Research on Grasping Method of Industrial Robot Based on Deep Learning and Machine Vision

Can Yang¹*°

¹Department of Mechanical Engineering, Tianjin College, University of Science and Technology Beijing, Tianjin, China, 301830

*Corresponding author e-mail: yangcan@ustb.edu.cn

Abstract. Recently, the development of industrial robots is very rapid. Its emergence can make a great contribution to the development of various industrial fields. As cutting-edge technologies in the area of robots, some machine learning methods, such as machine vision technology and deep learning are considered to be promising to combine with industrial robots to solve their existing problems. This study discusses the development status of industrial robots, the design and grasping principle of industrial robots, and the design of industrial robots with the using of machine vision and deep learning, which provides a reference for the combination of deep learning and machine vision and industrial robots.

Keywords: Machine Vision, Industrial Robot, Deep Learning

1. The basic situation of traditional computer experiment teaching

Industrial robot is an important automation equipment in modern manufacturing industry, which integrates multi-disciplinary advanced technology, such as machinery, electronics, control, computer, sensor, artificial intelligence and so on. With the deepening and popularization of industrial automation, more and more industrial robots are applied to the forefront of production. These industrial robots used in actual production can not only improve the production efficiency, but also greatly save the labor cost and avoid the product damage caused by manual misoperation. For the sorting system, in the handling process of the industrial robot, in most cases, the industrial robot is required to identify the object and move the object to the designated position. However, for some special objects encountered, industrial robots also need to carry out special treatment to the items and then transport them to the designated location.

Industrial robot is very suitable to replace human work in harsh environment or boring repetitive work, such as processing, welding, spraying, assembly, handling and so on. A large part of these production tasks are closely related to object grasping. As an important part of the research field of industrial robot, grasping operation includes many technologies, such as artificial intelligence, sensor, motion planning, automatic control and so on [1].

As a big manufacturing country, China's industrial robot market began to enter a period of prosperity under the background of the transformation and upgrading of the manufacturing industry. Up to now, China has become the largest consumer market for industrial robots in the world. Driven
by the adjustment of the industrial structure and the rising domestic labor costs year by year, it is able to be expected that the scale of industrial robot market in China will continue to grow at a high speed for a long time in the future.

At present, it is difficult for industrial robots to grasp as dexterously as human arms. In the traditional teaching programming and off-line programming mode of the industrial robot, the joints and connecting rods run according to the predetermined control parameters, and the position and posture of the grasping target must be fixed. This working mode requires that the industrial robot has enough rigidity to ensure the stability and accuracy of the operation. Of course, improving the rigidity is also easy to cause the mechanical structure to be too bulky, so it is necessary to make a tradeoff between rigidity and precision. The flexibility of the existing robot is too poor, if the type of product produced changes, or even as long as the position of the workpiece changes, the whole production line needs to be readjusted, which can not meet the requirements of small batch and multi-type intelligent production.

Therefore, industrial robots pay more and more attention to flexibility and intelligence, and these two indicators have gradually become important standards to measure industrial robots. The application of industrial robot greatly increases the labor cost of factories and enterprises, and avoids the error problems caused by manual operation. For the sorting system, the separation from manual operation can greatly improve the efficiency of industrial production and transportation, and the industrial robot sorting and handling items can be accurately placed in the designated position. For some special items, industrial robots and sensor equipment are needed to classify them. The installation of the sensor line has a high requirement on the site, which is also the limitation of the traditional sensor applied to the sorting of items in the past. The emergence of deep learning industrial robots can avoid this defect. The design of a sorting industrial robot which can model, identify, memorize and learn items can overcome this limitation and greatly improve the accuracy and efficiency of sorting items.

2. The Design of industrial robot and the principle of grasping method

2.1. The basic structure of industrial robot

The hardware of industrial robot is composed of industrial robot body, robot control cabinet, PC, pneumatic claw, camera, sucker and vacuum generator. Among them, the control cabinet is the core component, which is connected with the robot body through the cable.

The communication between PC and control cabinet is based on TCP network communication protocol. The camera that detects the object is connected by USB and PC. The pneumatic claw and the sucker are connected with the vacuum generator through the windpipe, which is used for grasping and releasing objects and carrying them [2].

![Figure 1. System hardware structure diagram.](image)

The software part of the system is mainly composed of four parts: object detection module, image capture module, image recognition module and industrial robot sorting and marking module. The image recognition part of the object is mainly realized by the cooperation of the camera and the photoelectric sensor. When the photoelectric sensor detects that the object has reached the specified area, the sensor notifies the industrial robot control cabinet through the I hand O signal that the
object has reached the specified position. After receiving the detection signal in place, the control cabinet sends a command to turn on the camera to the PC machine through Ethernet. Then the PC machine analyzes and processes the image transmitted by the camera through the deep learning network of the image feature recognition module [3].

![Object in place detection](image1) ![Image capture](image2) ![Picture analysis](image3) ![Article sorting operation](image4)

**Figure 2.** System software flow chart.

2.2. *Grasping method of industrial robot*

In the process of grasping, a series of technologies related to machine vision, such as target detection, location and tracking, are needed. Therefore, machine vision is really vital to realize the intelligence of industrial robot. The industrial robot based on machine vision feedback sets the scene image through vision, and obtains the shape and position of the target object, and the position and posture of the end gripper. These letters can be used to evaluate the grasping state. Then rearrange the posture of the end-effector due to the results of evaluation to increase the power of the grasping operation.

