Research on Trajectory Planning of Six Degrees of Freedom Robot

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Abstract. With the continuous development of industrial automation, the demand for industrial robots in the manufacturing field is gradually increasing. In order to meet the needs of different occasions and functions, the planning of the trajectory of the robot becomes the research direction of the six-degree-of-freedom robot. The research object of this paper is a six-degree-of-freedom industrial robot. According to engineering needs, a structure of a handling robot is designed. The kinematics of the robot and its trajectory planning are studied, and the simulation analysis is made.

1 The introduction

Industrial robot [1] is an electromechanical integration device in the industrial field, mainly a humanoid robot with multiple degrees of freedom. Such robots tend to be autonomous and can be programmed repeatedly. Since the first industrial robot appeared in the United States, more and more attention has been paid to industrial robots by scholars.

Compared with foreign countries, although China is the world's largest market, in the high-end field, the robot market has been basically monopolized by foreign countries. According to the latest data, the top-selling model in the Chinese market is multi-joint robot, among which there are more six-axis robots. However, many products in China are basically dependent on imports. The competitiveness of domestic industrial robots is very poor, and the research foundation is very weak.

The system of the six-degree of robot [4] requires strong coupling, strong non-linearity, and uncertainty in some aspects, such as parameters and interference of the external environment. This brings about certain difficulties in control. With the rapid development of modern industry, people have strict requirements on quality, especially in laser cutting, welding and other occasions more stringent. This puts forward higher requirements for robot tracking accuracy [5]. How to make the manipulator [6] stable, accurate and control its speed has become the top priority. These are things that need to be explored. How to realize the high-precision movement of robot has become a key factor restricting the level of robot in our country and even enhancing the competitiveness.

2 Dynamic analysis

Industrial robots are usually multi-rigid-body coupling, multi-dimensional and high-precision motion devices [7]. In addition to the general equipment design requirements, it also needs to have flexibility and accuracy. Robot mechanical structure design often needs to consider the linkage and motion. The robot design first analyzes and draws lessons from the existing robot. After major innovations and even improvements, we can realize the maximum value of this robot. This requires repeated tests on the model [8]. In the analysis of the robot, it is necessary to carry out dynamic analysis and verify the robot separately. Figure 1 is a schematic of the robot.

This robot needs to achieve θ_1 specific action according to the difference of six angles. For example, when A is used, waist rotation can be achieved. However, its range of action and speed are also required. The maximum is 160°/*s*; At θ_2, the pitch of the big arm can be achieved. Its Angle range is -145 to 90, and its maximum speed is the same as that at θ_1; At θ_3, the pitch of the forearm can be achieved. Its Angle ranges from -125 to +128, and its maximum speed is 220°/*s*. At θ_4, you can rotate the wrist, and its Angle range is, the maximum speed is 500°/*s*; At θ_5, you can flip the wrist, which has the same Angle range and maximum speed as at θ_4; At θ_6, you can achieve wrist deflection, and it's Angle range is, the maximum speed is 330°/*s*. As can be seen from the figure, wrist movement is mainly controlled by l4-l6. When the robot moves, there are six degrees of freedom in total. At this time, the structure improves the flexibility of the robot [9].

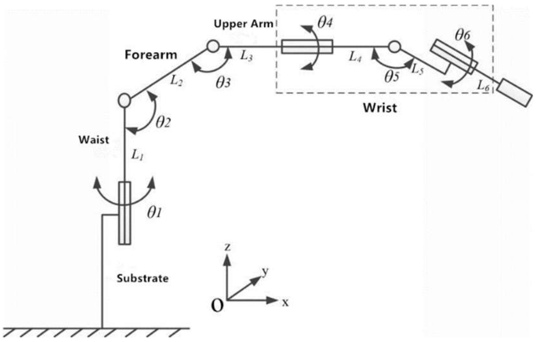

Figure 1. Schematic diagram of robot

3 Trajectory planning

Before tracking tasks, mechanical arms [10] usually need to understand tracking targets and assign tasks to different joints. Generally, the operation of the robot is curvilinear motion. At this time, displacement and velocity need to be determined to achieve the desired trajectory planning. Trajectory planning is the basis of tracking tasks, usually joint space or cartesian coordinate space. Trajectory planning is the main content of motion planning. Trajectory planning [11] mainly considers inserting an intermediate point between the start and the end to make its path correspond to the corresponding time, so as to realize the movement of the robot along the trajectory. Generally, manual input path and constraint conditions are used to determine the target position, time, speed and other parameters, and finally trajectory is generated based on calculation [12]. Trajectory planning often requires its function to be continuous and smooth, and even needs to consider the obstacles encountered in the middle. Its planning flow chart is shown in figure 2.

