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Design of Circular Region Detection Algorithm Based on Image Processing

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Abstract: The coordinates and radius of the circular area of the detection precision and agility in visual processing, artificial intelligence and other related image plays an important role in this paper. By processing and detection of the circular area contains pictures, the coordinates and radius of automatic identification of circular area in the image acquisition stage. Firstly, the use of color image CCD camera includes a white circle. Then the digital image for image processing using image processing software MATLAB. Then the round degree circular region feature extraction and recognition using Hough transform algorithm, the circular area coordinates and radius. Through a large number of pictures of the test proved that the circular shaped region the accuracy and feasibility of the algorithm can be realized quickly and accurately.
Keywords: Image processing; Hough; Round detection.

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1. INTRODUCTION

Circular areas are ubiquitous in industrial production, so it is often necessary to measure the coordinates and radii of circular areas. Existing methods can indirectly or directly get the parameters of circular areas, but there are some problems such as low measurement efficiency and human error. With the rapid development of digital image processing technology, circular area detection, as a key step of robot vision processing, is increasingly widely used. This paper deals with and detects pictures containing circular areas, and uses Hough transform to realize the function of automatically identifying coordinates and radii of circular areas.

2. DIGITAL IMAGE ACQUISITION AND PROCESSING

2.1 Image acquisition

An image acquisition system composed of industrial CCD camera, image capture card and computer [1].Convert the target entity into digital images, and the acquired images are as shown in figure 1.

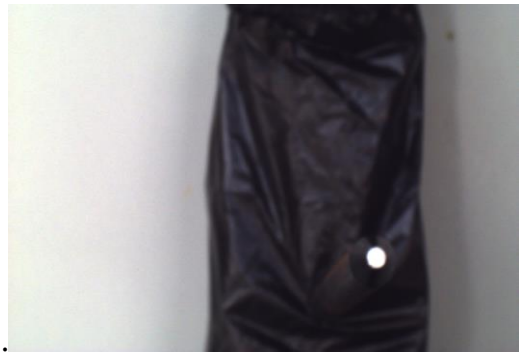

Fig 1 Collecting original images containing circular areas

2.2 Image preprocessing

When using CCD camera to collect color images containing white circles, interference will be generated due to the influence of the position of parts, lighting conditions and so on, which will result in deformation of circular areas. Preprocessing can make the boundaries of circles clearer, and the main processes include image graying, median filtering, and image linearization and so on.

2.2.1. Image graying

Graying is to remove useless color information from pictures, leaving only corresponding brightness information. In this way, not only can the computing speed be improved, but also the discrimination ability of man-machine can be ensured. There are mainly three methods of graying, namely maximum method, average method and weighted average method [2]. This process adopts weighted average method according to experience and actual situation. After repeated experiments, the weight values are $\omega R = 0.29$, $\omega G = 0.60$ and $\omega B = 0.11$, respectively, and the highest quality grayscale pictures can be obtained.Its formula is:$R=G=B=R*\omega R+G*\omega G+B*\omega B$.Image graying is as shown in figure 2.

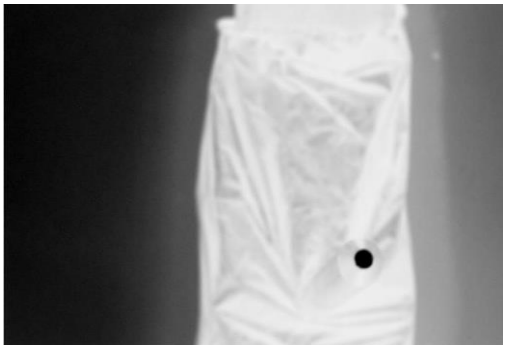

Fig 2 Grayscale image

2.2.2. Image smoothing

Noise will be generated in the process of image shooting, and image smoothing can eliminate these noises as much as possible. Methods of image smoothing commonly used in MATLAB include neighborhood average method and median filter [3]. The circular areas in this paper are neat in edges, suitable for median filtering and calling functions'=medfilt2 (hand).

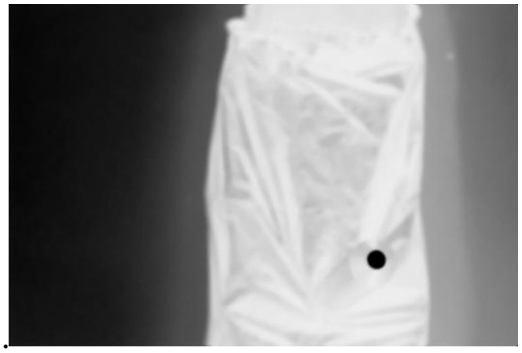

Fig 3 When n = 7, median filter processed image

Through experimental observation, the number of pixel points in the detection area changes. When the window value n = 7, the noise in the image can be effectively removed without affecting the size of the circular area, as shown in fig. 3.