In the early study of industrial robot grasping, the method of establishing target object model is generally adopted. Under the background of machine learning algorithms, the strategy based on learning capture has been accepted by scientists. Machine learning-based methods indeed illustrate great recognition and grasping ability, the methods still have to extract features and construct 3-Dimension models of objects by hand. Manual feature extraction is extremely time-consuming and lack of mobility, while the calculation of 3D reconstruction based on point cloud is complex, and the geometric accuracy is difficult to be guaranteed.

In recent years, deep learning algorithms have achieved big success in the areas of image recognition, data analysis and natural language processing. But the algorithms are still in their initial stage in the area of robot grasping in various industries. Compared with traditional machine learning algorithms, deep learning does not need to design features by hand, but is generated by the deep network itself. Its recognition accuracy is very high, and it is a learning algorithm with broad prospects, which is very worthy to be used in the area of industrial robots as well as their grasping applications.

3. *Industrial robot combining deep learning and machine vision*

3.1. *The principle of deep learning*

The main idea of deep learning is similar to human neural network. The processing of information in the human visual system is hierarchical, extracting edge features from the low-level nerve cells, and then constantly iterating and abstracting to the high-level nerve cells, that is to say, the high-level features are a combination of low-level features. For deep learning, the first step is to stack multiple layers, and the information is assigned to these separate and interrelated layers. To put it simply, the output of the upper layer serves as the input of the next layer, and each level behind performs more complex functions according to the information sent from the previous layer. The essence of deep learning is to learn more useful features by building machine learning models with many hidden layers and massive training data, so as to improve the accuracy of classification or prediction [4].

Deep learning has completely changed the traditional image and speech recognition technology of the robot, which enables the robot to understand the information in the image or voice, and has become the most powerful visual and auditory technology of the robot at present. Such robots not only have the functions of traditional robots, but also have some great advantages [5]:

(1) With a simple structure, the robot can convey complex computing tasks to the cloud and receive huge amounts of data at the same time.

(2) Robots can share information and resources, and have stronger learning ability.

(3) Robots can provide worldwide information and knowledge base, as well as share open source code.
3.2. Grasping process of industrial robot combining deep learning and machine vision

The main module of the overall system software of the robot grasping function is object detection. Shooting and scanning items by camera is convenient for the establishment and formation of the picture module, and the types of items are analyzed and sorted through image recognition. Its specific work flow is to detect the object in place, and then to capture the picture, and then to analyze the image, and the last step is to sort the items. The realization of this process is established through the combination of software and hardware of the system, and the image capture of the camera is transmitted to the PC through the USB interface protocol. The PC carries on the classification and identification of the item modeling, and then sends the item type to the control cabinet through the network protocol. The industrial robot receives the signal from the PC machine and orders to sort the items.

In machine vision technology, the vision module of robot needs to collect and scan objects in practice to make up for the lack of data collection. Machine vision needs to test the pictures taken in the picture part and the practice scene, and carry on the collective training simulation test. In the end, the accuracy of the training will not be less than 95%. The overall recognition rate of the test directly determines the fault tolerance rate of the sorting work.

After deep learning and analysis, the computer transmits data to the item name category through the TCP/IP protocol, and the PC machine chooses whether to transfer the item type or not. After checking and verifying the accuracy of the industrial robot's article network analysis database, the workpiece picking decision is made. During this period, if the robot is idle, it will continue to carry out the operation, move the object according to the planned path instructions sent by the computer, complete the handling instructions, and after completing the handling instructions, the robot will return to the work instruction to receive the origin according to the prescribed route and stand by.

4. Conclusion

Applying the key algorithms of deep learning theory to the R & D and production process of industrial robot can make the development of industrial robot technology more rapid. Many algorithms in deep learning theory can solve the communication problems, security problems and learning problems faced in the study and development of industrial robots [6]. In addition, the introduction of vision technology promotes the intelligence and the level of industrial robots, so that the industrial process can better adapt to the variation of the environment. Industrial robot sorting system which uses deep learning and machine vision system will be more and more widely used in industrial field because of its advantages such as intelligence.

Acknowledgement
The work was financially supported by the Scientific Research Project of Tianjin Education Commission (Grant No. 2019KJ146).

References
[1] Wang Shiyu; The Research of Industrial Robots Sorting Technology Based on Robot Vision [J]; Modular Machine Tool & Automatic Manufacturing Technique; 2017.
[2] Li Yin; Design of Industrial Robot object Identification and sorting system based on Deep Learning [J]; Hubei Agricultural Mechanization; 2019.
[3] Han Rui; Design of Industrial Robot object Identification and sorting system based on Deep Learning [J]; Modern Industrial Economy and Informationization; 2019.
[4] Wang Xinyu; Research on the Future Development Direction of Industrial Robot based on Deep Learning and Cloud Robot [J]; Science and Technology Innovation Herald; 2016.
[5] Wang Dongmei, Jin Xiao Chen, Wu Quanyu; The Role of Deep Learning in Promoting the Development of Industrial Robots [J]; Journal of Jiangsu University of Technology; 2018.
[6] Xie Mengzhao, Xie Fei; A brief analysis of the future development prospect of industrial robot from the perspective of cloud robot [J]; Modern Economic Information; 2017.