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Research and Development of Target Recognition and Location Crawling Platform based on Binocular Vision

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Abstract. The application of visual recognition technology in industrial robot crawling and placing operation is one of the key tasks in the field of robot research. In order to improve the efficiency and intelligence of the material sorting in the production line, especially to realize the sorting of the scattered items, the robot target recognition and positioning crawling platform based on binocular vision is researched and developed. The images were collected by binocular camera, and the images were pretreated. Harris operator was used to identify the corners of the images. The Canny operator was used to identify the images. Hough-chain code recognition was used to identify the images. The target image in the image, obtain the coordinates of each vertex of the image, calculate the spatial position and posture of the target item, and determine the information needed to capture the movement and transmit it to the robot control crawling operation. Finally，In this paper, we use this method to experiment the wrapping problem in the express sorting process The experimental results show that the platform can effectively solve the problem of sorting of loose parts, so as to achieve the purpose of efficient and intelligent sorting.

1. Introduction

For industrial robots working on automated production lines, the crawling of an item is one of the most common tasks that needs to complete. Traditional positioning and crawling must be accurate after manual operation, in accordance with the procedures "teaching" to complete, but many workplace items in the posture is not fixed or regular, which on the industrial robot's own object recognition ability. It is one of the important ways to solve this problem by using the camera to simulate the shape position and attitude of the manipulated objects. With the interaction of image processing technology and industrial robot technology mature [1], the use of binocular stereoscopic vision to imitate human vision, not only can achieve the identification of the target object, but also get the scene depth information, the binocular camera for the recognition and positioning of target objects have important practical application prospects. With the progress of technology, vision-based robot has a lot of space for development, in which visual recognition technology in the industrialization of sorting research has become one of the hot spots. Muller J et al. uses the binocular vision system to identify the target by edge detection and color segmentation [2]. Burget F et al.obtaine three-dimensional information of the target object by image processing technology The corresponding grasp of the attitude of the target object to crawl [3].Honda developed bionic robot, based on visual recognition and positioning technology to complete the task of life service successfully [4]. Purdue University use simple circular boundary characteristics of the Bin-picking part sorting system, which distinguishes a variety of different parts, can be used to pick up target parts from cluttered parts with a variety of different parts[5] .Murakami utilizes a CCD camera Sensing technology, the development of arc welding robot tracking control system [6].University of Western Australia with CCD camera with six degrees of freedom robot developed three-dimensional palletizing robot, to achieve three-dimensional space palletizing [7]. Suez Canal University developed a automatic sorting potato system that can quickly and accurately sort potatoes by size [8].Shanghai University Professor He Yongyi team developed furniture services wheeled robots using three head camera, to achieve the object recognition and other functions [9].Huazhong University of Science and Technology puts forward the hand-eye robot system based on visual guidance and ultrasonic distance measurement, and realizes the tracking and crawling of moving objects [10].Beijing Jiaotong University Shang Qian and others have been equipped with binocular camera robot as the experimental platform, in the HSV color space using image segmentation to complete the identification of the target [11].Huazhong University of Science and Technology Yang Min, who use visual and ultrasonic measurement of information fusion method to achieve the identification and positioning of the workpiece [12].Institute of Chinese Academy of Sciences Zong Zhicai set up a visual information based on the industrial robot grinding system, with video camera to collect image information, the use of computer identification and positioning, control machinery [13].

The research work of this paper mainly focuses on the items in complex cases, analyzes the collected image information through binocular vision technology, determines the operation target of the robot in the platform and calculates its position and attitude, and finally obtains the motion control information of the robot.

2. Basic principles and overall workflow

The work of this platform includes four parts: image preprocessing, target extraction, pose analysis, calculation of crawling place

Hardware consists of binocular camera, the central controller. Binocular camera is responsible for collecting image information; the central controller to process the information collected to complete the target recognition and pose analysis which is transmit to central controller.

The basic working principle of the platform includes:

1. Set up the coordinate system to calibrate the binocular camera.

The establishment of the camera coordinate system, the world coordinate system, the robot coordinate system, and clear the relationship between the coordinate system.

On this basis the binocular camera calibration parameters inside and outside.

2. Image preprocessing. The camera in the acquisition of images, subject to a variety of objective factors, resulting in image distortion or by noise, resulting in the image can not be directly used. After the smoothing, binarization, contour extraction and other operations to complete the image preprocessing.

