A Faster Method Aiming Iris Extraction

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Abstract: In this paper, we present a technique for iris segmentation. The method finds the pupil in the first step. Next, it segments the iris using the pupil location. The proposed approach is based on the mathematical morphology operators of opening and closing, as well as histogram expansion and thresholding. The CASIA Iris Database from the Institute of Automation of the Chinese Academy of Sciences has been used for the tests. Several tests were performed with 200 different images, showing the efficiency of the proposed method.

1 INTRODUCTION

Nowadays, the automatic identification of individuals is an important application of computer vision techniques. The iris biometrics is a great proposal in this area because the complex random patterns of iris are unique (Daugman, 2004). Biometrics is a very active research area that encompasses methods for automatic identification of individuals. Biometric systems are used in areas such as companies, banks, shops, universities, government departments, police department, etc. For instance, biometrics can be used to identify criminals and to replace passwords. Despite of its utility, biometrics still remains expensive. Our methodology aims to segment the iris using a fast algorithm and a low cost platform.

There are many works for iris segmentation. Daugman uses the integro-differential operator to locate the pupil and the iris region (Daugman, 2004). The Hough Transform can be used to find circular objects in the image, and so it has been used to extract the iris (Borovicka, 2011). Besides, Shah applied the geodesic active contours to segment the iris (Shah, 2009).

The paper is organized as follows. In section 2, the background is explained. In the section 3, the methodology is described. The section 4 reports the obtained results. Finally, section 5 presents the conclusions and further works.

2 MATERIALS AND METHODS

The tests have been performed using the CASIA Iris Database. Two hundred images of different people were used for these tests. The tests were done on a desktop with Intel Core2 Duo E7500 @2.93Ghz, Microsoft Windows 7 Ultimate, 2GB DDR2 RAM. We have used the OpenCV 2.1 library (OPENCV, 2011), Code Blocks 10.05 and C++ language. The techniques used in this paper are well known. They are based on mathematical morphology operations, such as opening and closing, the threholding method and the histogram expansion.

2.1 Mathematical Morphology in Gray Levels

Two techniques widely used in Mathematical Morphology in Gray levels are erosion and dilation operations (Serra, 1982).

Greyscale erosion consists in pass through all pixels of an image, and in each pixel, check for the lowest value among it and its neighbours and replace the value of this pixel by the lowest value. The neighbours of a pixel are selected according to the structuring element.

Greyscale dilatation consists in the same idea of greyscale erosion, but instead of finding the lowest value, the greyscale dilation seeks for the biggest one between the pixel and its neighbors.

Erosion and dilatation operations have different results depending on the structuring element utilized.

Structuring element is a set of pixels used to probe or interact with a given image. In our case, it is used to define the neighbours to be compared, to check the lowest value (erosion), and the biggest value (dilation). For example, in a dilatation or erosion, if the cross shaped structuring element with size 3x3 is used, only the current pixel (x, y), the pixel from above $(x, y - 1)$, the pixel from below $(x, y + 1)$, the pixel from the left $(x - 1, y)$ and the pixel on the right $(x + 1, y)$ are scanned.

The verification aims to find the lowest or biggest value (for erosion and dilation, respectively) of the pixels of the current region and replace the current pixel (x, y) by this value. This process is applied for all pixels in the image. The new value generated is not used for comparisons in the same iteration of the morphological operation. Another area of memory is allocated to save the new values, and thus the original image is not changed.

The closing and opening operators are based on the erosion and dilatation techniques. The opening operator is intended to remove small bright areas that are surrounded by darker areas. Also, the closing operator removes small black details that are surrounded by lighter regions.

2.2 Thresholding

The thresholding is a method for image segmentation (Gonzalez and Woods, 2007). This technique is often used when it is necessary to separate objects from the background. To use this technique, you must set a value that will be used to segment the image. This value is called threshold, which can be obtained by a variety of automatic techniques, or manually inserted.
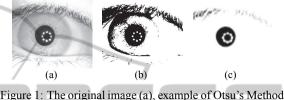
One of the most used methods for thresholding is the Otsu's method. This method is based on the use of bimodal histogram (separating the image into two classes of pixels), splitting the image into two parts and calculating the best threshold for those parts where the intra-class variance of them is minimal (Otsu, 1979). An example of application of the Otsu's method, using an image from CASIA (CASIA,

2011), is represented in Figure 1, where the original image in gray levels is transformed into a binary image (Figure 1-b).

Another way to utilize the thresholding method is to manually set the threshold. An example is showed in the Figure 1-c, using the value of thirty (30) for the threshold.

2.3 Histogram Expansion

The Histogram Expansion is a linear transformation that expands a range of colour levels [xmin , xmax] to a range from 0 to ymax (typically 0 to 255). An adaptation of histogram expansion is mainly used for images with low contrast. A manually chosen p value is used to modify the xmin and xmax. The idea is to compress the ends of the histogram to expand the center of the histogram. The lower the p value the greater the intensity of the operation.

(a) (b) (c)

Figure 1: The original image (a), example of Otsu's Method (b) and example of manual thresholding (c).

3 METHODOLOGY

Our method aims to find the region of the pupil, and through it, to segment the iris of the eye. The method- ology is organized in the following pipeline: image acquisition, pre-processing and processing as shown in Figure 2.

Figure 2: The propose pipeline.

