds to corrupt areas within the iris pattern, and marks bits in the template as corrupt (as shown in Figure. 8 (b)). The total number of bits in the template (9600 bits) will be the angular resolution (240) times the radial resolution (10), times 2, times the number of filters used (2).

(a)

(b)

Figure 8. Iris encoding , (a) binary code, (b) mask code.

## III. AUTHENTICATION MODE

*A. Used database*

The proposed method has been tested on Casia v1 database [16] in order to evaluate its performance in two operating modes: authentication and identification. Casia v1 database contains 756 iris images from 108 individuals. For each person, 7 images were acquired in two separate sessions in few weeks, 5 iris images were used for the learning and the rest for the tests.

*B. Introduction*

In authentication mode, it is necessary to ascertain whether a person is who they claim to be. It is therefore to compare the distance between two features vectors compared to a predetermined threshold during a learning phase [13].

*C. Comparison and decision- Hamming Distance*

The comparison of features vectors of two irises is performed by the Hamming distance as follows:

$$HD = \frac{\left\|(codeA \otimes codeb) \cap maskA \cap maskB\right\|}{\left\|maskA \cap maskB\right\|} \quad (3)$$

Where codeA and codeB are two codes calculated from two images of iris by the process previously described, and maskA and maskB represent their associated masks. Literally, the Hamming distance calculates the number of different and valid bits for the two irises between the codeA and the codeB. In fact, more the Hamming distance is smaller the two codes are similar. A distance of 0 corresponds to a perfect match between the two irises images as two iris images of different person have a Hamming distance close to 0.50.

### D. Calculation of decision threshold

To determine the value of the decision threshold, we calculated for each threshold the different evaluation of the verification process i.e. False Acceptance Rate (FAR) and False Rejection Rate (FRR).

TABLE I. FALSE ACCEPTANCE RATE (FAR) AND FALSE REJECTION RATE (FRR) FOR DIFFERENT LEVELS.

| Threshold | FAR(%) | FRR(%) |
|---|---|---|
| 0.05 | 0 | 100 |
| 0.1 | 0 | 100 |
| 0.15 | 0 | 99.86 |
| 0.2 | 0 | 94.57 |
| 0.25 | 0 | 70.06 |
| 0.3 | 0 | 35.14 |
| 0.35 | 0.11 | 14.06 |
| 0.4 | 0.64 | 5.42 |
| **0.41** | **1.39** | **4.45** |
| 0.45 | 25.65 | 0.92 |
| 0.5 | 98.20 | 0 |
| 0.55 | 99.99 | 0 |
| 0.6 | 100 | 0 |
| 0.65 | 100 | 0 |
| 0.7 | 100 | 0 |

#### 1) *Discussion*

We note from Table I. that the best rate of false acceptance and false rejection are FAR=1.39%, FRR=4.45% that correspond to a decision threshold equals to 0.41.

Figure. 9 represents the ROC curve (Receiver Operating Characteristic) which shows the False Acceptance Rate (FAR) according to the False Rejection Rate (FRR).

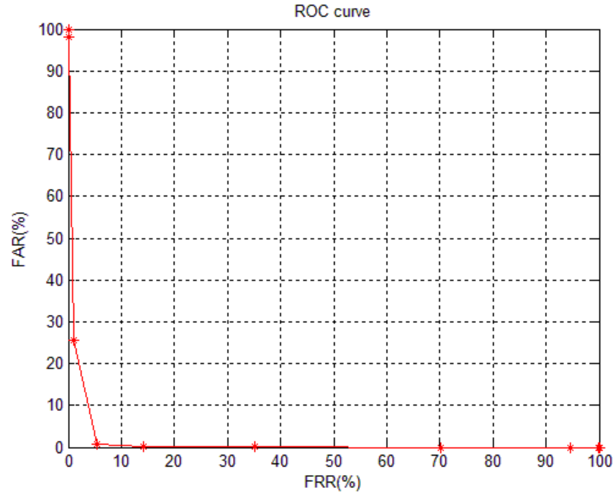



Figure 9. ROC curve (Receiver Operating Characteristic).

### E. Evaluation criteria

There are many evaluation criteria of biometric verification system such as: HTER (Half Total Error Rate), TER (Total Error Rate), the most used is the EER (Equal Error Rate).