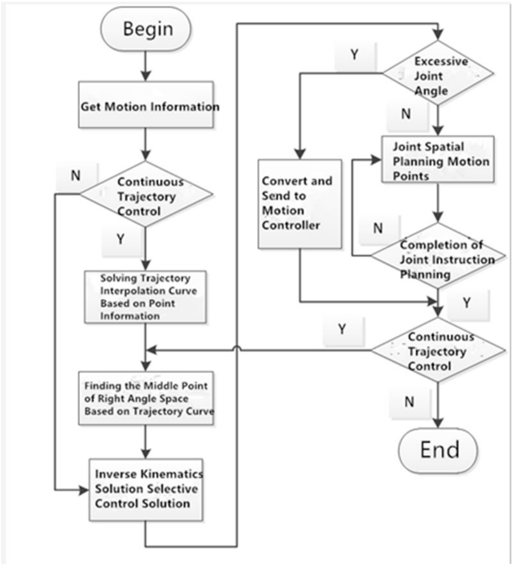

Figure 2. Trajectory planning process

When the robot moves to the target point, the planner usually puts forward some requirements to the user, and usually provides some explicit constraints, such as smoothness or continuity. At this time, the planner uses some functions to operate on the corresponding nodes according to the requirements, so as to formulate different path segments, and then drives the manipulator to reach the specified path point according to the controller, and then reaches the target position.

4 Simulation analysis

In general, the transformation of each joint required by the planning of spatial trajectory can be basically regarded as a function of time, that is, all joints pass through a certain point at the same time, so the planning of trajectory needs to have a strong real-time performance. The setting and planning of constraint conditions are usually carried out in space, without considering obstacles, and generally applicable to point-to-point.

The way to select the joint quantity to show the robot's motion is to describe the joint space. However, joint space planning is roughly divided into two steps: on the one hand, the assumed path point coordinates are calculated by inverse kinematics solution to calculate the vector values of their key nodes, and then the vector values of each joint are integrated into a smooth order, and finally it is made into a function of the path points. This trajectory planning can not only ensure the continuity of joints, but also demonstrate its real-time performance. Its disadvantage is that it is difficult to determine the trajectory of the end, which is only suitable for point-to-point. In addition, the smoothness of its velocity should even be considered. Sometimes the overshoot of speed causes the motor to oscillate, and then affects its response time. If the acceleration is large, it will directly affect the torque of the motor, at the same time, it will accelerate the loss of machinery and bring unnecessary trouble to the system.

For cartesian space, its trajectory planning is developed by changing the posture of the end-effector in space, mainly considering its transformation sequence. Because the requirements of tasks are different, the paths used by users in the task space are also different, such as arc, line and spline curve, etc., so according to the different path trajectories, this kind of planning can be summarized as arc trajectory planning and linear function interpolation. This kind of space description method is more intuitive, and the trajectory of its end is very clear, which is a kind of suitable trajectory planning for continuous path. The path points of this method may be difficult to become joint space problems. Sometimes, the inverse solution of kinematics needs to be solved many times in each interpolation cycle, and even the problem of joint Angle needs to be considered. In addition, the control of joint movement needs to be considered, resulting in a huge amount of calculation.

If the end of the manipulator wants to perform pose operation, it is necessary to control the action of these operations as a function of time, such as speed, etc. Then, the principle of inverse kinematics is adopted to solve joint variables, and its motion trajectory can be clearly displayed. If the pose cannot be directly measured, it usually relies on joint space to find the inverse solution, so joint space coordinates or cartesian space coordinates are used to switch, resulting in a large amount of computation. FIG. 3 shows simulation with joint space model on the left and cartesian space model on the right.

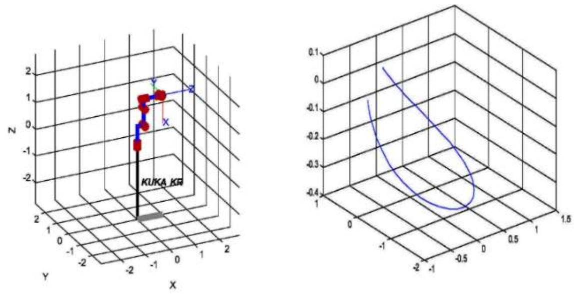

Figure 3. Simulation of two methods

For robots, there must be two problems with planning: first, the constraints of the basis, which can be listed as speed and displacement of each joint. On the other hand, we need to consider the outside world to determine whether obstacles affect the movement of robots.

5 Conclusion

This paper mainly makes a simple introduction to the six-degree of robot, designs the trajectory planning process, emphatically explores the planning process of joint space and cartesian space, and simulates its trajectory planning with MATLAB software, hoping to provide theoretical basis for the further realization of the follow-up trajectory tracking research.

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