An Iris Location Algorithm Based on Gray Projection and Hough Transform

Baoju Zhang(✉) and Jingqi Fei

Tianjin Key Laboratory of Wireless Mobile Communications and Power Transmission, Tianjin Normal University, Tianjin 300387, China
wdxyzbj@163.com

Abstract. In order to improve the performance of the existing iris location algorithm, a transform algorithm based on gray projection and Hough is proposed. The algorithm uses the grayscale transformation of the binary image to obtain a graph of the gray projection. At the same time, according to the value of the peak or trough in the graph, the maximum radius of the circle is obtained. The result of experiment shows that: The algorithm can get the parameters needed in Hough transform, which greatly improves the speed and accuracy of iris positioning.

Keywords: Iris recognition · Canny edge detection · Binarization · Grayscale projection · Hough transform

1 Introduction

With the development of society, the importance of identity recognition is increasingly evident. In recent years, in the fields of maintaining national security, aviation safety, financial security, social security, and network security, there is a need for more accurate, reliable, and more practical authentication methods for identifying and authenticating identity. However, relying on identity documents, user names, and identity authentication in the form of passwords is far from meeting the requirements of the information age for the validity of authentication and the accuracy of identification. As an important identification feature, iris has the advantages of uniqueness, stability, collectability, and non-invasion. One of the keys to the iris recognition algorithm is to accurately locate the iris region from the acquired iris image. It mainly includes the edge position of the pupil and the iris, the iris and the sclera, hereinafter referred to as the inner edge and the outer edge.

There are many articles on iris recognition at domestic and foreign, including Daugman [1], who used the characteristics of the inner and outer edge of the iris as an approximate circle, a circular difference operator is proposed to extract the edge of the iris. Wildes [2] uses a two-step method combining edge detection and Hough transform to locate the iris region. Both of these iris location methods have high accuracy, but both searching in three-dimensional space, positioning speed is slow and is unable to meet the requirements of real-time systems. Tisse proposes to extract iris features using a time-phase technique. Weiqi Yuan [3] uses the traditional gray projection method to roughly locate the pupil center and position and then uses Hough transform to

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accurately position. When the iris image contains thick eyelashes, the gray projection method can easily misplace the eyelash position as the pupil position, so that the accuracy of this method is lower.

In order to overcome the above defects and further improve the iris recognition system, according to the characteristics of the iris itself, an iris location algorithm based on gray projection and Hough transform is proposed. This method can not only suppress noise interference, but also improve the accuracy of iris location.

2 Iris Localization Algorithm

2.1 Iris Image Smoothing and Edge Extraction

The collected iris images have different levels of interference. Filtering before the iris boundary location can help to eliminate the effect of interference on the boundary location. The image should be smoothed. On the one hand, it can highlight a large area, a low-frequency component and a trunk part, on the other hand, smoothed can suppress image noise and interfere with high-frequency components. At the same time, it can reduce a sudden gradient, and improve image quality [4]. In addition, taking into account the edge extraction of the grayscale image of the iris, the inner and outer boundaries of the iris belong to the detailed information. In order to not only retain the iris edge information but also effectively eliminate high-frequency interference, Gaussian filter templates are used for smoothing. The formula is as follows:

$$H_{ij} = \frac{1}{2\pi\delta^2}\exp\left(-\frac{[i-(k+1)]^2 + [j-(k+1)]^2}{2\delta^2}\right) \tag{1}$$

When Gaussian template filtering is used, the point farther from the center point will have less effect on the smoothing effect. According to the distance, selecting a weighting coefficient can construct Gaussian templates of different sizes whose filter parameters can be determined by the variance of the Gaussian function. The Gaussian template can well protect the contour information of the iris region while filtering the noise, so as not to cause the edges to be too fuzzy. Figure 1a is the original. The result is shown in Fig. 1b.

