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An Effective Iris Identification System Using Segmentation and Hough Transform

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Abstract: This study presents an iris identification system composed of an automatic segmentation mechanism which is based on Hough transform to locate the circular area of iris and the pupil. The area extracted from iris is then standardized in a rectangular block with constant dimensions. The instantaneous phase and the emergent frequency were used for the extraction and the coding of the single model of the iris in a biometric gauge to display it in the form of code bars. The Hamming distance was used to compare the binary code already recorded to decide on the dissension or the agreement between these code compared code .

Key words: Wavelets, texture, iris recognition, identification, emergent frequency, segmentation, security

INTRODUCTION

A biometric system provides the automatic identification of a person based on a certain type of device or proper characteristic of a person. Other biometric systems were developed, they are based on fingerprints, facial devices, the voice, the geometry of the hand, the writing, the retina[1]. We present in this study : the iris identification system. A system of checking by recognition of iris[2] can be decomposed into two major units:

- An optical unit of capture of iris image capture (device of vision),
- A treatment unit of the data (extraction and comparison between discriminating informations and those stored beforehand in the enrôlement stage).

The biometric systems functionning is based on capture of a sample of a device such as recording a signal numerical for the identification of voice, or to take a digital image for the identification of face. The sample is then transformed by using a certain type of mathematical function in biometric gauge. The biometric gauge will provide a standardized, effective and strongly distinctive representation of the device, which can then be objectively compared with other gauges in order to determine the identity. The majority of the biometric systems allow two operating modes. A mode of inscription to add gauges to a data base and a mode of identification, where a gauge is created for an individual and then a match is required in the data base of the pre-registered gauges.

Techniques of image processing can be used to extract the single iris model from a digitalized image of the eye and coding it in a biometric gauge, which can be stored in a data base[3].

System of identification: The system is composed from a number of functions, which correspond to each stage of iris identification . These stages are Fig. 1:

- The module of pretreatment.
- The module of insulation of iris.
- The module of standardization or change of co-ordinates.
- The module of extraction and generation of iris codes (biometric gauge).

The entry of the system will be an image of the eye and the exit will be the iris codes, which will provide a mathematical representation of the area iris Fig. 2.

Pretreatment:

- We must firstly before all treat our image with the level of gray.
- A reduction of the image size to 1/4 to accelerate calculations.
- From the Histogram[4] we can deduce the treatments frompre-filtering such as: Smoothing of the histogram for a suppression of the noise like the lashes for a better detection of the zone of interest. Fig. 3

Isolation of iris

Detection of the pupil: We have used here a technique based on a segmentation of the histogram[4].

Stages:

- Creation of the histogram of the image.
- Smoothing of the histogram by a morphological filter.
- Calculation of the thresholds minimum and maximum of the smoothed histogram
- Segmentation on the first peak of the smoothed and thresholded histogram.
- Morphological treatment on the image is so necessary.

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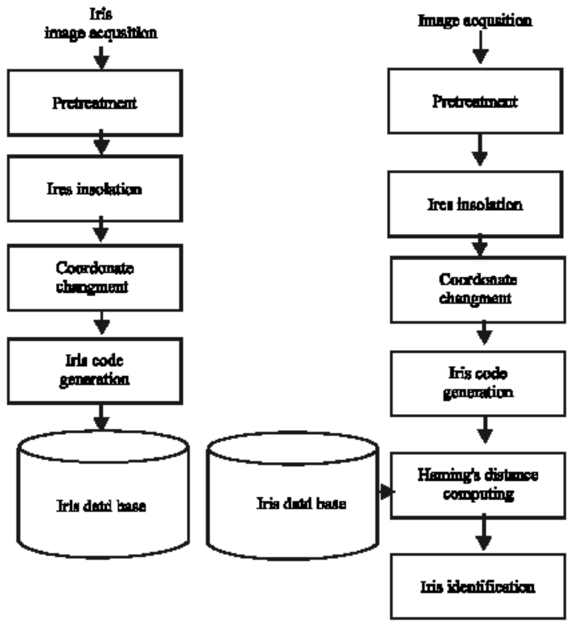