3. Corner detection. The Harris operator is used to detect the corner points of the image, and the feature points are extracted so that the subsequent feature contours can be extracted.

4. Contour extraction. Using the chain code method to find the corner point as a starting point to find a closed quadrilateral, and get closed four corners of the four corners of the plane coordinates to complete the contour extraction. A closed quadrilateral is a complete surface of a parcel and is conventionally the most easily gradable surface.

5. Robot to seize the position to determine. According to the internal and external parameters of the binocular camera, the extracted plane contour is transformed into the spatial position and attitude data, which is the basis for the robot to crawl.

6. The robot controller accepts the target item pose information. The overall workflow is shown in Figure 1:

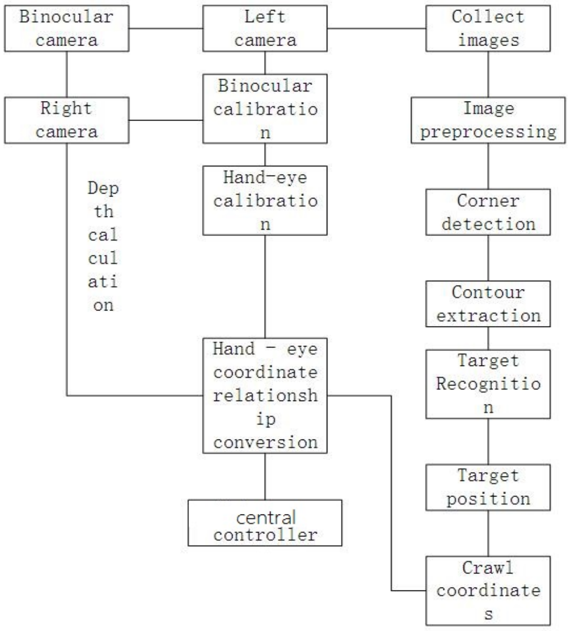

Figure 1. Overall

3. Coordinate transformation

In order to complete the crawling action, it is necessary to convert the coordinates of the target item in the camera coordinate system into the coordinates of the robot coordinate system. Therefore, it is necessary to establish the coordinate system of the robot and the camera coordinate system and determine the conversion relationship between the two coordinate systems. The conversion between the two coordinate systems is established by establishing the world coordinate system as the intermediate coordinate system. The transformation of the camera coordinate system with the world coordinate system [14] as shown in Figure 2:

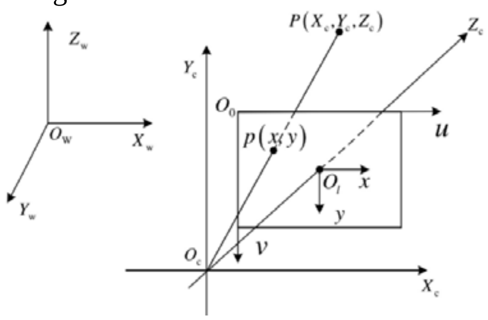

Figure 2. Camera coordinate system and the world coordinate system position diagram

Since the collected images are composed of pixels, the image pixel coordinate system O_1xy and the image physical coordinate system O0uv are established. The world coordinate system is represented by $O_wX_wY_wZ_w$, which is the coordinate reference system of the object in the real world. The camera coordinate system is based on the camera light The X_c axis is parallel to the u axis of the image pixel coordinate system, and the Y_c axis is parallel to the image pixel coordinate system v axis; the image axis is the coordinate system of the camera coordinate system, The coordinate origin O_1xy of the physical coordinate system O_1xy coincides with the projection center of the camera, and the x-axis is parallel to the u-axis of the image pixel coordinate system O_0uv; the y-axis is parallel to the v-axis of the image pixel coordinate system O_0uv. The coordinate system of the camera can be obtained by rotating the world coordinate system.