For effective edge extraction, Canny edge detection is used in this paper. In the first step, the gradient intensity and direction of each pixel in the image are calculated for the smoothed image. Edges in the image can point in all directions, so the Canny algorithm uses four operators to detect horizontal, vertical, and diagonal edges in the image. The operator of the edge detection (such as Roberts, Prewitt, and Sobel) returns the first derivative value of the horizontal G_x and vertical G_y directions, thereby determining the gradient G and the direction theta of the pixel [5]. The formula is as follows:

$$G = \sqrt{G_x^2 + G_y^2} \tag{2}$$

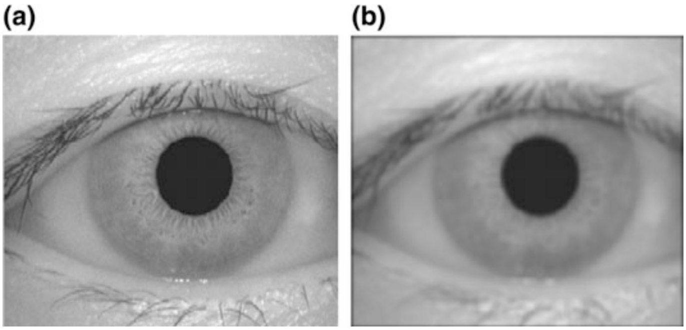

Fig. 1. (a) Original image (b) Gaussian image

$$\theta = \arctan\left(G_y/G_x\right) \tag{3}$$

In the second step, non-maximum suppression is performed to compare the gradient intensity of the current pixel with two pixels in the positive and negative gradient directions. If the gradient intensity of the current pixel is the largest compared to the other two pixels, the pixel remains as an edge point, otherwise the pixel will be suppressed. The third step, it is dual threshold detection. After non-maximal suppression, the remaining pixels can more accurately represent the actual edges in the image. However, there are still some edge pixels caused by noise and color changes. In order to solve this type of edge pixels, weak gradient values are used to filter edge pixels, and edge pixels with high gradient values are retained, which is achieved by selecting high and low thresholds [6]. If the edge pixel's gradient value is higher than the high threshold, it is marked as a strong edge pixel; if the edge pixel's gradient value is less than the high threshold and greater than the low threshold, it is marked as a weak edge pixel; if the edge pixel's gradient value is less than low thresholds, it will be suppressed. The choice of threshold depends on the content of a given input image. The result is shown in Fig. 2.

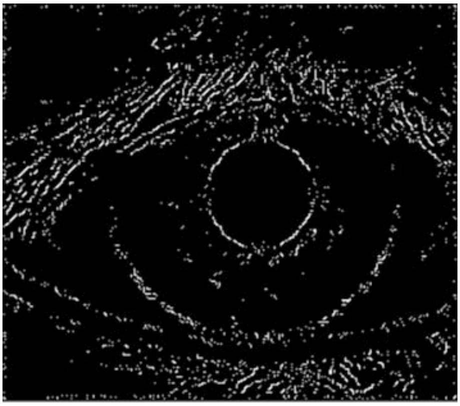

Fig. 2. Edge contour extraction map of the entire eye

2.2 Iris Boundary Localization

To locate the inner circle, we need to extract the inner circle. By setting the threshold, the image is binarized and the pupil is extracted. The formula is as follows:

$$\begin{cases} B(m,n) = 1, & \text{if} \quad I(m,n) > \alpha \\ B(m,n) = 0, & \text{if} \quad I(m,n) \leq \alpha \end{cases} \tag{4}$$

According to the formula, in this paper, α has a value of 47, the binarized picture obtained, at the same time, we should extract the outline, as shown in Fig. 3a, b.