Fig. 1: The rolling up of the system

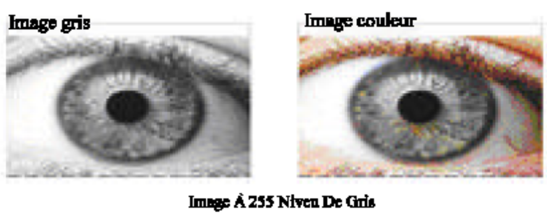

Fig. 2. Image of an iris captured (A) image level of gray, (b) real image[11]

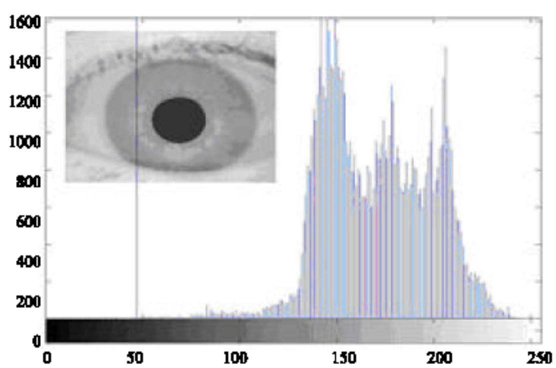

Fig. 3: Poor contrasted image and histogram of brightness

- Extraction of the points of the border (ray) and centers of this erea segmented by the method of Hough.

Detection of the iris: Once again the technique of segmentation is used for the insulation of the iris area but on the second peak of the histogram (Zone of iris) and the extraction of the zone of interest also by using the method of Hough Fig. 4.

$$x_c + y_c - r^2 = 0$$

Change of co-ordinates (daugman's rubber sheet model): The model of the homogeneous rubber sheet designed by Daugman[5], transforms each point of the iris area in a pair of polar co-ordinates (ρ, θ) where ρ is on the interval [0.1] and θ is the angle [$0,2\pi$] Fig. 5.
This transformation :

$$\{I(X(\rho,\theta), Y(\rho,\theta)) \rightarrow I(\rho,\theta)\}$$

results in the following relations:

$$X(\rho,\theta) = (1-\rho) * X_p(\theta) + \rho * X_i(\theta) \quad (1)$$

$$Y(\rho,\theta) = (1-\rho) * Y_p(\theta) + \rho * Y_i(\theta) \quad (2)$$

With:

$$X_p(\theta) = X_{p0}(\theta) + r_p * \cos(\theta) \quad (3)$$

$$Y_p(\theta) = Y_{p0}(\theta) + r_p * \sin(\theta) \quad (4)$$

$$X_p(\theta) = X_{i0}(\theta) + r_i * \cos(\theta) \quad (5)$$

$$Y_p(\theta) = Y_{i0}(\theta) + r_i * \sin(\theta) \quad (6)$$

where r_p and r_i are the ray of the pupil and the iris respectively and ($X_{p(\theta)}$, $Y_{p(\theta)}$) and ($X_{i(\theta)}$,$Y_{p(\theta)}$) are the co-ordinates of the borders of the pupil and of the Iris in direction of θ.

GENERATION OF IRIS CODES

The instantaneous phase and emergent frequency: The instantaneous phase is obtained by building the analytical signal, which is the combination of the initial signal and its Hilbert transform. For any real signal X(t), we can formulate the complex signal Zx (t) of X as follows:

$$Zx(t) = x(t) + j.H\{x(t)\} \quad (7)$$

Where H(x(t)) is the Hilbert transform of x(t).

