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# Iris Pathological Features Detection Based on Matlab

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# Iris Pathological Features Detection Based on Matlab

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**Abstract**. The region of the iris reflects the health status of human body organs. Through the detection of iris pathological features, the potential diseases of the human body can be initially detected, and the examination and treatment of related diseases can be further carried out. There are a lot of kinds of iris pathological features, but this paper mainly studies the detection of iris hyper pigmentation. First of all, the iris image is preprocessed in this paper. Then, the Otsu image segmentation algorithm and the Canny edge detection algorithm are used to realize the detection of iris hyper pigmentation. Finally, the GUI (Graphical Use Interface) of iris hyper pigmentation is designed by Matlab in this paper.

## 1. Introduction

The healthy iris has a dense surface density, uniform color distribution, and no distortion of the fiber structure, without any defects. When people are too nervous, the pressure is too large, or functional lesions occur in the body organs, the texture of the iris area will change, and a series of pathological features, such as radii solar, sodium ring and hyper pigmentation, will appear in the iris area[1]. Once the iris has pathological features, it indicates that the human body is in a sub-health state.

This paper mainly studies hyper pigmentation, which is commonly known as plaque. Its color is black or brown, the shape is mostly spotted, and the size of it varies, distributed in the iris area of the network structure, as shown in Figure 1. Plaques usually appear in the heart and circulatory system of the iris. When plaques occur in these areas, it indicates that the body may suffer from heart disease or myocardial infarction. People who have taken drugs for a long time or have poor metabolism and poor detoxification may develop hyper pigmentation.

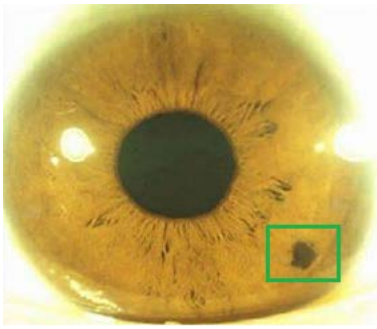


**Figure 1.** Hyper pigmentation.

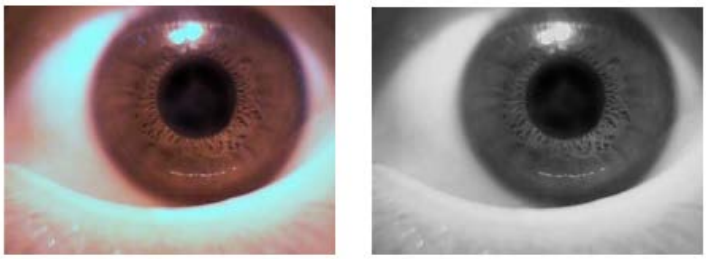
## 2. Preprocessing of iris image

### *2.1. Iris image grayscale processing*

There is no difference between the gray image and the color image in terms of the integral image, the local brightness and chroma characteristics. Therefore, so as to reduce the complexity of the image and the amount of information processing in the digital image processing, the color image is often converted to a gray image.

In the digital image, when the components of RGB take different values, it will appear as color image. The grayscale processing is the process of converting the color image which has three channels into the gray image which has single channel. That is to say, when R=G=B, the digital image will show gray, and we call the image is gray image. In this paper, according to the importance of the RGB component and other specific conditions, we use weighted average method to assign weighted average operation to the three components, as shown in formula 1.Then, we use formula 1 to convert the input iris image to a grayscale image, as shown in Figure 2.

