Research on Off-Line Programming Technology of Industrial Robot in Complex Surface Working Environment

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Abstract: The off-line programming of industrial robot is actually to build the geometric model of robot working environment based on computer graphics, make full use of the planning algorithm, effectively control the graphics, and reasonably plan its motion trajectory when it is off-line. After the off-line programming, 3D animation simulation is carried out to verify the accuracy of the program. Through the verification, the code can be transmitted to the robot control system, so as to realize the scientific and reasonable control of the industrial robot. According to this, the off-line programming technology of industrial robot is analyzed in detail.

1. Off Line Programming Technology in Industrial Robots

1.1. Human Machine Interface

In the design and development of industrial robots, it is necessary to analyze the dynamic performance and kinematics in detail and plan the running track reasonably. However, because the robot has the characteristics of multi link space and multi degree of freedom, the complexity of its dynamics and kinematics is deepened, which directly increases the calculation amount and difficulty. For example, the simulation object is the manipulator[1]. By applying the robot principle and computer graphics technology, the geometry is displayed in the way of animation by computer, and then the kinematics is analyzed in detail, so as to realize the structural design, and simulate the relevant problems such as the control of the manipulator and the collision and obstacle avoidance in the working environment, which can effectively solve the problems encountered in the development of the manipulator Problem. There are various types and functions of existing simulation software, and there are numerous precedents in the field of industrial application.

No matter with any development platform as assistance, the scientific rationality of building the model is an important factor that directly affects the practical effect. In addition, there is a deviation between the model built by software storage data and robot principle parameters and the actual model, so it is necessary to calibrate it in time, further analyze and measure the error, and take measures to correct the deviation in time. Due to the gradual expansion of the application of robots, the ambiguities generated by the working environment directly affect whether the task can be successfully completed. Therefore, the environment model is not fixed, otherwise it is easy to lead to job failure. Therefore, it is a big challenge for the practical application of this system to choose the environment and modify the environment model.

1.2. Trajectory Planning

Planning trajectory is actually to further calculate the expected trajectory according to the specific requirements of the task. The inverse kinematics solution and path interpolation of path points are the key points in the task of track planning module in off-line programming[2]. There are two ways of trajectory planning, i.e. joint space trajectory planning, to clarify the relevant constraints of trajectory key points and path points; Cartesian space trajectory planning, to clarify the parametric path. Cartesian space trajectory planning includes lines, arcs, velocity curves and

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splines; joint space trajectory planning includes cubic polynomials, trapezoid velocity interpolation, cubic splines and so on.

1.3. Offline Programming

The off-line programming is divided into four modules, which are task programming, unknown matrix solving, transformation equation building, robot task description. Based on the results of dynamic graphic simulation, the problems in the program are modified to ensure the good effect, and the robot can realize online control and complete the operation. The best goal of robot programming is to fully describe the working process of robot by using appropriate natural like language. Through the robot intelligent facilities and equipment to obtain environment related information, complete the movement and task planning, so that the robot can be automated and intelligent control in the process of operation. The off-line programming language integrates the kinematic and geometric characteristics of the robot based on the universal interface encapsulation, so it can be better associated with a variety of objects including sensors[4]. Because off-line programming language can directly operate geometric information and has good spatial reasoning ability, it can quickly complete programming and automatic planning.

1.4. Post Processing and Simulation

In the off-line programming of industrial robots, the effective application of post-processing is very important. It directly determines whether it can be applied to the production practice after the program programming, and it is also the practical part of the system which links programming and processing. Among them, the robot inverse kinematics solution is the core component. According to the node position reached by the robot end actuator, the robot joint angles are obtained, so as to effectively control the robot attitude. In post-processing, I / O control signal command shall also be programmed to facilitate timely response to external facilities and equipment in the process of automation. After post-processing, the robot program instruction code is generated. During the simulation, in order to ensure the consistency between the simulation and the motion, DCAM simulation can be used, and the program module can be imported into robot studio to realize the motion simulation, and the motion accessibility and stability can be analyzed in detail, so as to demonstrate the accuracy of the operation program.

2. Offline Programming System Test

In order to test the practical application effect of off-line programming system of industrial robot, the experiment is carried out.

2.1. Test Conditions

Robot selection

ABB industrial robot is selected for testing.