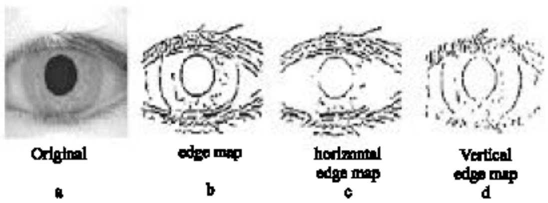

Fig. 4: a) An image of eye b) Contour of the eye c) With horizontal gradients d) With vertical gradients

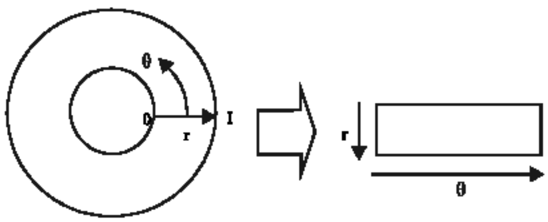

Fig. 5: Daugman's rubber sheet model

The signal Zx (t) is called the analytical signal. The Hilbert transform Hx of the real signal x(t) can be expressed in Fourier field by:

$$TF\left[H_X\right](f) = \left(-j.\text{signe}(f)\right).X(f) \quad (8)$$

The particular complex extension of the image, called analytical image, was presented by A. Bovik and J.P. Havlicek[6], which gives a practical installation of the complex extension of Z(n1, n2) of N*M real actual values of image f (n_1, n_2):

$$Z(n_1,n_2) = f(n_1,n_2) + j.g(n_1,n_2) = f(n_1,n_2) + j.H\left[f(n_1,n_2)\right] \quad (9)$$

In the Fourier field:

$$G(u,v) = TF\left[g(n_1,n_2)\right] = H(u,v).*F(u,v) \quad (10)$$

Thus: Z(n1, n2) is obtained by taking the Fourier reverse transform

$$"Z(u,v) = F(u,v) + j.G(u,v)"$$

More efficient algorithm for the calculation of Z(u,v) can be derived because for each u and v, Z(u,v) assumes only on tree possible values: zero, F(u,v) and 2.F(u,v).
With:

$$H(u,v) = \begin{cases} -j & \text{when } u = 1,2,...(n/2)-1 \\ j & \text{when } u = (n/2)+1,(n/2)+2...N-1 \\ -j & \text{when } u = 0, v = 1,2,\ldots(M/2)\text{-}1 \\ -j & \text{when } u = (N/2), v = 1,2,\ldots(M/2)\text{-}1 \\ j & \text{when } u = 0, v = (M/2)+1,(M/2)+2,\ldots M\text{-}1 \\ j & \text{when } u = (N/2), v = (M/2)+1,(M/2)+2,\ldots M\text{-}1 \\ 0 & \text{otherwise} \end{cases}$$

Like any physical signal, the textured rectangular image of the iris consists of Q components AM-FM and can be expressed by the following eq:

$$f(\rho,\theta) = \sum_{q=1}^{Q} a_q(\rho,\theta).\cos\left[\varphi(\rho,\theta)\right] \quad (11)$$

To isolate the Q principal components which constitute the texture of the Iris, we uses a bench of band pass filter, defined in the frequential field by the product of two windows of Hamming[7]:

$$X(u,v) = X_1(u).X_2(v) \quad (12)$$

With:

$$X_i(f) = \alpha_i + (1-\alpha_i)\cos\pi\frac{f - f_{qi}}{f_{0i}} \quad (13)$$

f_{qi}: Indicates the central frequency according to u and v, respectively.

{X_1 (u). X_2 (v)}: Filters 1 D of -3 dB band-width per octave.

$$f_{0i} = \frac{\pi}{3.\arccos\left[\frac{1/2-\alpha_i}{1-\alpha_i}\right]} f_{qi} \quad (14)$$

Then the signal component of demodulation algorithms[8] Fig. 6 is applied directly to the answers of filter to identify the functions of modulation of the component FM by using analytical image Z(ρ, θ) as follows:

$$\left|\Delta\varphi D_i(\rho,\theta)\right| = \arccos\left[\frac{z(\rho,\theta+1)+z(\rho,\theta-1)}{2z(\rho,\theta)}\right] \quad (15)$$

Moreover, to extract the I nstantaneous phase φ_i (ρ, θ) can be extracted by using its algebraical expression as:

$$\varphi_i(\rho,\theta) = \arctan\frac{\mathrm{Im}(z_i(\rho,\theta))}{\mathrm{Re}(z_i(\rho,\theta))} \qquad (16)$$

The coding of the devices of iris will be done by introducing the emergent frequency module Eq. 15 and the real part Re(φ I (ρ,θ)) and imaginary part Im(φ I (ρ,θ)) of the instantaneous phase φi (ρ, θ) Eq. 16.

