Programming Methods for 6-Degree of Freedom Robot Teaching

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Abstract: In this paper, programming method for industrial robot teaching and composing of robot language system is described. Through the RBT - 6T/S01S as an example, the program and instruction function of the robot language are summarized. The composition of RBT - 6T/S01S robot system is studied, and the programming of robot clamping and assembly parts teaching is made.
Keywords: Six degree of freedom; Teaching programming; Robot control
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1. Introduction

Robot can imitate the simple actions of people, instead of people to do simple repetitive work, can completed scraping, moving objects or operating tools, et al. Replacing people's work with heavy and dirty work can avoid people's work in harmful environments. It is extremely protective of people's lives and is used widely in various fields. Before robot work, it is necessary for people to carry out corresponding teaching programming according to specific work requirements. Since the development of the robot in the 1960s, it has undergone three phases, namely, the reappearance stage, the offline programming stage and the autonomous programming stage[1].There are also some references[2]. Based on the traditional teaching programming, the virtual teaching programming technique is developed, but the technology is newer, it needs to be further improved and has not been applied in many applications. So at present, most of the domestic and foreign countries are still in the teaching programming stage. Taking RBT - 6T/S01S series join robot as the objects, it has six series joints, adopt servo motor and stepper motor control, installed on the shaft of each corner encoder, you can feedback the current position of each axis movement, in the work can be continuously adjusted, achieve closed-loop control, improve the working accuracy of the robot. Objects in space have six degrees of freedom, so a robot with six degrees of freedom is required to reach any position in space[3]. Robot teaching mainly has two kinds of methods, one kind is through the controller to online teaching robot, one is from the actual robot working environment, through to the offline teaching for the modeling of the robot. This paper studies its teaching programming method by direct teaching.

2. Robot System

2.1 Configuration of Robot

The robot is composed by mechanical arms, control panel and programming controller. The structure is shown in Figure 1-2.

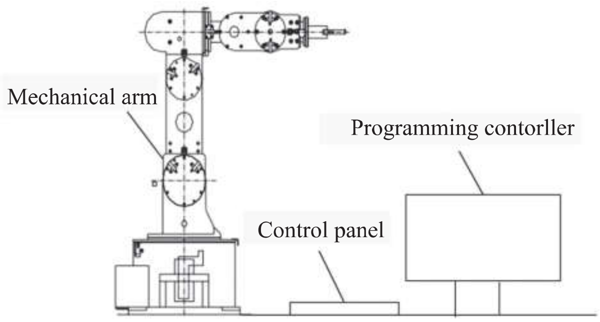


Figure 1. Schematic map of robot

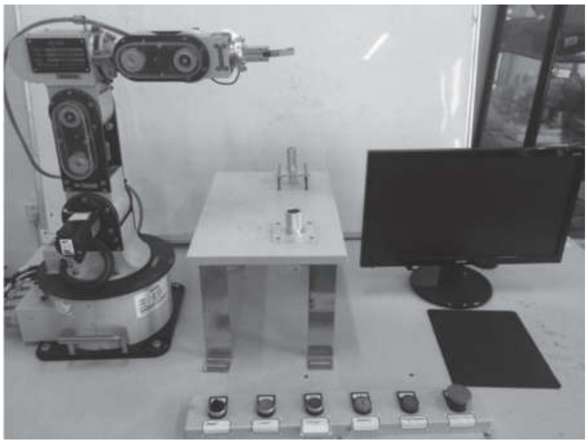


Figure 2. Physical map of robot

2.2 Robot Control System

The robot control system is a general term for the software unit and hardware unit that control the robot to complete the expected motion trajectory, and its structure is shown in Fig.3. Robot and peripheral equipment integration as a system, usually as a whole to complete the task, the robot control system includes information processing module and motion control module, to complete information processing and motion control. The information processing module can complete human-computer interaction and respond to external sensor feedback. The motion control module can control the motor to achieve the specified position according to the position and speed of each joint requirement. These two module are combined to form the closed-loop control, which greatly improves the working accuracy compared with open-loop control.

