Fast identification of individuals based on iris characteristics for biometric systems

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ABSTRACT: Nowadays, systems based on biometric techniques have a wide acceptance in many different areas, due to their levels of safety and accuracy. A biometric technique that is gaining prominence is the identification of individuals through iris recognition. However, to be proficiently used these systems must process their recognition task as fast as possible. The goal of this work has been the development of an iris recognition method to produce results rapidly, yet without losing the recognition accuracy. The experimental results show that the method is quite promising.

1 INTRODUCTION

Due to the increasing rate of violence in almost all the world, the biometric techniques are gaining attention both in academic and commercial areas, because in this type of technique the access keys are physical or behavioral characteristics of individuals. One of the biometric techniques that has attained considerable attention in recent years is the identification of individuals through iris recognition, due to some characteristics of this region of the human body, such as: suffers light change over time, is fairly well protected, and presents many particular details.

There are several iris-based recognition methods, some of which are very accurate. However, when it comes to restricted area access systems, a high processing speed is also required, as long as delayed outcomes potentially generate service delays.

A fundamental step for the recognition of individuals through the iris is the exact localization of the iris to be analyzed in the input image. Failures in this process can lead to recognition errors, jeopardizing overall system reliability. However, the precise segmentation of this region is usually unfeasible as it often demands high computational costs.

This paper aims at developing a method to locate the iris with minimal computational cost. To achieve this goal, we do not use well-known techniques, such as Daugman integro-differential operator and Hough transform, which despite being proven effective, have high computational costs. Instead, our method is based on histogram variations, morphological operators, and distance calculations.

In section 2 we present the two main methods used in the segmentation of the input iris images. Afterwards, in section 3 we discuss in details the implementation achieved as well as the tools used for iris localization.

In section 4 we present the experimental tests performed, then we discuss the results obtained, and compare our results to the ones reported in the literature.

Finally, in section 5, we draw the conclusions.

2. RELATED WORK

For the location of the iris in eye images, two methods are widely used: the Hough Transform and Daugman Integro-Differential Operator.

2.1. Hough Transform

Patterns free from noise and discontinuities are hardly found in images. Hough Transform has been an efficient technique for the detection of approximately circular shapes in digital images [5].

To achieve this goal it uses a process of accumulation of votes, in which the votes are allocated to the crossing points of the possible circles in the input image. For this, it defines a mapping between the image space and the parameter space. The votes are accumulated in an array, and a possible circle is detected when a high amount of votes is attained.

Most studies using the Hough Transform start from images already preprocessed, for example, from image with the edges previously detected, in order to make the process simpler and quicker, since, despite high rates of identification of circles in images, the Hough Transform has a high computational cost, making it barely indicated for cases requiring a very fast processing.

Equation 1 shows how \( x \) and \( y \) coordinates on the plane, points \( a \) and \( b \) as the center of the circle that is
being sought and \( r \) as radius. The parameter space is discretized and represented as an array of integers or cells, where each position in the array corresponds to a range of parameters in the real space. Wanted all circles \((a, b, r)\) passing through each point \((x, y)\).

\[ r^2 = (x-a)^2 + (y-b)^2 \]  \hspace{1cm} (1)

Figure 1 shows an example of using the Hough Transform, where Figure 1(a) is the original image, obtained from segmenting one image of a human eye, and Figure 1(b) is the image obtained after using the Hough Transform, i.e. the circle detected.

![Image 1](image1.png)

Figure 1 – Example of the application of the Hough Transform: (a) segmented image of a human eye, (b) circle detected by the Hough Transform.

As can be seen in Figure 1, the Hough transform, when associated with an efficient segmentation method can produce good results in the identification of the iris in images.

2.2. Integro-Differential Operator

Another method widely referenced for the localization of the iris in images is the Integro-Differential operator, proposed by Daugman[1]. This operator is given by the equation 2.

\[ \max \left| G_{\sigma}(r) \ast \frac{\partial}{\partial r} \int_{(r,x_0,y_0)} I(x,y) \frac{1}{2\pi} ds \right| \]  \hspace{1cm} (2)

where, \( I(x, y) \) is the image containing the eye to be analyzed, \( r \) is the radius and \( x_0, y_0 \) are the coordinates of the iris center. In this equation, the symbol \( \ast \) denotes the image convolution and is a function of smoothing with a Gaussian filter of scale \( \sigma \). Looking over the image domain by the maximum value of the partial derivative with respect to the radius \( r \), the normalized integral of the contour of the image along a circular arc \( ds \) [1].

According to Daugman[1], with this technique it is possible to estimate separately the parameters of the iris and pupil, delimiting the inner contour of the iris with the pupil and the outer with the sclera. In Figure 2 the iris has been limited by the Daugman operator.

![Image 2](image2.png)

Figure 2. - Image of an iris located by the method of Daugman [1].

3. FAST IRIS LOCATION

The identification process consists in the image segmentation to separate the region of interest of the iris.

