Design of Automatic Container Positioning System Based on Machine Vision

Caiyun Xu, Yongsheng Zhou, Ge Tian

School of Mechanical and Electrical Engineering, Zhoukou Normal University, Zhoukou 466000, China.

Abstract

Accurate positioning of containers is the key to improving the automation level of their lifting operations. This article designs a set of automatic container positioning system in view of the large area of the container yard and strict requirements for placement. The system first stores the theoretical position of the container through a database, then collects container pictures through a binocular camera, and uses image processing technology to identify and locate the container keyhole. MATLAB programming results show that the system has high positioning accuracy, simple algorithm processing, high efficiency, and strong applicability. It can improve the mechanical automation level of terminals, ports, freight yards and other places, and improve the efficiency of cranes in lifting containers.

Keywords

Image processing, database, recognition, positioning.

1. Introduction

With the rapid development of the logistics industry and the increase in labor costs, there is an urgent need for terminals, ports, freight yards and other places to improve the automation level of machinery to increase the efficiency of cargo turnover and reduce the cost of manpower management. Among them, the link of lifting the container by the crane has higher requirements for the driver's operation, and the manual operation is time-consuming when the spreader is aligned with the container. The key to improving the efficiency of this link is to realize the automatic alignment of the spreader and the lock hole on the container. With the advancement of computer, image processing, artificial intelligence, intelligent control and other technologies, flexible automation technology based on machine vision can be realized and developed rapidly. At present, container identification and positioning technology based on machine vision has become a hot spot for scholars [1].

2. Container theoretical location archive database

No matter the pier, port or freight yard, the containers are arranged in rows and occupy a large area. However, the field of view of the current industrial cameras on the market is limited. Directly using industrial cameras to scan and collect images requires a lot of work and high cost. It is necessary to first know the theoretical position of the container to be positioned, and then it is feasible to use machine vision for precise positioning.

The automatic container positioning system designed in this paper first uses radio frequency identification RFID technology to identify the warehousing container when the container is warehousing, uploads the identified container number and other information to the warehousing system, and the warehousing system performs a check on the yard database. The row finds the empty space, the container spreader hoists the inbound container to the empty space, and at the same time saves the container number and theoretical position in the yard

ISSN: 2664-9640

database. Similarly, when the container is out of the warehouse, the outbound system searches for the theoretical position in the database where the container is located. After the spreader reaches the theoretical position, the machine vision is used for precise positioning, automatically aligns the keyhole for lifting, and the database updates the outbound information. Delete the location information of the yard database corresponding to the container.

3. Container binocular stereo vision positioning

When the spreader puts the container, external factors such as the swing of the spreader will interfere with it. Therefore, the theoretical position of the container stored in the database may deviate from the actual position, and a binocular camera needs to be used for secondary accuracy. Positioning. To find out the precise position of the keyhole on the container, binocular stereo vision is a typical method of machine vision application. Before the binocular camera collects images, the binocular camera needs to be calibrated. This article uses the MATLAB calibration toolbox to calibrate. The camera collects 15 sets of pictures with a calibration board from different positions and different angles, and imports the toolbox to run to obtain the camera's internal and external parameters to prepare for 3D reconstruction. The machine vision positioning algorithm is shown in Figure 1. After the container spreader runs to the theoretical position, the calibrated binocular camera installed on the spreader is used to collect container pictures, and the collected pictures are image processed to extract the edges of the container, and then the background is removed. At this time, with the container as the background and the keyhole as the target, image processing is performed to segment the keyhole image, and finally the keyhole image is matched with feature points, and the three-dimensional reconstruction of the feature points is performed according to the pixel coordinates of the matched feature points and the internal and external parameters of the camera.