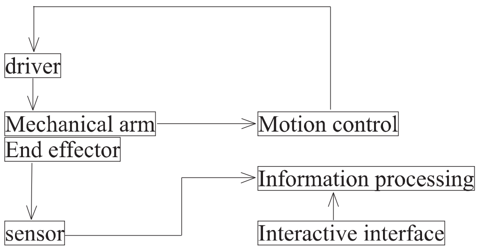


Figure 3. Schematics of robot control system

2.3 Mechanical Structure of the Robot

The principle of robot work is revolving various of joints to move the end controller to the designated position in the space to carry out the corresponding work. See Figure.4. The robot body is mainly composed of the original moving parts, transmission parts and actuating parts. The original moving parts is composed of stepping motor and servo motor, joint Ⅰ, Ⅱ adopts servo motor drive mode; Joint Ⅲ, Ⅳ, Ⅴ, Ⅵ adopts stepper motor drive mode. In the transmission part, the synchronous toothed belt transmission and harmonic reduction transmission are adopted. The actuator adopts the pneumatic actuated claw mechanism to complete the assembly operation.

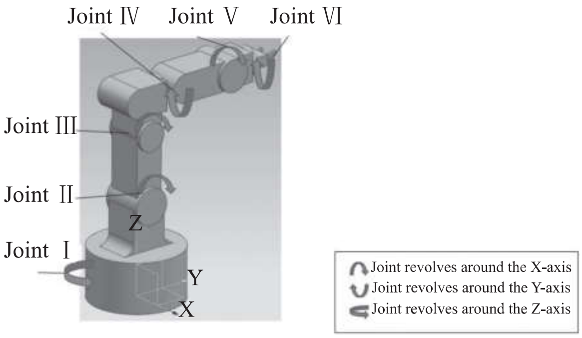


Figure 4. Schematic diagram of robot space movement

3. Robot Teaching Programming

3.1 Direct Teaching Method

The teaching method used in this paper is the direct teaching in two teaching methods, and the direct teaching can be divided into the master-slave teaching, the teaching box and programming teaching and other teaching methods.

1) Master-slave teaching, composed of active small robot and passive target robot of the same structure, the operator can manipulate the small robot manually and let the target robot perform the same motion gesture by the sensor feedback signal installed at each joint of the robot, thus completing the teaching operation.

2) Teaching box, the use of teaching box equipped with single-chip microcomputer control, the teaching point to program format input to the microcontroller, when the reproduction, in accordance with the procedural statements one by one implementation. This method is mostly used in the larger batch of molded products. Refer to [1] [5] [11] for reference in the MOTOMAN Industrial Robot Teach Pendant.

3) Programming teaching, this teaching method and microcontroller control methods are generally the same, only by the computer as a host computer PC-side programming control. This method is simple and reliable for single-piece, low-volume robots and teaching robots. This is the teaching method used in this article.

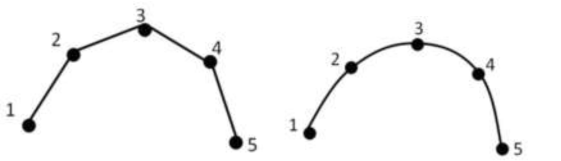
3.2 Robot Language Classification

At present, people generally divide the robot language into three categories according to the level of job description: executive level, coordination level and decision level. The executive language is based on the movement of the robot as the description center. It consists of a series of commands. One command corresponds to one action. The language is simple and easy to program. The disadvantage is that it cannot perform complex mathematical operations. The coordination language is based on the description of the relationship between operating objects as the center of the language. In comparison, decision levels are relatively advanced robotics languages that allow users to directly order subscripts required by a work task without specifying the details of every action the robot will make. As long as the original environment model and the final working state are given according to a certain principle, the robot can perform inference calculation automatically and finally generate a robot action. The RBT-6T / S01S robot uses executive level robot language.

3.3 Robot Language Instruction Function

RBT-6T/S01S robot instruction functions include: motion control function, environment definition function, operation function, program control function, input and output function etc.[4]

The motion control function is the core of the language command function. There are two kinds of control modes of the robot trajectory: CP (continuous path control) control mode and PTP (point-to-point control) control mode. The differences between the two control modes are shown in Fig.5 As shown. The RBT-6T / S01S robot uses the PTP control method. By directly recording the initial point position and the target point position, the shortest path is selected by the linear interpolation method to complete the path planning.



(a) PTP control method (b) CP control method

Figure 5. Two ways of controlling the trajectory differences

4. Teaching Programming Case

4.1 Experimental Equipment

The experimental equipment includes one RBT-6T / S01S robot, one RBT-6T / S01S robot control cabinet, one computer equipped with motion control card, one shaft and hub.