This work proposes to use only the inner region of the iris, discarding the outer region. Two reasons led to this decision:

1) The internal region of the iris, closest to the pupil, is one that concentrates most of the specific features of every human being, while the external region, nearer the sclera, has a smaller number of specific features [8].

2) The process of segmentation of the iris is usually one of the most computational expensive steps of the common recognition process. The use only the inner region of the iris reduces the processing time for separating the region of interest without losing the most important features for the iris recognition.

In this work, due to using only the inner region of the iris, is not necessary the location of the boundary between the iris and sclera. Targeting the boundary between the pupil and the iris is possible to separate the region of interest for the achievement of the following processes.

As the pupil has lower intensity than the rest of the image, we can use the histogram equalization followed by thresholding and a sequence of morphological operations to perform the segmentation of the boundary between the pupil and iris. The use of morphological operations instead of edge detection operators makes the segmentation process faster, which is highly relevant when one intends to use the iris recognition system in real time.

The sequence of talks used in the segmentation process of the pupil are: 1) histogram equalization, which aims to achieve a better distribution of the gray levels over the input image, causing a higher differentiation of the intensities presented; 2) thresholding the equalized image, aiming to separate
the spatial resolution of the used images. Tests were conducted using fixed distances between 20 pixels and 80 pixels, being 50 the number of pixels for this distance that led to the best results during the recognition process.

3. Region of interest defined through a percentage inversely proportional to the distance from the border of the iris with the pupil to the border of the iris with the sclera. The number of pixels was kept approximately constant during comparisons, disregarding eventual dilation or contraction of the pupil.

After applying some tests on the database, we decided to use the fixed distance approach to locate the region of interest, as this one presented the best results. Such results are presented in section 4. Figure 4 shows an example of the region of interest located in the iris.

![Figure 4 - Identification of the iris region of interest: (a) image with the pupil identified, (b) identified region of interest of the iris.](image)

4. TESTS AND RESULTS

For the experimental tests, we used the images of the iris database of the Chinese Academy of Sciences - Institute of Automation (CASIA). The choice of this image database is due to the fact that it has been used for testing in the works used in this work for comparison purpose. We also used two different computational platforms during the tests:


To locate the region of interest of the iris three different models were tested, as described in section 3. Table 1 displays the results obtained from the three models with respect to the localization of the region of interest accuracy ratio. It can be seen that the model based on a fixed region around the pupil presented the best results, thus being used as the method of choice for the present work.
The worst results presented by the model based on the length of the radius of the pupil are related to cases were the pupil is too dilated, in which case the radius of the pupil is larger than the radius of the iris. In such occurrences, the method takes regions of the sclera as regions of interest of the iris.

The worst results obtained from the method that takes a percentage of the whole iris are due to the difficulty in finding the border between the iris and the sclera. In this case the border is incorrectly guessed for several of the images.

The location of the region of interest of the iris represented in an eye image is one of the most complex processes in recognition of people through the iris and, without doubt, the process that requires the highest computational cost. The reduction of the recognition area of the iris, as reported in section 3, gives to the proposed algorithm a high gain with respect to the time necessary to carry out the recognition process. Moreover, the need for detecting only the border between the iris and pupil makes the localization relatively simple and provides a high accuracy.

Table 2 shows a comparison between the accuracy rates in localizing the iris in the image of the database used between the proposed method and other methods used as reference. It can be observed that the proposed method is the only that had localized successfully the region of interest in all testing images.

Table 3 presents the comparison in terms of the average computational time required to locate the region of interest in the testing images. We can verify that the proposed method requires a time lower than the other methods for locating the region of interest of the iris, which is due to a decrease in the region to be analyzed. It should be noted the high computational time required by the Masek method. This method uses as a basis for the exact location of the iris the Hough Transform, which despite being proven effective for locating circles in images, is very computationally expensive.

<table>
<thead>
<tr>
<th>Method</th>
<th>Accuracy (%)</th>
</tr>
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<tbody>
<tr>
<td>Proposed</td>
<td>100.00</td>
</tr>
<tr>
<td>Daugman[1]</td>
<td>98.60</td>
</tr>
<tr>
<td>Masek[3]</td>
<td>82.53</td>
</tr>
</tbody>
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The times shown in Table 3 were obtained using Machine I. Performing the test of the proposed method using the Machine II, the average computational was 0.27 seconds.

5. CONCLUSION

The recognition of individuals based on biometric techniques has gained great prominence in recent years. Among these techniques the one that presents the most interesting results is the recognition of individuals through iris features.

However, most existing methods have the drawback of high computational costs, mainly because segmentation of the iris from the rest of the input image is needed.

In this paper we presented a method in which the segmentation process can be performed with minimal computational cost, and that could identify successfully all the irises in the testing image database used. We could verify that the proposed method is very promising, primarily for its excellent performance with respect to the required computational effort and especially for not failing to identify the region of interest in all of the testing images used.

In spite of the main goal of the described work having been the speed up of the iris segmentation process, it should be noted an important outcome that was also obtained, which may lead to a promising future research: using only the region of the iris nearest to the pupil, a 99.42% level of accuracy over the entire image database as achieved.

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REFERENCES