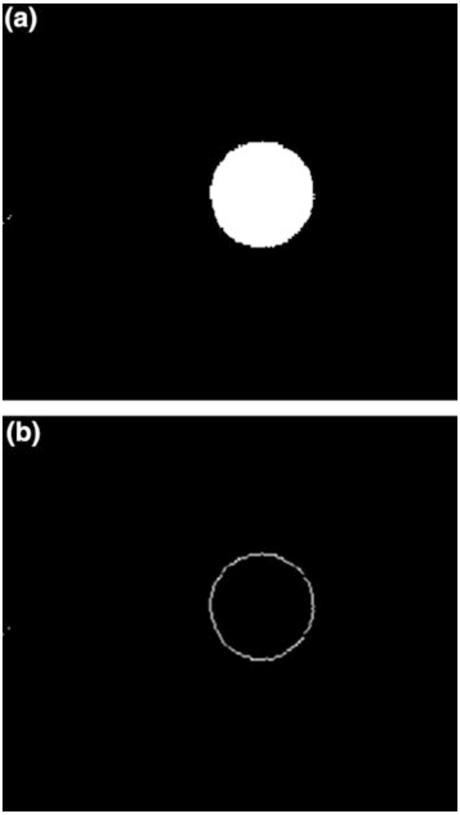

Fig. 3. (a) and (b) show further extraction of contours by binarization

Thus leaving only the outline of the inner circle. Then we can use the information of the gray change to determine the parameters of the pupil. The algorithm is as follows:

Step 1. Find the horizontal grayscale projection curve. The image is represented by a matrix of $M * N$, then M can be regarded as a matrix, i and j are the matrix rows and columns, and the horizontal grayscale projection curve of the image, then the abscissa is the row number of each row of the matrix, and the ordinate is a matrix [7]. The sum of the row elements, that is, the sum of the pixel values for each row in the picture. Actually, the curve contains the change in the sum of the pixels in each row of the image.

Step 2. Based on the calculation of the gray curve, the peaks and troughs of the curve are obtained, as shown in Fig. 4a. Since the black gray value is 0 and the white gray value is 255, the region coordinates information with a smaller gray value is included in the trough.

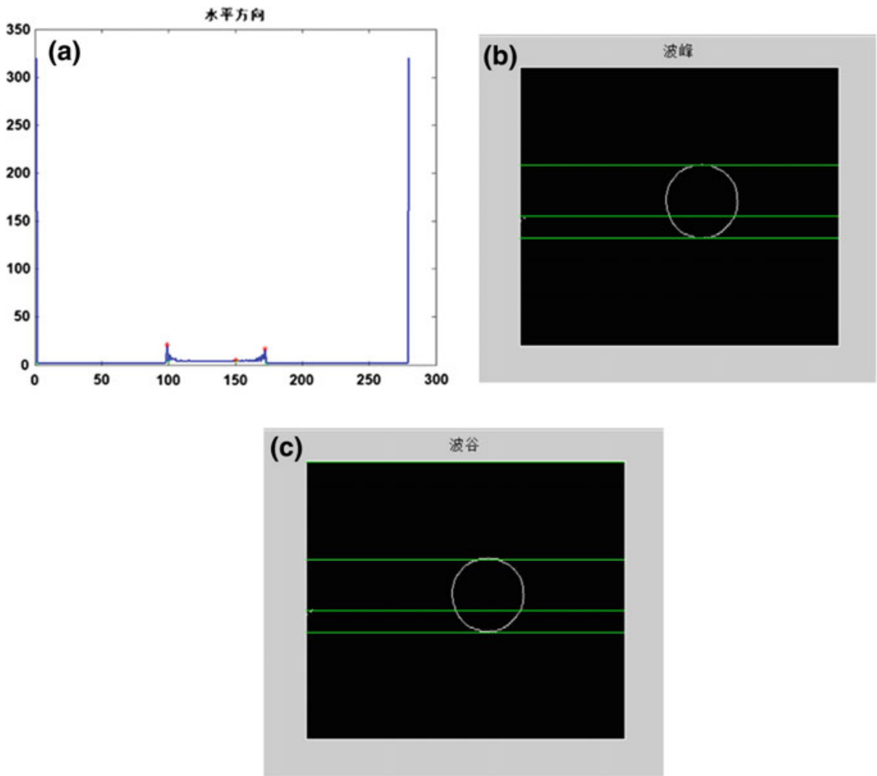

Fig. 4. (a) Shows a chart of pixels in the horizontal direction (b) and (c) show the peaks and valleys of the outline according to the chart

Step 3. Drawing the line information of the image represented by the abscissa of the wave trough, as shown in Fig. 4b, c, and the maximum value of the radius can take the maximum difference r_max in the crest or trough. According to the prior knowledge, the minimum radius can be obtained by subtracting 13 from the maximum difference r_max.