4.2 Teaching Content

The robot needs to complete the task is: First, move to the location of the shaft, and then grab the shaft, the shaft transported to the top of the sleeve, and finally completed the shaft and sleeve assembly work.

4.3 Teaching Process

The RBT-6T / S01S robot uses the PTP path planning method, so it is necessary to determine each teaching point on the path. Teach point planning shown in Fig.6.

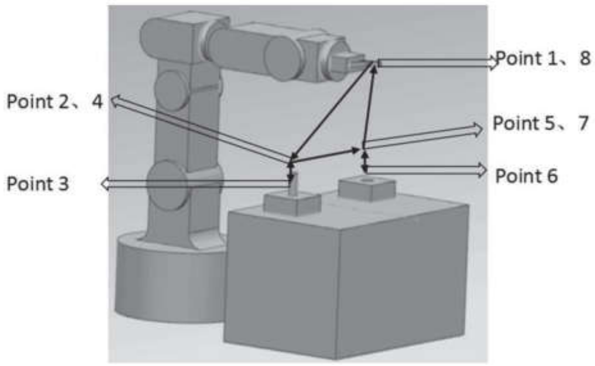


Figure 6. Teaching points plan

4.4 Teach Program Code

P01 X: 0.00, Y: -90.00, Z: 0.00, U: 0.00, V: 0.00,W: 0.00, S: 30, H: 0, G: 0

// robot is at zero

P02 X: -15.39, Y: -63.15, Z: 17.17, U: 0.00,V: -34.01, W: 0.00, S: 30, H: 0, G: 0

// robot hand claw close to the top of the shaft

P03 X: -15.39, Y: -60.14, Z: 18.00, U: 0.00, V: -37.90, W: 0.00, S: 30, H: 0, G: 0

// paw movement to shaft center position

P04 X: -15.39, Y: -60.14, Z: 18.00, U: 0.00, V: -37.90, W: 0.00, S: 30, H: 1, G: 0

// Close the gripper

P05 X: -15.39, Y: -66.61, Z: 18.00, U: 0.00, V: -37.90, W: 0.00, S: 30, H: 1, G: 0

// Gripping shaft off the base

P06 X: 15.75, Y: -66.61, Z: 18.00, U: 0.00, V: -37.90, W: 0.00, S: 30, H: 1, G: 0

// The robot's gripper grips the shaft above the sleeve

P07 X: 15.75, Y: -60.14, Z: 18.00, U: 0.00, V: -37.90, W: 0.00, S: 30, H: 1, G: 0

// Shaft assembly such as a sleeve

P08 X: 15.75, Y: -60.14, Z: 18.00, U: 0.00, V: -37.90, W: 0.00, S: 30, H: 0, G: 0

// Open the gripper

P09 X: 15.75, Y: -66.82, Z: 18.00, U: 0.00, V: -37.90, W: 0.00, S: 30, H: 0, G: 0

// The robot gripper moves to the top of the assembly

P10 X: 0.00, Y: -90.00, Z: 0.00, U: 0.00, V: 0.00, W: 0.00, S: 30, H: 0, G: 0

// robot to zero operation

4.5 Teaching Results and Analysis

The assembly work of the sleeve is more difficult than that of the teaching experiment of the written text in the reference[5]. Because of its more complicated route than writing, if the posture cannot be adjusted reasonably, there will be a situation that the shaft cannot be completely pulled out of the base, so that the next teaching cannot be performed and a collision event may occur, causing damage to the robot and the work piece. Robot assembly work attitude shown in Figure 7.

Figure 7. Robot assembly work gesture

5. Conclusion

In this paper, the different teaching methods of industrial robots and the classification and composition of robot language system are introduced in a comprehensive way. The final robotic RBT-6TS01S is used to capture and assemble the shaft. However, during the experiment, some parts of the robot that need to be further improved, such as the robot can be connected to the remote control handle and install a variety of input and output devices, so that the operator can quickly become familiar with and operate the robot. There are also different according to the work object, the replacement of different end-effector. For example, if the quality of the assembly object is light, you can use the pneumatic suction cup as the end effector, so you can save four teaching paths and greatly improve work efficiency.

Anyway, through the teaching of programming experience, we can find through the teaching point connection, freedom to plan out the robot's exercise program. In the "machine replacement" process accelerating today, continuous improvement of robot technology and promote the social development has a huge role.

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