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Intelligent Depalletizing System Utilizing 3D Image Recognition and Industrial Robot for Camshaft

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Due to labor shortages and the increasing tendency of factories to automate production, the demands for robotic palletizing have increased significantly. This paper introduces an intelligent depalletizing system including an RGB-D depth camera and a six-axis serial industrial robot for handling camshafts. The main functions of system realize material image recognition, handling sequence decision and material handling. Firstly, the core technology of target detection of camshafts is applying instance segmentation algorithm of MASKR-CNN. Then, the average value of center line calculated by mask information involving depth information of each camshaft captured by RGB-D depth camera determines the material grabbing sequence. The smaller the calculated average value, the higher the priority of camshaft grabbing. Subsequently, a self-designed magnetic gripper mounted at the end of the robot realizes the grasping of the center position of the camshaft. In order to reduce the rigid collision during the grabbing process, the gripper adopts the combined design of linear bearing and smooth shaft. Finally, the proposed system achieved a 100% success rate for the grasping results in the case of disorderly placement of camshafts.

NOMENCLATURE

b = The bit size of the image file
h = Image depth value
p = Image pixel values

1. Introduction

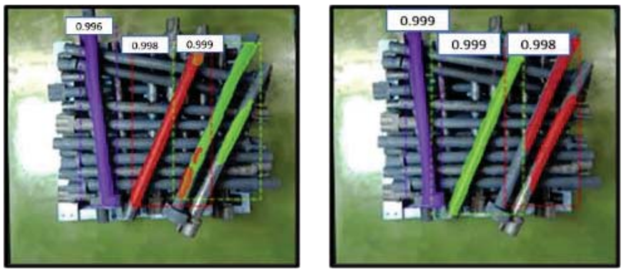
With the development of industrial robot and machine vision, intelligent palletizing is gradually applied in manufacturing. Intelligent palletizing technology not only improves production efficiency but also reduces labor costs. Therefore, many scholars have studied the application of intelligent palletizing technology in different objects. Robert Krug[1] converged a visual system and a specific gripper manipulator to complete the handling experiment of the can pile. Changchun Li[2] applied binocular vision technology to generate depth images and extract depth data, and realized the identification and palletizing of stacked packaged foods.

However, few studies focus on intelligent depalletizing and grabbing of camshafts under disorderly placement. In this paper, the image recognition algorithm and its core hardware system of the intelligent depalletizing system are developed for the metal camshaft.

2. Camshaft identification and handling sequence planning

2.1 Camshaft identification

The image recognition system mainly includes two parts: im age acquisition and image processing. The image acquisition part is to transmit the image information collected by the RGB-D de pth camera to the special computer. According to the collected i mage information, we apply a neural network model named MA SKR-CNN which is proposed by Kaiming He[3] to realize the recognition of camshafts at different positions in the image. In order to improve the recognition effect, the main parameter coefficients such as DETECTION_MIN_CONFIDENCE are modified in this paper. By comparing the recognition effects in Fig. 1, both object match value and match area of the image after modification are better than the image without modification.



(a) Before modification (b) After modification

Fig. 1 Recognition results of camshaft image

2.2 Crawl sequence planning

According to the image information processed by MASKR-CNN, each camshaft placed at the top layer can be identified and its mask containing depth value information can be returned. Then, OpenCV is used to place the recognized mask in a single-channel image. In order to obtain the midline of the mask-shaped center, the mask image is processed by grayscale conversion and binarization respectively. Then, the center of the mask is calculated by the length and width of the image, as shown in Fig. 2.

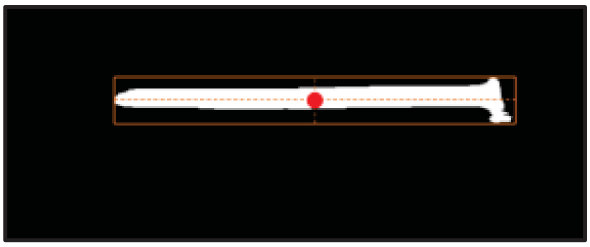


Fig. 2 The midline of the mask-shaped center

According to the image of recognized mask in the single-channel, the pixel values of each image are calculated by the function in OpenCV. Then, the depth value of the image is calculated by the equation of $d = b/p$. When the identification situation is shown in Fig. 3, four images of recognized masks are placed in four single-channel binary images shown in Fig. 4. The depth values of midline are added from each point of the recognized mask image.