3.1 Image Acquisition

The images were acquired from the iris database of CASIA from "Institute of Automation of the Chinese Academy of Sciences." The version used was the CA- SIA V3 Interval. The CASIA was chosen because it is widely used in the literature. We used 200 images of different people for testing. They all have the influence of reflection of light in the pupil, the region where we will focus for the segmentation of the iris.

The images from CASIA Interval V3 Iris Database have more details, because they were taken from a shorter distance and the light is focused on the pupil, showing the details of the iris.

3.2 Pre-processing

This part is divided in the opening, closing and

histogram expansion operations. The first step is to perform the gray scale opening. This operation has the goal to removing small areas that are lighter than the surrounding areas (see Figure 3-a). We observe that, the reflection of light present in the pupil is removed. Fifteen iterations of the morphological opening operation were performed. The next step is to apply the morphological closing operator.

The morphological closing operator is used to remove small areas that are darker than the surrounding ones. The idea of this operation is to increase the gray levels of dark artifacts in the image. Most of these artifacts are eyelashes. This operation is executed because the eyelashes are close to the iris and have almost the same gray level of the pupil. Thus, the eyelashes are not segmented along the pupil when the thresholding technique is applied. Fifteen iterations of the closing operation are performed as illustrated in Figure 3-b.

Then, a histogram expansion is applied in the image (Figure 3-c). In this case, the value of p is zero. This technique is utilized to highlight the pupil area from other ones in order to get only the pupil region after the thresholding.
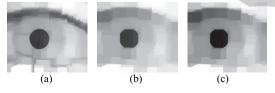

(a)   (b)   (c)

Figure 3: Image after Opening operation (a), followed by the Closing operation (b) and the Histogram Expansion (c).

3.3 Processing

In this section, the processing step is presented. After the histogram expansion, a thresholding technique is used. The threshold value is thirty. This value was chosen after analyzing several images from CA-SIA. It was found that most of the pixels of the pupil have gray levels less than or equal to this value. Moreover, the rest of the image pixels have a value greater than thirty. Using the thresholding technique, the pupil is segmented (black area) from the rest of the image (white area).

The next step is to find the extreme points of the area of the pupil. The mathematical morphology operations damaged the region of the pupil. Therefore, a correction process is necessary.

The idea is to find out these extreme points, and from these points, creating a circle that replaces the region of the pupil. To find out these points, the image is scanned to find the black pixels with the

smallest value of x (left), the lower value of y (up), the largest value of x (right) and the highest value y (down).

Using these points, a circle is created at the same position of the pupil as shown in Figure 4. Furthermore, another circle larger than the previous one is created, in this case having a radius equal to twenty pixels. All black pixels of the larger circle, which at the same position of the smaller circle are white, possess the same position that the pixels in the inner region of the iris.

(a)   (b)   (c)

Figure 4: Application of the Threshold Method (a), followed by the creation of small circle (b) and a big circle (c).

The pixels of the images of the circles are compared with each other. If in a position (x, y), the pixel of the smaller circle is white and the pixel from the larger circle is black, the pixel of the original image with the same position (x, y) is saved in another image. Thus, only the pixels in the inner region of the iris are segmented as illustrated in Figure 5.
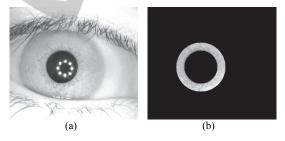

(a)   (b)

Figure 5: The original image (a) and iris segmented (b). Only the inner region of the iris is obtained.

4 RESULTS

From the two hundred images tested, twelve (12) images showed some errors in the segmentation process. This result shows that our method has an accuracy rate of 94%.

4.1 Errors Encountered

Some images did not show the expected result. This section is designed to show the errors encountered in the process.

In Figure 6-a, the pupil is very small and has artifacts due to the reflection. So the thresholding

does not properly work, resulting in segmentation errors (Figure 6-b). The same error occurs in Figure 6-c, where the pupil is also small and has high influence of reflection of light.
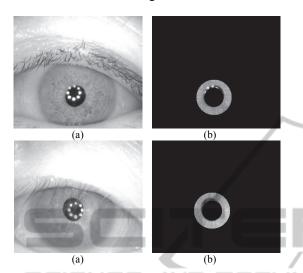

Figure 6: Original images (a), (c) and the respective segmented images (b), (d).

Another example is shown in Figure 7-a. Even with the application of histogram expansion (Figure 7-b), part of the region of the eyelashes is segmented along the pupil (Figure 7-c) once those pixels have an intensity value equal or below the threshold. The result ended up being a defective segmentation (Figure 7-d).

5 CONCLUSIONS

The tests show that our method has an accuracy rate of 94%. The images for which the method fails contain large artifacts due to eyelashes and reflections. Such artifacts increase the difficulty of the problem.

The proposed methodology has been developed for segmentation of iris using a reduced amount of a priori knowledge. The results show the efficiency of the technique. Besides, the proposed pipeline runs very fast in commonly used desktops due to the low computational cost of the operations involved.

Studies have been carried out in order to apply the method to identify persons. In further studies we will compare the proposed technique with other approaches such as (Shamsi and Kenari, 2009) and (Wang and Jain, 2003).
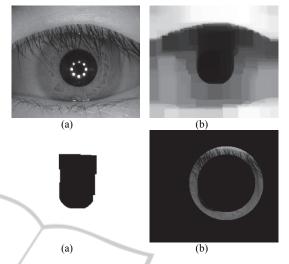

Figure 7: The original image (a). A histogram expansion is applied at the image (b) and after that, a thresholding technique (c). Finally, the inner region of the iris is segmented (d). Unfortunately, this process has failed.

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