$$Gray = 0.299* R(i, j)+0.587 *G(i, j)+0.114* B(i, j) \quad (1)$$

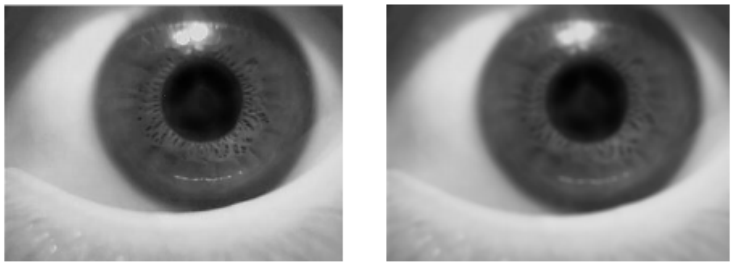


(a) Original image (b) Gray image

**Figure 2.** Convert color image to gray image.

### *2.2. Smooth processing and edge extraction of iris image*

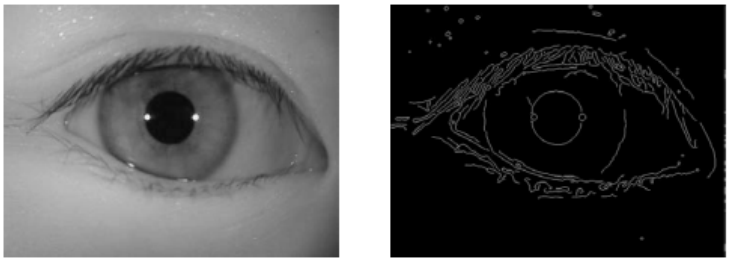
*2.2.1. Smooth processing.* Smooth processing, also known as blur processing, is usually used to highlight large areas of the image, low-frequency components, backbone parts, or to suppress image noise and high-frequency components, which can reduce the abrupt gradient and improve image quality[2]. In order to protect the contour information of the iris region while filtering noise, and not to cause the edge to be too blurred, a 5×5 Gaussian template will be used for smoothing, as shown in Figure 3.



(a) Original image (b) Image after smooth processing

**Figure 3.** Use gaussian filter template to smooth the image.

*2.2.2. Edge extraction.* As shown in Figure 4, in order to better extract the edge of iris image, Canny edge detection algorithm was utilized to extract the binary image of the iris gray image. This algorithm selects two thresholds to detect the boundary points, and the extracted boundary is a combination of strong and weak edge points[3]. Compared with the method using a single fixed threshold, it is not easy to be disturbed by noise, the blurry weak boundary is well detected .



(a) Gray image after filtering (b) Binary edge image

**Figure 4.** Gray image edge extraction.

*2.3. Localization of iris inner and outer boundary*

Considering the accuracy and stability of the algorithm, this paper adopts the iris boundary location algorithm based on Hough transform voting mechanism[4].

*2.3.1. Estimation of the center of the pupil.* As shown in formula 2, taking the threshold Th=220, when a certain pixel gray value of the iris grayscale image is greater than the threshold, the value 100 will be automatically assigned. Using the image characteristics with the smallest pupil gray value, the full 1 template window is convolved with the image J(x,y), and the position where the convolution is the smallest is the center of the pupil, as shown in formula 3and formula 4.

$$J(x,y)=\begin{cases} I(x,y), & I(x,y)<Th \\ 100, & I(x,y)\geq Th \end{cases} \tag{2}$$

$$Window(x,y,size)=\begin{bmatrix} 1 & 1 & \cdots & 1 \\ 1 & 1 & \cdots & 1 \\ \vdots & \vdots & \ddots & \vdots \\ 1 & 1 & \cdots & 1 \end{bmatrix}_{size\times size} \tag{3}$$

$$(x_p^*, y_p^*)=(x,y)\,|\,\min(\bigcup_{x,y} Window(x,y,size)*J(x,y)) \tag{4}$$

*2.3.2. Location of the inner boundary of the iris. Firstly b*ased on the coordinate of the center of the pupil that has been found, a binary image for locating the inner boundary of the iris is intercepted according to formula 5. Then, the remaining effective edge points in the binary image are collected by formula 6, and the round equation is fitted by Hough transform. Finally, the equation with the largest number of votes is the round equation closest to the inner boundary, and the parameters are $(x_p, y_p, r_p)$.