#### 1) *EER (Equal Error Rate):*

The EER is the operating point for which the false rejection rate is equal to the false acceptance rate (as shown in Figure. 10).

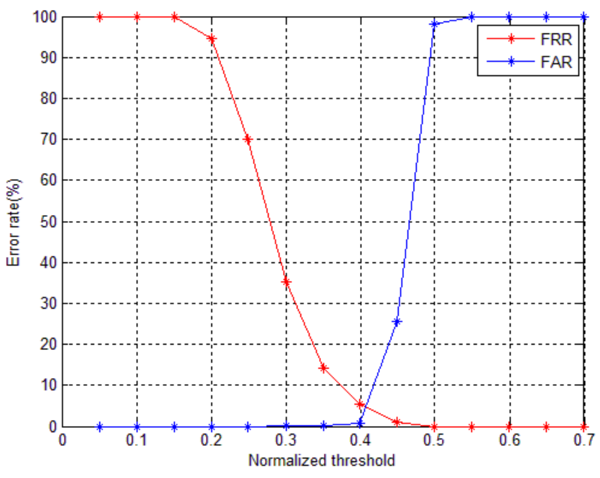



Figure 10. ROC curve (Receiver Operating Characteristic) which determine the EER.

#### 2) *Discussion*

Figure. 10 represents the ROC curve that shows the FAR and FRR according to the normalized threshold, the intersection point of FAR and FRR curves correspond to the value of EER which equal to 4.69%.

## IV. IDENTIFICATION MODE

### A. Introduction

In identification mode, it exists two types of biometric systems: a closed system to insure the existence of a candidate in the database, and an open system that cannot insure the existence the candidate in the database. In our work, we have considered the closed system [13].

### B. Multiclass SVM based Approach.

The support vector machine (SVM) is a well accepted approach for pattern classification due to features and promising performance. Support vector classifiers devise a computationally efficient way of learning good separating hyper plane in a high dimension feature space. In this work, we apply multi class SVM to classify the iris pattern due to its outstanding generalization performance. Here, the SVM is employed as an iris pattern classifier because of its advantageous features over other classification scheme and also because of its promising performance as a multiclass classifier. In an SVM, a few important data point called support vectors (SV) are selected on which a decision boundary is exclusively dependent [17].

The SVM is also well suited for the case where the sample proportion between two classes is poorly balanced [18].

In this method, we used Libsvm 3.11 tool [19], that adopting approach one against one. We chose it after doing the following comparison [21] "1-against-the rest" is a good method whose performance is comparable to "1-against-1." We do the latter simply because its training time is shorter.

### C. Results – discussion

TABLE II. RESULTS OF THE TESTS ON CASIA V1 BY BOTH METHODS.

| Casia v1 | Identification rate (%) | Classification rate | EER (%) | FAR (%) | FRR (%) |
|---|---|---|---|---|---|
| L.Masek method | 96.30 | 208/216 | 5.4 | 1.61 | 5.90 |
| Proposed method | 98.61 | 213/216 | 4.69 | 1.39 | 4.45 |

#### 1) Discussion

To be clear, we integrated our module of identification to the iris authentication system of Libor Masek, on purpose to make it as an iris recognition system. As shown in table II, our method is more accurate than L. Masek method, where the proposed method achieves the rates of 98.61%, 213/216, 4.69%, 1.39%, and 4.45%, for the identification, the classification, EER, FAR, FRR, respectively, on whole Casia v1 database (756 iris images). While the obtained results of L. Masek method on whole Casia v1 database (756 iris images) achieves the rates of 96.30%, 208/216, 5.4%, 1.61%, and 5.90% for the identification, the classification, EER, FAR and FRR, respectively.

Finally, we conclude that our system is slightly reliable as Masek system in terms of overall accuracy.

## V. CONCLUSION

The objective of our work is to pre-process: segment, and normalize the iris, and characterize: Extract parameters and encode the iris. For the segmentation part, the detection of the iris/pupil circles was performed by Hough circular transform. We delimited the upper and lower parts of the eye by two segments by using the linear Hough transform, which gave us a good segmentation despite some errors due to the variation of the light intensity. Iris normalization part was performed by the Daugman rubber sheet model with resolution of 10x240. This stage was analyzed by the bench of two 1D Log- Gabor filters to generate a binary code of 1200 bytes. Hamming distance was used to establish the authentication process with a global FAR of 1.39%, and a global FRR of 4.45%. The classification of the obtained data was done by Multiclass SVM, which based on the approach one against one. This stage was applied to improve the identification process. The obtained results of the identification are very satisfactory of a rate equals to 98.61%.