2.2.3. Linearization of images

Binarization means changing pictures with 256 kinds of brightness into pictures with only 0 and 255 kinds of pixel brightness. [4] Separate the target object from the useless background, which is convenient for the detection of later round areas. In MATLAB, the internal code im2bw or dithe can be binarized. Here, we choose the self-adaptive threshold to process pictures, and the calling function is: h=im2bw (h,graythresh(h)).The processing results are shown in figure 4.

Fig 4 Image finalization

2.2.4. Edge detection of images

Edge detection is an important step in pattern recognition, which is to determine the boundary line between the target object and the background area. When the edge of the circle is extracted, the edge function has many operators for us to choose from, including the Sobel operator, Rober operator, canny, etc. The experiment compares the performance characteristics of various operators. This design selects the sobel operator as applicable. The operator of circular region detection in this paper. With the self-applicable threshold selected as the appropriate threshold, the function is called: BW1=edge (bow, `sable, 0.4).

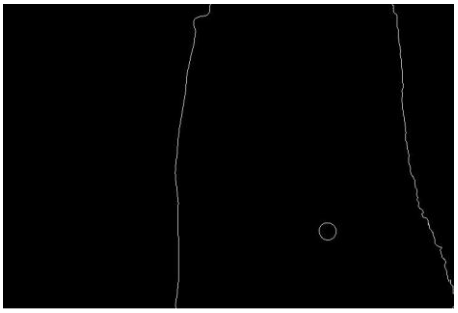

Fig 5 Sober operator edge detection

3. HOUGH TRANSFORM

Hough transform is widely used in the detection and location of straight lines, triangles and diamonds in practical applications. The detection problem in image space is transformed into parameter space, and the detection is completed by statistics in parameter space. [5] The popularization of Hough transform can be applied to detect some special graphics in pictures. This paper uses this method to detect circles. Here is the way to find circles with unknown radius.

Firstly, set the equation of circle as follows:

$$x^2 + y^2 + ax + by + c = 0$$

Where a, b and c are coefficients. Respectively derivate the coefficients in the formula to obtain:

$$\frac{\partial \varphi}{\partial a} = \sum_z 2x_z(x_z^2 + y_z^2 + ax_z + by_z + c) = 0$$

$$\frac{\partial \varphi}{\partial \mathrm{b}} = \sum_z 2y_z(x_z^2 + y_z^2 + ax_z + by_z + c) = 0$$

$$\frac{\partial \varphi}{\partial \mathrm{c}} = \sum_z 2(x_z^2 + y_z^2 + ax_z + by_z + c) = 0$$

φ Is the variance of pixel points on the edge, and (oz., is) is the coordinates of pixel points. By combining the above equations, we can get the following results:

$$c\sum_z x_z^2 + a\sum_z x_z y_z + b\sum_z x_z + \sum_z x_z^2 \sum_z x_z y_z^2 = 0$$

$$c\sum_z x_z y_z + \sum_z x_z^2 y_z + a\sum_z y_z + b\sum_z y_z + \sum_z y_z^2 = 0$$

$$c\sum_z x_z + \sum_z x_z^2 + a\sum_z y_z + \sum_z y_z^2 + \mathrm{n}g = 0$$

The g is the number of pixel points, and by combining the above three equations, a, b and c can be obtained.

$$(x - a_1)^2 + (y - a_2)^2 = r^2$$

By comparing the circular center equation, we can get:

$$R = \sqrt{[(c^2 + m^2)/4] - f}, \quad \mathrm{a}_1 = -c/2, \quad \mathrm{a}_2 = -a/2$$

And when Hough transform is used, the selection of input parameters in source code will directly affect the detection speed and accuracy of results. The following describes some important input parameters:

Function [Hough, space, Hough, circle, para] =

Hough circle (BW, step_ r, step_ angle, r_ min, r_ max, p)

BW is a binary graph, step _ r is the radius step, step _ angle is the angle step, r _ min is the smallest circle radius detected, and p is the threshold value. The size and quantity of the observed detection results are obtained by detecting a large number of pictures and modifying input parameters for many times. When r _ max = 25, r _ min = 5, step _ r = 1, step _ angle = pi / 24, p = 0.9, the detected result is the best.

4. RESULTS AND ANALYSIS

When this algorithm tests, a large number of pictures are detected, and the following table shows the detection results of one group. From the detection results, it can be seen that the detection algorithm can accurately obtain the coordinates and radii of white circles in color images, and the detection results are stable.

Table 1 Summary of picture detection results

Serial number	Coordinates and radius	Serial number	Coordinates and radius
1	Center 358 537 radius 14	6	Center 19 326 radius 15
2	Center 427 508 radius 14	7	Center 50 449 radius 14
3	Center 107 159 radius 14	8	Center 462 489 radius 14
4	Center 207 304 radius 14	9	Center 235 422 radius 14
5	Center 239 396 radius 14	10	Center 408 240 radius 13

This algorithm is designed to study the circle detection algorithm based on image processing, which mainly includes three processes: image acquisition, preprocessing and boundary identification. The function of circular area detection based on picture processing is realized. Within the allowable error range, the coordinates and radius of the target can be accurately and quickly determined.

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