Robot installation

Generally speaking, the main way of processing and installation of industrial robots is front mounting. However, due to the large size of the workpiece to be processed, the general front mounting method is used, no matter where the workpiece is, because it is necessary to avoid contact with the robot base area, resulting in the failure of robot roots in some areas to reach smoothly. For the area that can not be processed, only the workpiece can be installed for the second time. Each time when the workpiece is installed, the workpiece must be calibrated in detail, so that the processing efficiency will be significantly reduced. Therefore, when the robot is reversed for reverse installation, and the base is installed on the gantry, when the workpiece is installed, there is no need to consider the phenomenon of collision with the robot. Therefore, in the process of this test, the robot is installed reversely.

Machining workpiece

The die of automobile body covering part is selected for processing workpiece, and the die size is 2.5m $\times$ 1.2m $\times$ 0.68m. The test machining area is the workpiece surface, and its curvature

radius is 5mm.

test tools

Because it belongs to the test, the test tool should not contact with the workpiece, to avoid excessive friction during the contact, resulting in damage to the tool. In the front part of the test tool, the radius of curvature is 6.5mm, and the distance between the tool and the workpiece is exactly controlled at 1.5mm, so as to facilitate the observation of the accuracy of the robot movement, and prevent the foundation between the tool and the workpiece, resulting in serious damage to the workpiece or tool[5].

Programming parameters

The setting distance is 1.5mm, the machining speed is V200, and the feed / retract speed is V500.

2.2. Test Process

According to the specific operation process, the off-line programming work is carried out for the workpiece surface to be processed. The programmed code is imported into ABB Robot System to drive it to start moving.

2.3. Test Results

When testing the motion, the specific distance between the front part of the tool and the workpiece is tested, and the smoothness of the robot motion is observed in real time. The test results show that the distance deviation of ABB Robot is about $\pm$ 0.1mm when it is running, and it runs smoothly and naturally, with good dynamic performance, which is clearly consistent with the off-line processing requirements of industrial robots.

3. Analysis of the Development Trend of Off-Line Programming in Industrial Robots

Off line programming can be studied and developed in some aspects. First, Sensor technology is widely used. At the present stage, the absolute positioning accuracy of the industrial robot is the most prominent influence on the practical application of off-line programming technology. It is necessary to collect a large number of deviation information between simulation and practical application. The absolute positioning accuracy of the robot affected by environmental factors can be effectively reduced by making corresponding algorithms and sensors based on the amount of information. Secondly, the path planning method is deeply explored, which can effectively solve the basic problems, but there are also some defects. Subsequently, based on the combination of manifold and graph theory, we can develop a wide range of general trajectory research methods on the geometric level[7].

4. Overview of Off-Line Programming Technology for Industrial Robots

Industrial robot off-line programming is one of the core technologies of industrial robot technology. It uses computer graphics to build the geometric model of the robot and its working environment in the special software environment of off-line programming, and then controls and operates the graphics with the help of some planning algorithms. The main purpose of this technology is to enable students to master the skills of offline programming using robot studio.

5. Off Line Programming Hybrid Technology Construction of Industrial Robot

The off-line programming of industrial robot is a highly practical and operational technology, and the single theory teaching can not achieve the teaching goal, while the hybrid teaching breaks the traditional teaching mode, combines the modern information technology means with the traditional teaching mode, and adopts the online and offline hybrid teaching mode to improve the learning interest and teaching effect. Promote good teaching effect.

In this paper, the off-line programming hybrid technology of industrial robot is established based on the teaching platform of youmu course, which consists of six modules: basic information, unit

learning, technical resources, technical activities, classroom teaching and skill competition. Basic information module, students can understand the basic information and contact information of teachers, technical information and teaching arrangements. Unit learning module is the main online learning platform for students, including courseware ppt, micro class video, etc., to help students preview before class and review after class. Some extracurricular expansion projects and corresponding teaching videos are included in the teaching resources, such as the learning course of robot DK offline programming. The technical activity module belongs to the online communication platform between teachers and students, including technical homework[8], Q & a discussion, online testing, test paper library. The skill contest module mainly includes the question bank of intelligent manufacturing industrial robot technology application contest.

6. Application of Hybrid Technology Teaching Mode of Off-Line Programming for Industrial Robots

Now combined with the technical content, taking the creation of the basic simulation workstation of subsection 1 industrial robot as an example, the teaching activity of subsection hybrid technology is designed, as shown in Figure 1, the robot and peripheral equipment are imported and the trajectory is established.