## REFERENCES

[15] Roudil Irène, "Biomètrie : reconnaissance de l'iris," Conférence de sensibilisation à la science, 19 janvier 2013.
[16] Daugman John. "Probing the Uniqueness and Randomness of Iris Codes: Results From 200 Billion Iris Pair Comparisons." Proceedings IEEE, vol.94 (11), Novembre 2006.
[17] Yong Z., Tieniu T., Yun Hong W. "Biometric personal identification based on iris patterns," 15th ICPR, Barcelone, Espagne, 2000.
[18] R.P. Wildes. "Iris recognition: an emerging biometric technology." In Proc of IEEE, Volume 85 (1):1348-1363, Septembre 1997.
[19] L. Tissé. "Contribution à la vérification biométrique de personne par reconnaissance de l'iris," thèse de doctorat, université de Montpellier II, 28 Octobre 2003.
[20] Khiari N., Mahersia H., Hamrouni K. "Iris recognition using steerable pyramids." International Workshops on Image Processing Theory: Tools and Applications, Sousse, Tunisie, 23-26 Novembre 2008.
[21] Libor M. "Recognition of Human Iris Patterns for Biometric Identification." Thèse de doctorat, University of Western Australia, 2003.
[22] Li M., Yunhong W., Tieniu T. "Iris recognition using circular symmetric filters," Pattern Recognition Proceedings, 16th International Conférence, Vol 2: 414-417, 11-15 Agust 2002.
[23] Hamrouni K., Melakh A., Krichen A. "Reconnaissance de l'iris par paquet d'ondelettes." Annales Maghrébines de l'Ingénieur, Vol 18, Octobre 2004.
[24] Amine K. "Reconnaissance des personnes par l'iris en mode dégradé." Thèse de doctorat, Université d'Evry-val d'Essonne, Octobre 2007.
[25] Daugman John : "How iris recognition works." IEEE Trans. Circuits Syst. Video Techn. 14(1): 21-30, 2004.

[26] R. Wildes. “Iris recognition: an emerging biometric technology.” Proceedings of the IEEE, Vol. 85, No. 9, 1997.

[27] Feddaoui Nadia et Hamrouni kamel¸ “Reconnaissance de l’iris par filtrage de Gabor et deux variantes de descripteurs de texture,” TAIMA, Hammamet, Tunisie, 2009.

[28] S. Sanderson, J. Erbetta. “Authentication for secure environments based on iris scanning technology.” IEEE Colloquium on Visual Biometrics, 2000.

[29] D. Field. “Relations between the statistics of natural images and the response properties of cortical cells.” Journal of the Optical Society of America, 1987.

[30] Chinese Academy of Sciences – Institute of Automation. Database of 756 Greyscale Eye Images. http://www.sinobiometrics.com Version 1.0, 2003.

[31] Upasana Tiwari, Deepali Kelkar, Abhishek Tiwari, “Study of Different Iris Recognition.” International Journal of Computer Technology and Electronics Engineering (IJCTEE), ISSN 2249-6343, Volume 2, Issue 1, February 2012.

[32] Kaushik Roy, Prabir Bhattacharya and Ramesh Chandra Debnath -“Multi-Class SVM Based Iris Recognition,”. 10th international conference on computer and information technology, Dhaka, Bangladesh, ISBN 978-1-4244-1550-2, page(s):1-6, 2007.

[33] C.-C. Chang and C.-J. Lin. LIBSVM: “A library for support vector machines.” ACM Transactions on Intelligent Systems and Technology, 2:27:1--27:27, 2011.

[34] L. Masek and P. Kovesi, “Biometric identification system based on iris patterns,” Matlab source code, The School of Computer Science and Software Engineering, The University of Western Australia, 2003.

[35] C.-W. Hsu and C.-J. Lin. “A comparison of methods for multi-class support vector machines,” IEEE Transactions on Neural Networks, 13, 415-425, 2002.