Iris feature encoding by 2D wavelet demodulation[9]: Each isolated iris pattern is then demodulated to extract its phase information using quadrature 2D Gabor wavelets. This encoding process is illustrated in Fig. 8. It amounts to a patch-wise phase quantization of the iris pattern, by identifying in which quadrant of the complex plane each resultant phasor lies when a given area of the iris is projected on to complex-valued 2D Gabor wavelets:

$$h_{\{RE,Im\}} = \mathrm{sgn}_{\{RE,Im\}} \int_\rho\int_\varphi i(\rho,\varphi) e^{-j\omega(\theta_0-\varphi)} e^{-(r_0-\rho)^2/\alpha^2} e^{-(\theta_0-\varphi)^2/\beta^2} \rho d\rho d\varphi \qquad (17)$$

where $h_{\{Re,Im\}}$ can be regarded as a complex-valued bit whose real and imaginary parts are either 1 or 0 (sgn) depending on the sign of the 2D integral; I(ρ,φ) is the raw iris image in a dimensionless polar coordinate system that is size and translation-invariant and which also corrects for pupil dilation as explained in a later section; α and β are the multi-scale 2D wavelet size parameters, spanning an 8-fold range from 0.15 to 1.2 mm on the iris; ù is wavelet frequency, spanning three octaves in inverse proportion to β and (r_0; θ_0) represent the polar coordinates of each region of iris for which the phasor coordinates $h_{\{Re,Im\}}$ are computed.

Such a phase quadrant coding sequence is illustrated for two irises by the bit streams pictured in Fig. 7. A desirable feature of the phase code explained in Fig. 8 is that it is a cyclic or Gray code: in rotating between any adjacent phase quadrants, only a single bit changes, unlike a binary code in which two bits may change, making some errors arbitrarily more costly than others. Altogether 2048 such phase bits (256 bytes) are computed for each iris, but in a major improvement over the earlier Daugman[10] algorithms, now an equal number of masking bits are also computed to signify whether any iris region is obscured by eyelids, contains any eyelash occlusions, specular reflections, boundary artifacts of hard contact lenses, or poor signal-to-noise ratio and thus should be ignored in the demodulation code as artifact.

Only phase information is used for recognizing irises because amplitude information is not very discriminating and it depends upon extraneous factors such as imaging

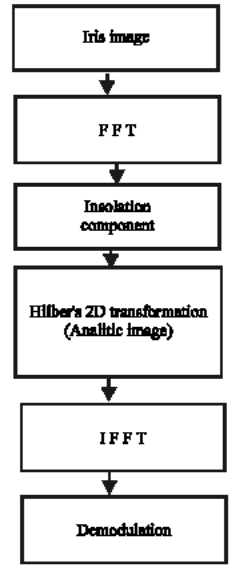

Fig. 6: Flow chart of extraction of information by complex extension.

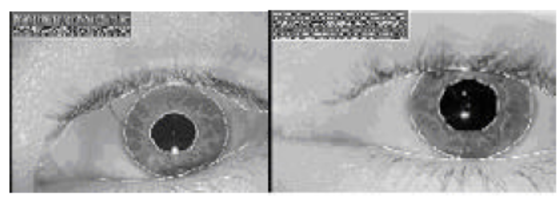

Fig. 7: Examples of iris patterns, imaged monochromatically with NIR illumination in the 700-900 nm band at distances of about 35 cm.. The bit streams are the results of demodulation with complex-valued 2D Gabor wavelets to encode iris patterns as a sequence of phasor quadrants