$$Binary(x,y)=\begin{cases} 0, & |x-x_p^*|>r_{\max} \ \ or \ \ |y-y_p^*|>r_{\max} \\ Binary(x,y), & others \end{cases} \tag{5}$$

$$\begin{cases} g(x_j, y_j, x_c, y_c, r) = (x_j - x_c)^2 + (y_j - y_c)^2 - r^2 \\ h(x_j, y_j, x_c, y_c, r) = \begin{cases} 1, & g(x_j, y_j, x_c, y_c, r) = 0 \\ 0, & g(x_j, y_j, x_c, y_c, r) \neq 0 \end{cases} \\ H(x_c, y_c, r) = \sum_{j=1}^{n} h(x_j, y_j, x_c, y_c, r) \\ (x_I, y_I, r_I) = (x_c, y_c, r) \mid \max(\bigcup_{x_c, y_c, r} H(x_c, y_c, r)) \end{cases} \tag{6}$$

In the formula :

$$r = [r_{\min}, r_{\max}], (x_j, y_j) \in \{(x, y) \mid Binary(x, y) = 1\}, x_c \in [x_p^* - 25, x_p^* + 25], y_c \in [y_p^* - 25, y_p^* + 25]$$

*2.3.3. Location of the outer boundary of the iris.* Based on the obtained inner boundary parameters of the iris, formula 7 is used to remove the edge points that is too far from the outer boundary of the iris in the horizontal direction and the edge points in the binary image where the distance from the pupil center is less than the radius of the iris inner boundary. Then, the remaining effective edge points in the binary image are collected by formula 8, and the round equation is fitted by Hough transform. Finally, the equation with the largest number of votes is the round equation closest to the outer boundary, and the parameters are $(x_I, y_I, r_I)$.

$$Binary(x, y) = \begin{cases} 0, & \mid x - x_p^* \mid > R_{\max} \quad or \quad \mid y - y_p^* \mid > r_p \quad or \quad \mid y - y_p^* \mid > r_p \\ Binary(x, y), & others \end{cases} \tag{7}$$

$$\begin{cases} g(x_j, y_j, x_c, y_c, r) = (x_j - x_c)^2 + (y_j - y_c)^2 - r^2 \\ h(x_j, y_j, x_c, y_c, r) = \begin{cases} 1, & g(x_j, y_j, x_c, y_c, r) = 0 \\ 0, & g(x_j, y_j, x_c, y_c, r) \neq 0 \end{cases} \\ H(x_c, y_c, r) = \sum_{j=1}^{n} h(x_j, y_j, x_c, y_c, r) \\ (x_I, y_I, r_I) = (x_c, y_c, r) \mid \max(\bigcup_{x_c, y_c, r} H(x_c, y_c, r)) \end{cases} \tag{8}$$

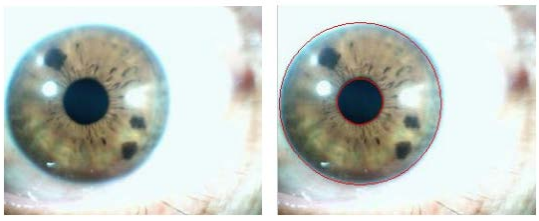
In the formula :

$$r = [R_{\min}, R_{\max}], (x_j, y_j) \in \{(x, y) \mid Binary(x, y) = 1\}, x_c \in [x_p^* - 10, x_p^* + 10], y_c \in [y_p^* - 10, y_p^* + 10]$$

## 3. Detection of iris hyper pigmentation

### *3.1. Distribution characteristics of hyper pigmentation*

In the iris region, as shown in Figure 5(a), the gray values of hyper pigmentation are different from that of the surrounding pixels, and they are in planar shape with different shapes and sizes. After image preprocessing, the located iris area is shown in Figure 5(b).



(a) Original image (b) Iris region location

**Figure 5.** Hyper pigmentation in iris image.

The annular iris region is expanded into a 64×512 rectangular picture. As shown in Figure 6, the iris pigmentation spots are spotted in the middle region of the iris development map and are not bordered by the upper and lower boundaries.