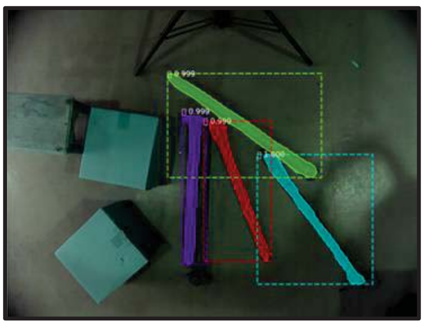


Fig. 3 Recognition result of random placement of camshafts

(a)Mask 1 (b)Mask 2 (c)Mask 3 (d)Mask 4

Fig. 4 Each recognized mask

Based on the above image processing flow, the mean value of the midline depth of each camshaft at the top layer can be compared. The smaller the calculated average value, the higher the priority of camshaft grabbing.

3. End adsorption device

The robot end tool head shown in the Fig. 5 includes electromagnetic adsorption and shock buffering functions. In order to realize the adsorption of the arc surface, a large obtuse angle symmetrical structure is designed. In addition, a linear spring-type track is designed to avoid rigid collision during the adsorption process, and its buffer displacement is 80mm.

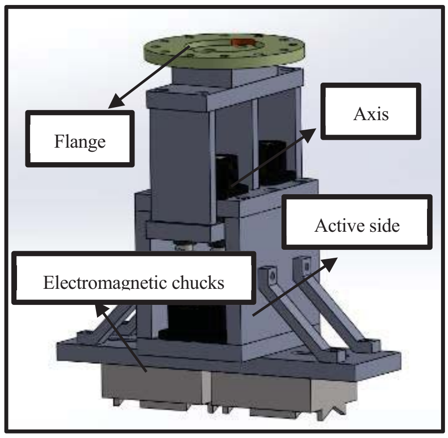


Fig. 5 Structure diagram of end adsorption device

4. Experiment

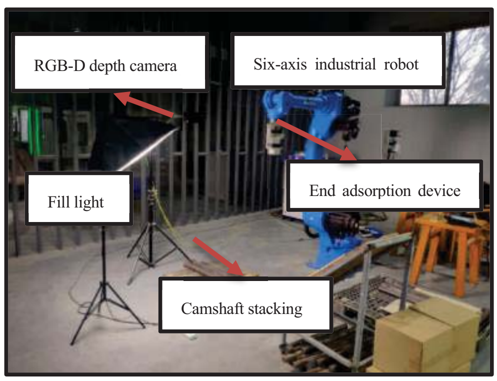


Fig. 6 Experimental layout diagram

The main hardware of the experimental platform includes a six-axis serial industrial robot, an end adsorption device, a RGB-D depth camera, a fill light and camshaft stacking shown in the Fig. 6.

(a) Adsorbing the camshaft (b) Picking up the camshaft

Fig. 7 Flow chart of experiment result

Camshaft recognition adsorption and gripping are shown in Fig. 7. The experiment carried out 10 sets of tests that the camshafts were placed in multiple layers at random. The results of the experiment indicate that camshafts can be successfully adsorbed, picked up and handled at each time.

5. Conclusions

The research has designed an intelligent depalletizing system utilizing 3D image recognition and industrial robot for camshaft. During image processing, the main parameter coefficients run by the MASKR-CNN are modified to improve the recognition effect. Then, the mean value of the median depth of each camshaft at the top layer determines the order of grasping. Also, a self-designed end adsorption device with shock buffering function is applied for adsorbing the camshaft. Finally, several sets of experiments were performed to verify the effectiveness of grabbing of camshafts under disorderly placement.

ACKNOWLEDGEMENT

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