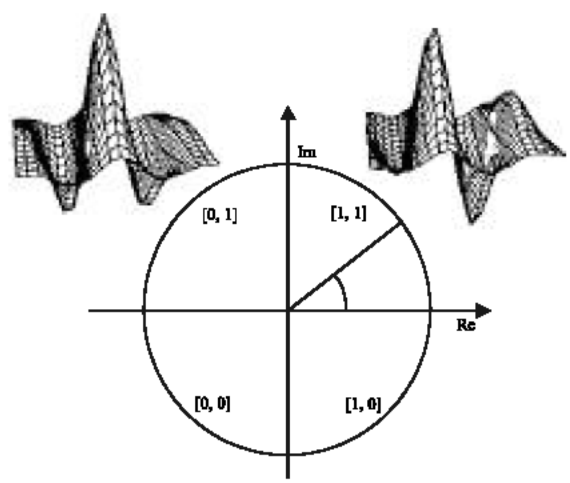

Fig. 8: The phase demodulation process used to encode iris patterns

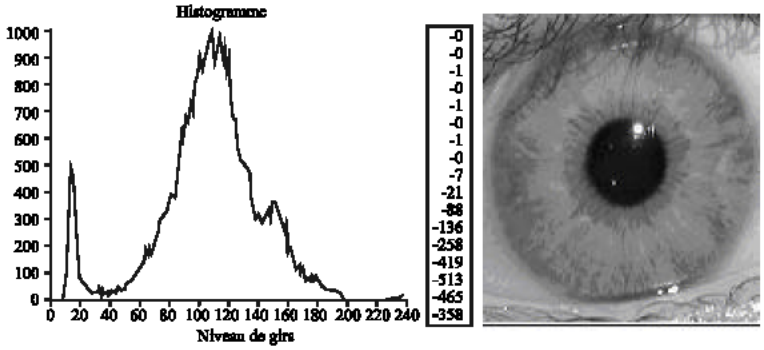

Fig. 9: Example of an image of eye treated and its histogram

contrast, illumination and camera gain. The phase bit settings which code the sequence of projection quadrants as shown in Fig. 8 capture the information of wavelet zero-crossings, as is clear from the sign operator in Eq. 17. The extraction of phase has the further advantage that phase angles are assigned regardless of how poor the image contrast may be, as illustrated by the extremely out-of-focus image in Fig. 8. Its phase bit stream has statistical properties such as run lengths similar to those of the code for the properly focused eye images in Fig. 7. The benefit which arises from the fact that phase bits are set also for a poorly focused image as shown here, even if based only on random CCD noise, is that different poorly focused irises never become confused with each other when their phase codes are compared. By contrast, images of different faces look increasingly alike when poorly resolved and may be confused with each other by face recognition algorithms.

Matching: By comparing the binary configurations X and Y of iris codes obtained from a file already recorded, we calculate the Hamming distance HD, which is given by the Eq.:

$$HD = \frac{1}{N}\sum_{j=1}^{N} X_j (XOR) Y_j \qquad (18)$$

Thus we decide of the dissension or the agreement between these two binary codes

Experimental

The module of pretreatment: The histogram Fig. 9 is a vector of 256 elements. Each element of the vector represents the number of pixels of the image having the same level of Gray, thus we can compare the histogram to the density of probability of the light intensities.

The module of insulation of iris: In this stage the detection of the center and the two circles of iris and the pupil is realized Fig. 10.

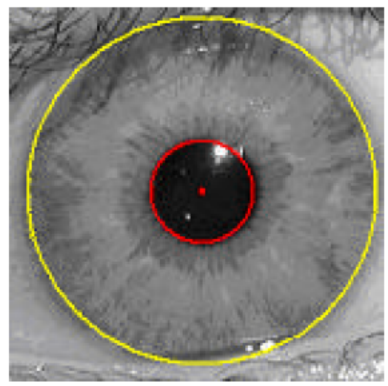

Fig. 10: Both circle representing the iris and the pupil

Fig. 11: The area of iris after change of co-ordinates

The automatic model of segmentation succeeded on a data base of iris[11] providing a the good segmentation. Practically for all pictures, the technique of segmentation arrived to segment the region of iris correctly about to a rate of success of 87.5%.