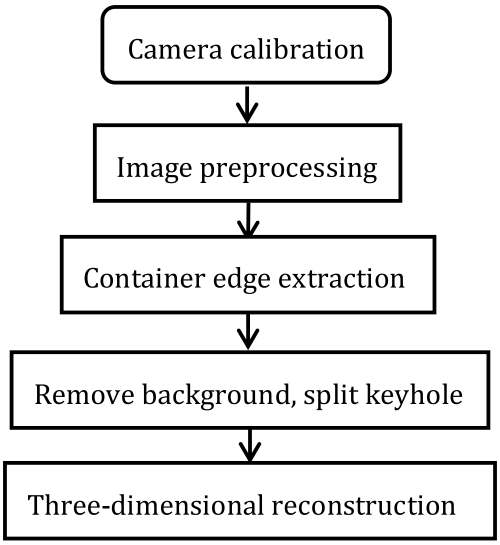

Figure1: Flow chart of machine vision positioning algorithm

3.1. Container edge extraction

In this paper, an improved multi-operator fusion algorithm is used to extract container edges. The multi-operator fusion algorithm combines the advantages of Sobel operator, Prewitt operator, Canny operator and Roberts operator. Sobel operator has a smooth suppression effect on noise, but the obtained edges are thicker and false edges may appear. Prewitt operator can remove some false edges, but it may cause false judgments of edge points. Canny operator weakens the influence of noise , But the edge detection is too refined, which is also not conducive to image texture feature extraction. Roberts operator can remove false edges very well, and the positioning is accurate, but it is sensitive to noise and cannot suppress the influence of noise[2]. In this paper, each operator takes the mutual union and finally obtains the corresponding image edge. The algorithm overcomes the influence of noise, and strictly follows the gray gradient to simulate human visual physiological characteristics, and extract the edge of the image. The extraction effect is shown in Figure 2. Shown. Because the multi-operator fusion algorithm combines the advantages of several classic algorithms, it can perform better positioning and segmentation of the image, and the segmentation accuracy is higher.

After the image is segmented by multi-operator fusion, the spreader offset is calculated according to the extracted container edge coordinates, and then the spreader is rotated according to the offset until the offset is zero, that is, the spreader is parallel to the container before taking pictures , Extract the edge, the purpose is to better remove the background and prepare for the keyhole segmentation.

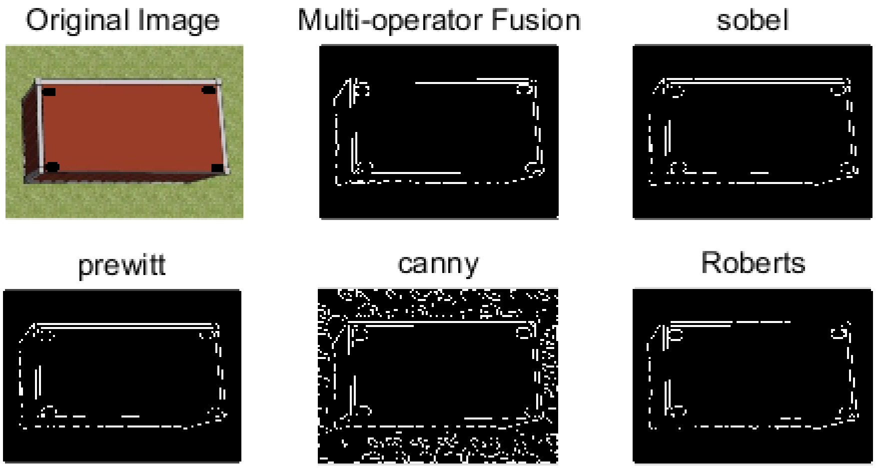

Figure2: Comparison of image edge detection with multiple operators

3.2. Container keyhole recognition

The identification of the position of the container lock hole is the key to realize the accurate lifting of the container. Most of the container lifting by the spreader is fixed and hoisted through the lock hole. The identification of the lock hole is very important to realize the automation of large-scale machinery and equipment[3]. Since the color difference near the container keyhole is small, and the contrast between the light and dark of the cavity is strong, this paper adopts Otsu threshold segmentation to identify the keyhole on the container image after removing the background. In the existing graphics image segmentation method, the threshold segmentation method separates the target from the background image by calculating the threshold, and generates a binary image to simplify the analysis and processing process. It is very useful for motion detection, optical recognition, image defect repair, etc. For good application effects, Otsu threshold segmentation assumes that an image is composed of foreground and background colors. A threshold is selected through statistical methods so that this threshold can separate the foreground and background colors as much as possible[4], segmentation effect As shown in Figure 3.