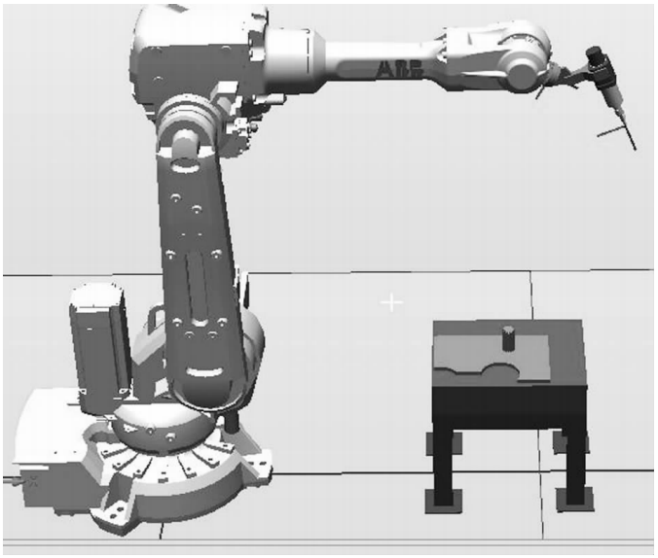

Figure 1 Creation of basic simulation workstation of industrial robot

Before class, let students use PPT and operation video on the platform of youmu class to learn independently, and use robot studio to complete the test of corresponding model establishment 10 minutes before class. According to the results of the students' tests, the paper focuses on the problems of building the industrial robot system in the incomprehensible part and creating the industrial robot motion track program in the problematic part. In the explanation of the program problem of the motion track, the TCP point positioning of the end actuator is emphasized[9], as shown in Figure 2. Finally, according to the explanation, let the students operate the robot studio by hand, the teacher inspects and guides, and after completing the corresponding exercises, import the corresponding programming operation model into the course of youmu and submit the assignments.

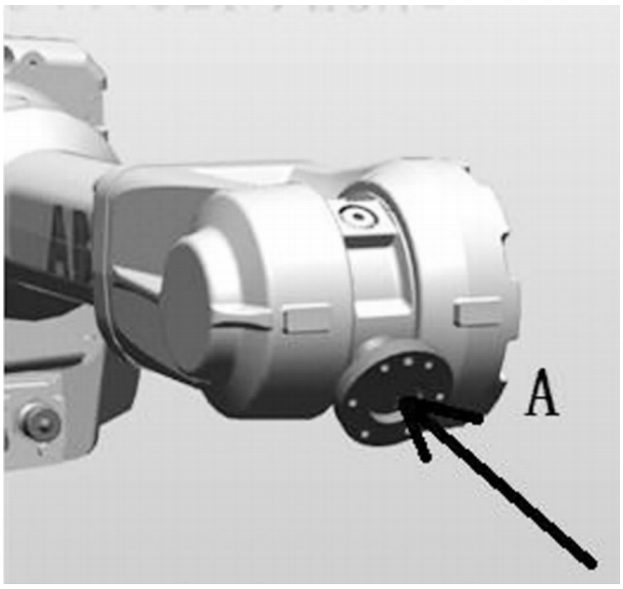

Figure 2 TCP point of industrial robot

The examination method of this technology is the reform examination method. The method of combination of learning assessment and operation assessment is adopted for assessment. The composition and proportion of the results are also divided into learning assessment results and operation assessment results. The attendance, attendance, questions and answers in class accounted for 10% of the learning assessment results (usual results), and the learning of youmu class accounted for 20%. The operation examination (final examination score) adopts the mode of taking questions, and the score accounts for 70%. Through these aspects of comprehensive assessment, improve the students' autonomy in preview and review.

7. Summary

In short, the off-line programming technology in industrial robots plays an irreplaceable role. Among them, the extensive application of industrial robots in the production field has gradually formed an advanced flexible production and manufacturing mode. At the same time, in the field of industrial robot training, off-line programming is the main teaching mode of robots in the future. Therefore, off-line programming plays a key role in the development of industrial robots, which directly determines the efficiency and quality of industrial robots. It is of great practical significance for the long-term sustainable development of industrial robot industry to constantly update and optimize off-line programming technology.

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