The module of standardization: The illustration of standarisation of iris image is showed in Fig. 11.

The process of normalization previously describes has perfectly functioned, some results are shown. However, the process of normalization could not perfectly rebuild the same model of pictures with the variable quantities of dilation of the pupil; therefore the distortion of the iris gives small changes of its outside models.

The module of extraction (iris codes): The coding which is carried out according to a quantification of phase according to two bits in form of code bar is illustrated in Fig. 12 with size of the code of 512 bytes.

(a) by using characteristics of texture

(b) By using 2D wavelet demodulation

Fig. 12: Iris codes or the gauge biometric in the form of bars code

Table 1: Execution time

	Past time (ms)	(%) of total time
Localization of iris	110	180
Change of co-ordinates	200	280
Demodulation let us use some To transform it of hilbert	< 1	< 1
Demodulation let us use the Filter of gabor 2d of it	< 2	< 2
Iris codes	< 1	< 1
Matching	< 1	< 1

We have here the generation of the codes in the two cases. except that we have better execution time in the first case.

Average computing time of the algorithm identification: We present in Table 1, the execution times measured for each stage of the identification algorthm, developped in c++ builder langage on a 1.79Ghz P4.

CONCLUSION

A process of identification of anyperson by using the iris is p resented in this study. The algorithm is inspired from the methodology introduced by Professor J. Daugman. This algorithmic breaks up into five modules:

- the module of pretreatment,
- the module of insulation of iris
- the module of standardization or change of co-ordinates
- the module of extraction and generation of iris codes and sssfinally
- the module of comparison of the biometric gauges.

Compared to the approaches described in the literature, we can say that:

- We carried out a time comparison between the extraction by using Iris feature encoding by 2D wavelet demodulation and the extraction by using the characteristics of texture of iris by demodulating the information of emergent frequency starting from the concept of analytical image Table 1.
- We developped an efficient method for the detection of the pupil and of the iris by usining the segmentation and Hough transform by benefitting from the circular shape especially of the human eye's pupil.

This system gave good results for all the modules. But isolating the spectral componants regarding to information contained in the original picture of the iris requires less calculation, rather than applaying a complexe filter, wich uses exponentiel mathemathics fonction (type Gabor) and more over, the filtering is carried in the field of Fourrier. The size of the biometric signature is 512 bytes and can be increased or decreased according to the level of safety required without a considerable increasing in the complexity of calculation and time of extraction.

REFFERENCES

1. Sanderson, S. and J. Erbetta, 2000. Authentification for the blocked environments based on the technology of sweeping of iris, Conference of IEE on Visual Biometrics.
2. Wildes, R., 1997. Identification of Iris an Emerging Biometric Tech, Proceeding of IEEE, pp: 1348-1363.
3. Wolff, E., 1976. Anatomy Eye and Orbit, 7th Edn. H.K Lewis And Co LTD.
4. Thierry Pun, 2001. Dispositif de capture des mouvements oculaires pour un simulateur de vision , Université de Genève, Faculté des sciences, juin. these, pp: 88.
5 Daugman, J., 2004. How iris recognition works, IEEE Transaction on Circuit and Systems for Video Technomogie, pp: 21-29.
6. Havlicek, J.P., J.W. Havlicek and A.C. Bovik, 1997. The analytic image, IEEE J., pp: 446-449.
7. Christel-loïc Lionel Martin, 2002. Lionel Torres, Michel Robert, Person identification technique using human iris recognition, Conf/pris, pp: 186-199.
8. Joseph P. Havlicek, 1996. The Discrete Quazi-Eigenfunction Approximation for AM, FM image analysis, In Proc. IEEE Intl. Conf.image Lausanne, pp: 633-636.

9. Daugman, J., 2003. The importance of being random: statistical principles of iris recognition, IEEE, Pattern Recognition n° 36 pp: 279-291.
10. Daugman, J., 1993. High confidence visual recognition of persons by a test of statistical independence, IEEE Trans. Pattern Anal. Mach. Intl. 15, pp: 1148-1161.
11. http:// iris.di.ubi.pt.