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Let P point for a collection of images of a pixel, according to Figure 2, the relationship between the various coordinate system:

$$Z_c\begin{bmatrix}u\\v\\1\end{bmatrix}=\begin{bmatrix}\frac{1}{d_x} & 0 & u_0\\ 0 & \frac{1}{d_y} & v_0\\ 0 & 0 & 1\end{bmatrix}\begin{bmatrix}f & 0 & 0 & 0\\ 0 & f & 0 & 0\\ 0 & 0 & 1 & 0\end{bmatrix}\begin{bmatrix}R & t\\ O^T & 1\end{bmatrix}\begin{bmatrix}X_w\\Y_w\\Z_w\\1\end{bmatrix}$$

$$=\begin{bmatrix}f_x & 0 & u_0\\ 0 & f_y & v_0\\ 0 & 0 & 1\end{bmatrix}\begin{bmatrix}R & t\\ o^T & 1\end{bmatrix}\begin{bmatrix}X_w\\Y_w\\Z_w\\1\end{bmatrix}=M_1M_2\begin{bmatrix}X_w\\Y_w\\Z_w\\1\end{bmatrix}$$

As the photographic chip in the production process can not reach the absolute accuracy, so the distortion can not be avoided, the distortion of the lens in the image plane on the square edge of the bend, so that the linear model and nonlinear distortion parameters constitute the camera's nonlinear model internal parameters The This study does not take into account the effects of distortion.

4. Target recognition

In this study, the crossover objects were identified by the preprocessing, corner detection, edge detection and contour extraction of the planar images.

4.1 Image smoothing

In order to improve the clarity of the image and reduce the interference of the noise to the image, the original image is needed to be smoothed. In this paper, the comparison between the commonly used method and the digital image conversion process will be used in the process of taking pictures. Mean filtering, median filtering and Gaussian filtering are three different filtering methods, Gaussian filtering method is choosen for smoothing, the results shown in Figure 3:

Figure 3 Image preprocessing results

Figure 4 Corner recognition map

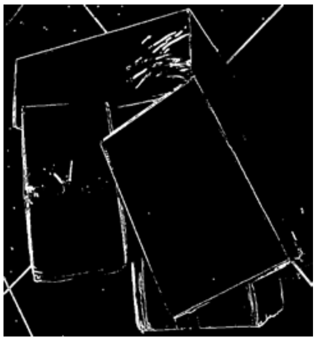

Figure 5 Edge detection chart

4.2 Corner detection

Combining the difference between the corner, edge and the eigenvalue of the quadratic term in the image, the corner detection is performed. If the two values are relatively small and basically the same, the autocorrelation function values are small in all directions, then the point is the point in the flat area of the image; if two of the two eigenvalues are large, the two points are on the edge; The eigenvalues are relatively large and approximately equal, then the point is the corner. The Harris corner detection used in this paper moves on the image with a Gaussian window. The original image is derived from the template window. The local structure matrix is derived from the template window. The eigenvalues of the matrix are used to determine whether the points in the region are corners. Harris corner detection results shown in Figure 4:

4.3 Edge detection

Edge detection has a variety of ways, where Canny edge detection has a good effect, the error rate is low, the precision is high, and the resulting edge width is the width of a single pixel. First, the gradient and the gradient direction are calculated, and then the image is convoluted with the Gaussian smoothing filter. The finite difference of the first order derivative is used to calculate the amplitude and direction of the gradient. Then, the gradient modulus of the image is applied to the non-maximum Through the double threshold processing and connectivity analysis, reduce the wrong edge points, select the appropriate threshold to determine whether the analysis point on the edge or not. The edge detection results are shown in Figure5:

4.4 Contour extraction

This study uses chain code as a tool for contour extraction. The chain code is a series of straight lines connected by a specified length and direction, and the contours are represented by these sequences. Since the two-dimensional contour of the target is a closed quadrilateral, each corner point detected by the corner point In the same direction to find a closed rectangle is the target object completely exposed to the outside of the grabable surface. Usually the direction of the contour is quantified into 4 adjacent chain codes or 8 adjacent chain codes, a series of contour direction values constitute the contour code,This article uses the sequence 8 adjacent chain code. According to the chain direction of the chain along the clock to find the closed quadrilateral in the image, as shown in Figure 6:

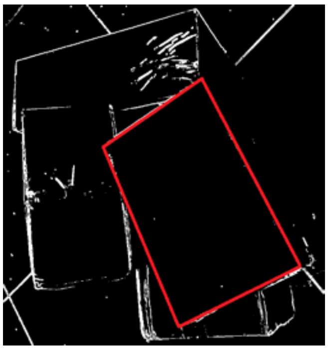

Figure 6 Outline extraction map

5. Catch the target pose calculation

In this study, we use the binocular camera, binocular vision three-dimensional reconstruction principle [15] as shown in Figure 7, point p as an example, if a point from two cameras were observed, then the point of the spatial coordinates It can be determined that the intersection of the two lines of sight is the location of the change point [16]