The Hough transform is used to locate the circle parameter. A circle is a typical and regular geometric shape with fewer parameters, namely the center coordinates and radius [8]. Therefore, detection of a circle becomes a process of voting on a parameter group. Define a three-dimensional array as

$$H(x_m, y_n, r) = \sum_{j=1}^{n} h(x_m, y_m, x_n, y_n, r) \tag{5}$$

Here, $H(x_m, y_n, r)$ is an accumulator corresponding to the parameter group (x_m, y_j, r) formed by the center point coordinate and the radius size, and the obtained value is used to accumulate the votes of the group of parameters. The number of votes is represented by the number of boundary points passed by the circle drawn by the parameter. If the edge point falls on the circle corresponding to the parameter group, it is equivalent to the edge point casting a vote for the parameter group, and the corresponding array element value is increased by 1, otherwise the corresponding array element value is not changed [9]. The formula is as follow:

$$h(x_m, y_m, x_n, y_n, r) = \begin{cases} 1 & g(x_m, y_m, x_n, y_n, r) = 0 \\ 0 & g(x_m, y_m, x_n, y_n, r) = 1 \end{cases} \tag{6}$$

In the formula, $g(x_m, y_m, x_n, y_n, r) = (x_m - x_n)^2 + (y_m - y_n)^2 - r^2$ is a decision function that satisfies the circular equation of the parameter (x_n, y_n, r). When $g(x_m, y_m, x_n, y_n, r) = 0$, the center of the circle is (x_n, y_n), and the boundary circle with the radius r passes through the edge point (x_m, y_m), indicating that the point will vote for the parameter (x_n, y_n, r). After passing through all votes of columnar-(5) statistic, the circle with the most votes will be used to determine the circle of the boundary equation [10]. In the end, the results obtained are shown in Fig. 5.

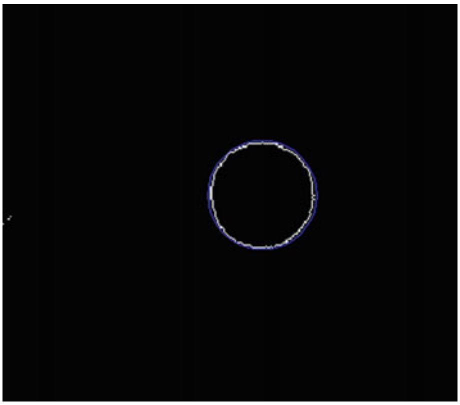

Fig. 5. Inner edge contour extraction image

3 Experiments Results

The computer CPU used in the experiment was clocked at 2.01 GHz and the memory was 1 G. The programming tool was MATLAB 2014a. The iris images used were all from the CASIA 1.0 database of the Chinese Academy of Sciences. According to the method mentioned above, the iris is positioned inside and outside the circle. The final result is shown in Fig. 6.

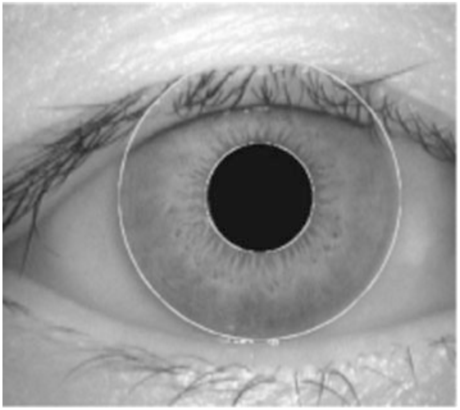

Fig. 6. The final result

4 Conclusions

Based on previous study of iris recognition, this paper proposes an algorithm which can locate iris by grayscale changes. Firstly, image which should be detected is binarized and the outline is extracted. Then, grayscale graph is drawn by taking advantage of gray change of the image. Finally, according to the peaks and valleys in the graph, the parameters required by the Hough transform are obtained. Experiments show that the method used in this paper reduces Hough transform traversal, which can make iris localization improve efficiently.

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