**Figure 6.** Panorama of iris hyper pigmentation.

### *3.2. The process of extracting iris hyper pigmentation*

*3.2.1. Binary image of iris hyper pigmentation.* Firstly, the iris expansion map is grayed out, and then the Otsu threshold segmentation method is used to segment hyper pigmentation in the grayscale image to obtain a binary image[5]. In this paper, as shown in Figure 7, the Otus threshold segmentation method is implemented by combining functions graythresh and im2bw in Matlab to convert the panorama of gray iris hyper pigmentation into a binary image.

**Figure 7.** Binary image of iris hyper pigmentation.

*3.2.2. Binary image of iris hyper pigmentation without iris frill.* Removing the area of iris frill that is useless for hyper pigmentation extraction in the iris binary image can reduce the range of searching for iris hyper pigmentation.

There are many small interference points above panorama of the iris, as shown in Figure 7. The one-third area of panorama of the iris near the upper boundary is the frill area of the iris, which is not an effective detection area of hyper pigmentation[6]. The gray value of the frill region of the iris is newly assigned to 0 (the value is all black), and a binary image as shown in Figure 8 is obtained.

**Figure 8.** Binary image of iris hyper pigmentation without iris frill.

*3.2.3. Edge detection based on Canny edge detection algorithm.* Firstly, the Canny edge detection algorithm is used to extract the edge of the binary image without iris frill, as shown in Figure 9. Then, fill the closed regions of the iris binary edge image, as shown in Figure 10.

**Figure 9.** Binary edge image of iris hyper pigmentation.

**Figure 10.** Fill the closed region of the iris binary edge image.

*3.2.4. Using morphological open operation to remove non-closed curve.* After a large number of sample analysis, we conclude that the iris hyper pigmentation are marginal closed areas. There are some non-closed white areas that are close to the lower boundary of the rectangle, which may be disturbed by eyelids or other factors. This interference can be eliminated by using morphological open operation to remove non-closed curve, as shown in Figure 11.

**Figure 11.** The result of Figure 8 with opening operation.

*3.2.5. Selection of eligible iris hyper pigmentation.* Screening conditions were set for the size of the iris hyper pigmentation, and the hyper pigmentation that met the conditions were retained and marked. Because the size of the hyper pigmentation are generally between 200~600, we can set the screening criteria to screen the size of the hyper pigmentation, as shown in formula 9.

$$Area(i) = \begin{cases} reserve, & 200 \le \text{Area}(i) \le 600 \\ delete, & \text{others} \end{cases} \tag{9}$$

In the formula, Area(i) represents the area of the i connected region, i =1 ,2 ,...,n, and n is the number of connected areas. The area of the connected region in the binary image is the number of pixels having a gray value of 255.

Therefore, calibrating the connected region in the picture 8, and then calculating the area of the connected region. According to the screening condition, we can obtain the result of selecting eligible iris hyper pigmentation, as shown in Figure 12.

**Figure 12.** The result of Figure 8 with opening operation.

The coordinates of the white patches in Figure 12 are marked in the original color image, as shown in Figure 13.

**Figure 13.** The result of iris hyper pigmentation detection

## 4. Design and demonstration of Matlab GUI

In the detection of iris hyper pigmentation, in order to facilitate the observation of the detection process, the GUI (Graphical Use Interface) was designed by Matlab in this paper. Through the GUI,

the interaction function between the person and the computer can be better realized, and the image in the detection process can be presented. The GUI of iris hyper pigmentation is shown in Figure 14.


**Figure 14.** The GUI of iris hyper pigmentation

## 5. Conclusion

Based on the Matlab software platform, we designed a set of feasible automatic detection method for the typical iris pigmentation pathological features to realize the process of extracting iris hyper pigmentation feature. Finally, the extracted feature result is marked on the iris rectangle image.

Through the study of this subject, I have a deep understanding of the detection of iris pathological features.Through the learning of Matlab software for image processing and the design of GUI, thinking ability and software design capabilities have been exercised.

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