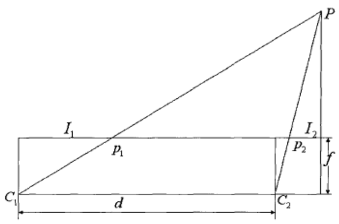

Figure 7 Schematic diagram of 3D reconstruction

Three-dimensional coordinates are based on the principle of parallax, usually in the binocular camera two pictures, there is a visual difference, we can parallax and camera imaging principle can restore the spatial coordinates of the three-dimensional coordinates. (x_L, y_L) on the left camera, the coordinates on the right camera (x_R, y_R), and the two cameras taken by the left and right cameras of the binocular camera, the coordinates of the object on the left side of the object, Figure in the same plane, so $y_L = y_R$:

$$\begin{cases} x_L = f\frac{X_p}{Z_p} \\ x_R = f\frac{(X_p - B)}{Z_p} \\ y = \mathrm{f}\frac{Y_p}{Z_p} \end{cases} \quad (1)$$

Then p points in the left camera under the three-dimensional coordinates

$$\begin{cases} X_p = \frac{B \cdot x_L}{d} \\ Y_p = \frac{B \cdot y}{d} \\ Z_p = \frac{B \cdot f}{d} \end{cases} \quad (2)$$

Formula (1) into the formula (2) :

$$\begin{cases} X_p = \dfrac{B(u_L - u_0)}{u_L - u_R} \\ Y_p = \dfrac{B(v_L - v_0)}{u_L - u_R} \\ Z_p = \dfrac{Bf_x}{u_L - u_R} \end{cases}$$

It can be seen, as long as the space point P in the left and right camera to capture the image of the pixel coordinates, you can get P in the space of the three coordinates.

The object of this study is similar to the rectangular object, so get the target object two-dimensional outline of the rectangle. According to the above method, four vertex coordinates A (x_1, y_1, z_1), B (x_2, y_2, z_2), C (x_3, y_3, z_3), D (x_4, y_4, z_4) Thereby calculating the position of the rectangle in the space description, and then determine the target item of the crawl position.

6. Experimental study

The four points obtained above are the four vertices of the object in the space,

To make the robot complete the crawl operation, we also need to know the three-dimensional coordinates of the position of the object in the space and the attitude, that is, the contours identify the spatial posture of the quadrilateral.

The target object of the crawl position we can use A, B, C, D coordinates of the four points to describe:

The robotic execution side of the target object to capture the location of the space rectangular two long sides of the midpoint, the specific coordinates of E($\frac{x1+x2}{2}$, $\frac{y1+y2}{2}$, $\frac{z1+z2}{2}$),F($\frac{x3+x4}{2}$, $\frac{y3+y4}{2}$, $\frac{z3+z4}{2}$), the robot execution side of the grappling attitude with the space of the geometric center of the normal direction. Rectangular geometric center coordinates are O（$\frac{x1+x2+x3+x4}{4}$, $\frac{y1+y2+y3+y4}{4}$, $\frac{z1+z2+z3+z4}{4}$）, then the execution direction is

$$\left(\begin{matrix} i & j & k \\ x2-x1 & y2-y1 & z2-z1 \\ x3-x1 & y3-y1 & z3-z1 \end{matrix} \right)$$

The following methods can be used to establish the inverse kinematics equation of the robot by using the DH method, and to calculate the inverse kinematics equation of the 6-DOF robot by using the DH

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method.

The final study of the approximate rectangular parcel as an example of the experiment, the courier in the package as shown in Figure 8 below.

Figure 8 Experiment to obtain parcel

Image processing and target detection using Visual studio to build the platform, use OPENCV library function for image processing: Among them, the Gaussian smoothing function: cvThreshold (); corner recognition function: cornerHarris (); contour recognition function: intfindcontours () The After the above treatment, the target item was wrapped in No. 5, as shown in Figure 9.

Figure 9 Target parcel

7. Concluding remarks

In this paper, the object recognition and location scoring based on binocular vision for chaotic placement and size of rectangular cubes are studied. Completed the image preprocessing, focus detection, contour recognition, target pose operations and other operations,and finally determine the robot's crawl information.Further work needs to be carried out in terms of the accuracy of the image recognition, the scope of application of the article shape, the information transmission and function integration with the sorting system,and then in the postal express and other industries to carry out applied research.

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