Method for iris recognition based on its internal region

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1. ABSTRACT

In the recent years, the recognition of individuals through the characteristics of the iris has become a well accepted practice due to its high reliability and non-invasive nature. The majority of the methods used in the solutions proposed for iris recognition seek for information over the entire region of the iris, which leads to very high computational costs, particularly for real-time applications. Considering that most characteristics of the iris are in its inner region, the goal of this work is to develop an algorithm for the recognition of individuals from the information just obtained from this region. Despite the promising results, our technique still needs further improvements in order to enhance its accuracy to the levels of the best existing technique.

2. INTRODUCTION

With the increase on criminality, a nowadays important concern of our society is related with the access to restricted places and devices. So far, most of the security mechanisms involve the use of physical keys or remote controls, which can be easy thievery or duplicate. Biometric techniques constitute efficient solutions to security problems as the features used in the control decision are based on the intrinsic characteristics of the persons. These techniques are already widely used for the recognition of persons using distinct physical characteristics, such as fingerprints, voice and hand shape. From the existing approaches, one that has revealed to be very promising is the iris recognition that is the subject of this work.

Recently, the recognition of individuals based on characteristics of the iris has attracted significant attention from the research community, mainly for being non-invasive. Some other important characteristics of the iris that are extremely usefully in recognition are the stability, as the iris suffers very few changes along aging and is reasonably protected against external aggressions, and the high robustness, as has extraordinarily details and individual specificities. Thus, information from texture, pigmentation, intensity and topography make virtually impossible to find two persons with identical iris.

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Nowadays, there are numerous algorithms for iris recognition that, based on different principles and features from the iris, seek to attain significant results, both from the viewpoint of reliability and of processing speed. However, a perfect solution has not been accomplished yet.

The objective of this work has been the development of an algorithm for identification of persons through iris recognition from features in its inner region, since this region present most of its specific characteristics [8].

3. IDENTIFICATION OF THE PUPIL

The process of iris identification is done after the acquisition of an image of the eye, being the first step the search for the iris in that image. Usually, the Daugman's circular integrodifferential operator [1] and the Hough transform [3], among others, are used to detect circles in images. In the following, our approach, which is based on the Hough transform, to identify the iris in the image to be processed is presented.

As previously mentioned, we only use the inner region of the iris. Thus, it is not necessary to identify the boundary between the iris and the sclera on the eyeball. To establish the inner region of the iris, we apply a sequence of morphological filters (opening, erosion and removal) on the original image to identify the pupil. The boundary between the pupil and the iris is the outcome of such filters. Then, the Hough transform is applied to locate the exact circle around the pupil as well as the corresponding center. Figure 1 shows step by step the process for identifying the pupil in an image.

After the identification of the pupil presented in the input image, the inner region of the iris can be found by considering the Euclidean distance associated to the radius of the pupil that defines an outer circle concentric with it. Thus, the inner region of the iris is determined as the region between the border of the pupil and the iris, and this outer circle, Figure 2.

4. NORMALIZATION

The normalization is the geometric transformation of the inner region of the iris to a format suitable for the posterior operations of filtering and features extraction [14]. Usually, this process has two major goals: the compensation of variations on the distance between the persons to be recognized and the camera used to acquire the images to be used in the recognition process, and to compensate over-dilation or over-contraction of the pupil to be analyzed due to excess or lack of luminosity when the images are acquired. Thus, this process transforms the input image G of the iris from the Cartesian plane $G(x,y)$ into a Polar coordinate rectangle $G(r,\theta)$ [1].

As the normalization process uses the pixels in the Polar coordinate rectangle in the searching for the corresponding pixel on the original image, in its implementation the parameters associated with the central point of the image, height and width of the rectangle are required:

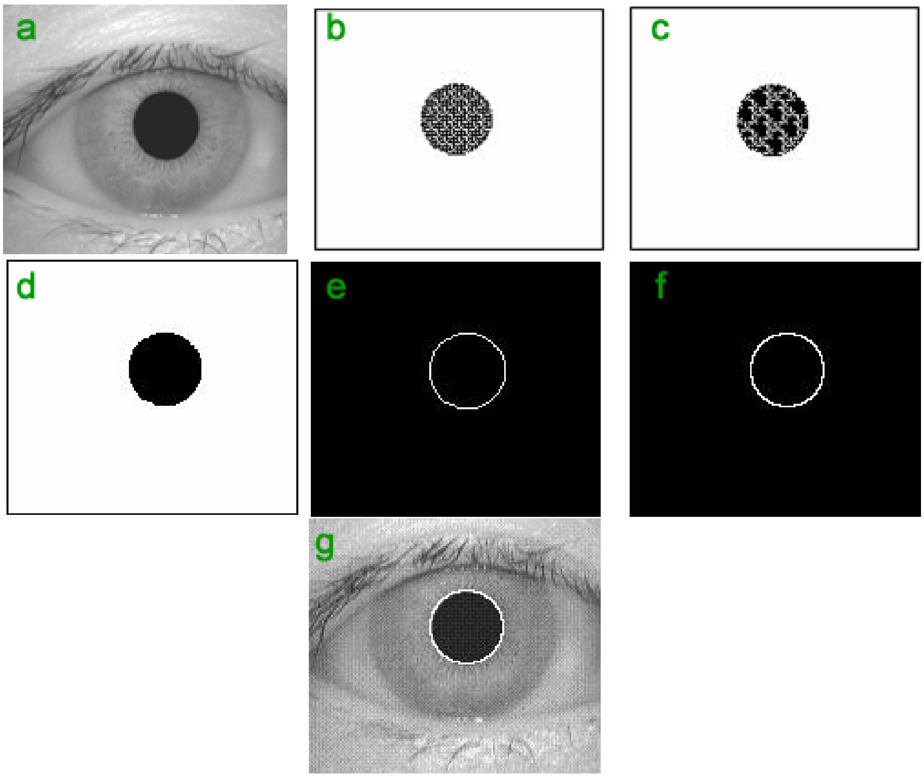

Figure 1: Identification of the pupil in an image: a) original image; b) image after thresholding; images after the application of the opening, erosion and removal filters (c-e); f) circle found by the Hough transform; g) original image overlapped with the circle of the pupil found.

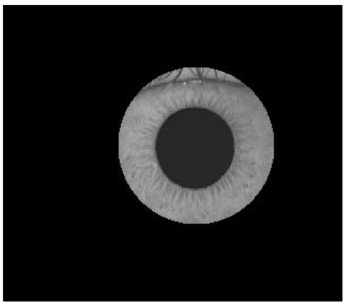

Figure 2: Inner region of the iris identified in an input image.

$$N(x,y) = G(r,\theta), \tag{1}$$

$$x = \sum_{1}^{M}\sum_{1}^{N}\left(\left(r_{Min} + (r_i - 1)\times\left(\frac{(r_{Max} - r_{Min})}{(M-1)}\right)\right)\cos\left((t_i - 1)\times\left(\frac{2\pi}{N}\right)\right)\right)\times c_X + c_Y, \tag{2}$$

$$y = \sum_{1}^{M}\sum_{1}^{N}\left(\left(r_{Min} + (r_i - 1)\times\left(\frac{(r_{Max} - r_{Min})}{(M-1)}\right)\right)\sin\left((t_i - 1)\times\left(\frac{2\pi}{N}\right)\right)\right)\times c_Y + c_X. \tag{3}$$

In the previous equations, M and N are the dimensions of the rectangle, c_X and c_Y represent the coordinates of the central points of the iris, and r_{Min} and r_{Max} are, respectively, the minimum and maximum radius of the circles that limit the inner region of the iris.

Using the aspect ratio proposed by Daugman [1], we empirically define the width and height of the rectangle to 32 and 256 bits, respectively, and kept them constant along the normalization process. Figure 3 displays the iris presented in Figure 1, after the normalization process.

Figure 3: Iris of Figure 1 after the normalization process.

5. FEATURES EXTRACTION

The process of features extraction involves obtaining relevant information from the image of the iris. From the information attained, an iris code for the iris under analysis can be produced. This code is then used for comparison with other iris codes previously stored in a database, for example.

In this work, to get the iris codes, we used a one dimensional log-Gabor wavelet filter [2], given by:

$$G(f) = \exp\left(\frac{-\left(\log\left(f/f_o\right)\right)^2}{2\left(\log\left(\sigma/f\right)\right)^2}\right), \qquad (4)$$

where f_o represents the central frequency and σ is the bandwidth of the filter. From the result obtained by applying the log-Gabor wavelet filter, it generated a bit-mask with the information on the iris analyzed. In Figure 4 is presented the bit-mask obtained by applying this filter on the normalized image of Figure 3.

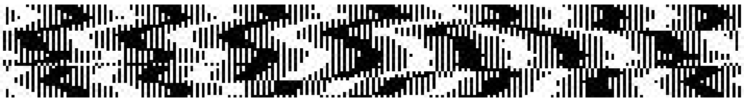

Figure 4: *Iriscode* generated from the image normalized of Figure 3.

6. COMPARISON

The comparison process involves verifying the similarity between different irises from their extracted features. This comparison determines if an iris under analysis belongs to a known individual or not.

In this work, the Hamming distance is used as a quantitative measure of the variation in terms of bits and masks. Thus, the value of the Hamming distance is obtained by bitwise comparison of the masks, followed by a calculation of the ratio between the amount of bits that do not correlate to each other, and the total amount of bit-to-bit comparisons done:

$$HD = \frac{1}{t}\sum_{j=1}^{t} A_j \left(XOR\right) B_j \,, \tag{5}$$

where t is the mask size, and A and B are the masks under comparison. Therefore, a match is considered successful when the outcome of the Hamming distance is below a predefined threshold. In the experimental work done, this threshold was equal to 0.44.

7. EXPERIMENTAL RESULTS

Experimental tests were performed by comparing 55 irises randomly taken from the CASIA Iris Image Database (Center for Biometrics and Security Research, China). The results obtained by our approach on these images are indicated in Table 1.

Table 1 – Results from the experimental tests done considering 55 irises.

Correct recognitions	**Incorrect recognitions**	**False Matches**	**False Rejections**
50 (90.91%)	5 (9.09%)	1 (1.82%)	4 (7.27%)

8. CONCLUSIONS

The use of a reduced portion of the iris for determining the similarity between irises reduces the computational cost associated to the recognition process. However, despite the considerable amount of relevant features that can be found in the inner region of the iris and the good results obtained, the performance of our algorithm is still somewhat modest when in comparison to the well-established Daugman's algorithm, which presents the best accuracy found until now (99.9%).

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