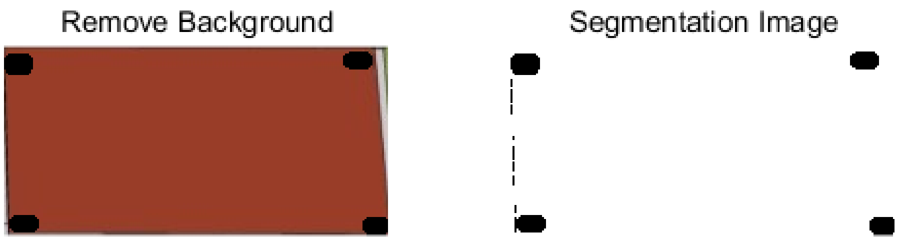

Figure3: Keyhole split effect diagram

3.3. Three-dimensional reconstruction of keyhole coordinates

The method of measuring the distance between the observed point and the observation point by observing the object from the left and right observation points is called three-dimensional reconstruction, also called parallax ranging method, and the deviation during observation is called parallax[5]. To obtain the spatial three-dimensional information of the image through binocular stereo vision, it is necessary to detect and match the feature points in the two images. This paper uses the centers of the four keyholes as the feature points, as shown in Figure 4, after comparing the feature points After calibration and matching, the internal and external parameters of the camera are substituted into the reconstruction model to obtain the disparity map, and then the three-dimensional coordinates of the keyhole center can be calculated. The system selects the left camera coordinate system as the world coordinate system. The measured three-dimensional coordinates of the keyhole center are shown in Table 1. Compared with the actual three-dimensional coordinates, the maximum error is -9mm, which is within the design error range of ±20mm. The main reason is When the spreader rotates, the deviation will occur due to inertia.

Figure4: Keyhole feature point extraction

Table 1: Measurement results

Keyhole center mark	Visual three-dimensional coordinates (mm)	Actual three-dimensional coordinates (mm)	Error
Upper left	(-2820,-1060,3010)	(-2815,-1065,3010)	(-5,5,0)
Lower left	(-2810,1070,3012)	(-2815,1065,3010)	(5,5,2)
Upper right	(2869,-1060,2993)	(2875,-1065,3010)	(-6, 5,-7)
Lower right	(2880,1072,2991)	(2875,1065,3010)	(5,7,-9)

4. Summary

This paper first stores the theoretical position of the container in the database, and then uses machine vision to perform secondary recognition and positioning of the container. The container image is collected by using the calibrated binocular camera, and the container edge coordinates are extracted by the multi-operator fusion algorithm on the collected image. Remove the background, and then segment the image after removing the background through

Otsu threshold processing to segment the container keyhole position, and finally use the keyhole center as the characteristic point to perform 3D reconstruction to obtain the 3D world coordinates of the keyhole center. The results show that the system algorithm processing Simple, high positioning accuracy and strong applicability.

References

[1] S. Wang. *Research on key technologies of tire crane automation based on machine vi*sion. (Ph.D., Jimei University, China 2016.), p.20.

[2] S. Xian, M.Z. Wang. Research on BPNN edge detection combining multi-operator information. Microcomputer Information, Vol. 17 (2010), p.209-211.

[3] H.B. Zhang, Y.J. Zhang. Image-based container keyhole positioning technology. Hoisting and Conveying Machinery, Vol. 10 (2015), p.67-69.

[4] S. Cao. *Image threshold segmentation technology based on OTSU algorithm*. (Ph.D., Taiyuan University of Technology, China 2018.), p.15.

[5] L. Ma. *Research on container recognition and positioning technology based on binocular stereo vision*. (Ph.D., Southwest Jiaotong University, China 2013.), p.10.