Research on the Trajectory Planning and Control Technology of Industrial Robots Guided by Computer Visualization

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Abstract. With the popularization of computers, the development of all walks of life has become more rapid. This article mainly analyzes the mechanical structure design of the Cartesian coordinate robot system, it also studies the motion control.

Keywords: High School English, Computer, Model

1. Introduction
In order to follow in the footsteps of Industry 4. 0, China is vigorously developing manufacturing to improve its national strength and competitiveness. The development direction of China's manufacturing industry has the characteristics of precision, high speed, and modularity. With continuous development, industrial production is gradually automated, which makes robots widely used in various fields. Our country vigorously develops the robot industry and advocates industrial robot innovation to improve the competitiveness of the manufacturing industry [1].

2. Development status

2.1. Current status of machine vision research
The carrier of machine vision technology is artificial intelligence, and the development of artificial intelligence technology also drives its development. It has been widely used in many industries, such as: industry, transportation, agriculture and medical care. Machine vision is a non-contact sensor. It uses computer technology to replace the human eye to complete the corresponding work. This not only improves work efficiency, but also has great advantages over manual labor in terms of accuracy, speed and quality. Moreover, the visual technology technology adapts to a wide range of environments, it will not be interfered by electromagnetic signals, and the sensing distance and range are relatively wide [2].

2.2. Research status of trajectory planning
Trajectory planning is relatively hot among many robotics research directions, and many researchers have invested in this direction. end effector or robot in the production in the industry. The trajectory refers to the path of the end effector or robot. Under the premise that the work task has been determined, trajectory planning refers to the ideal running path set in advance according to
requirements and performance indicators. With the rapid development of CNC technology, semiconductor processing industry, and robotics industry, these require higher and higher requirements for trajectory planning algorithms. For example, in the wafer cutting process in semiconductor processing, in order to be able to cut wafers with high precision, we need to plan the trajectory in advance, and during the cutting process, we need to compare the planned trajectory with the actual trajectory, and then feed back the error and re-plan the trajectory. This can improve the accuracy of the trajectory. Commonly used trajectory planning algorithms are: linear acceleration and deceleration planning algorithm, exponential acceleration and deceleration planning algorithm, linear plus parabola planning algorithm, s-type acceleration and deceleration planning algorithm [3].

2.3. Overview of the Cartesian coordinate robot
The Cartesian coordinate robot has a simple structure and a stable motion structure. It is composed of multiple linear motion mechanisms. As shown in Figure 1. Each part of the Cartesian coordinate robot is perpendicular to each other. The application of the right-angle index robot is very wide, and it is used in the semiconductor, glue coating, welding, handling and other industrial fields. The Cartesian coordinate robot can be connected to different end-effectors according to the requirements of the task, so as to complete the pre-set work tasks. Cartesian coordinate robots are divided into two structures: plane motion and space motion. With the continuous development of robotics technology, robots are no longer conceptually similar to human forms. The definition of robots is becoming more and more extensive, and the forms of robots are also in various poses.

![Figure 1. Cartesian coordinate robot](image)

Cartesian coordinate robot has the following characteristics:

1. It can choose the degree of freedom according to the actual application, and each degree of freedom is perpendicular to each other;
2. It can be combined arbitrarily, the length of each linear axis can reach up to 6 meters, and the maximum load can reach 200 kg;
3. The complete robot system is simple in composition;
4. It has the characteristics of high flexibility and versatility. It can be installed with different end effectors to achieve different functions according to the task requirements;
5. It has the characteristics of high speed, precision and high reliability;
6. Its structure is simple, which is convenient for maintenance, its application range is wide, and it can adapt to more environments [4].

3. The mechanical structure design of the Cartesian coordinate robot system

3.1. Robot movement mode selection
The basic movement form of the Cartesian coordinate robot is to move linearly along the X, Y, and Z axes in the space. Linear motion is the basic motion form of a Cartesian coordinate robot. The mechanical structure for linear motion mainly includes guide screw, synchronous toothed belt and worm gear. The characteristics of these motion modes are as follows.

The guide screw is the most used and ideal structure to convert rotary motion into linear motion. The main parts of the guide screw include screw, nut and guide, some auxiliary parts, such as: thrust bearing, support bearing of the screw, as shown in Figure 2. The guide screw is the most commonly used mechanical structure in linear motion. Its structural characteristics are low friction, high efficiency, high precision, and smooth transmission. The most commonly used guide screw is in the transmission of machine tools and precision instruments [5].

**Figure 2.** Guide rail screw drive

Synchronous belt transmission is a linear motion mode in which the driving wheel is connected by a motor, and the driving wheel meshes with the transmission belt. As shown in Figure 3, the synchronous belt drive includes structures, such as pulleys, motors, and couplings. Synchronous belt transmission can realize long-distance transmission, and its transmission speed is fast. The load of the synchronous belt transmission is related to the number of teeth of the belt. The more the number of teeth of the belt, the larger the load. But the disadvantage of the timing belt is its short life. In high-speed transmission equipment, the linear motion transmission method of the synchronous belt has a wide range of applications.

**Figure 3.** Synchronous belt transmission

The structure of the turbine worm is very simple, including two parts, a gear and a worm, as shown in Figure 4. Its principle is similar to that of a rack and pinion. They all use the meshing of gears to drive a worm to achieve linear motion. The advantages of the turbine worm are compact structure, smooth transmission, low noise, and it is self-locking. It is only suitable for short-distance transmission, so the transmission efficiency is low, and its heat dissipation is not good, and it can only
work intermittently [6]. Long-term non-stop work will cause a lot of wear and tear on the turbine and worm, which will reduce the service life. Turbine worm is suitable for heavy load, low speed occasions and intermittent working places.

![Turbine worm drive](image)

**Figure 4.** Turbine worm drive

3.2. **Robot power unit selection**

In a Cartesian coordinate robot, the motor is equivalent to a human muscle, which provides power for people's pre-set task requirements. The motor connection coupling used by the Cartesian coordinate robot drives the guide screw to complete the linear motion. However, if the accuracy of the motor is low, it is difficult to accurately reach the specified position, and the expected accuracy will not be achieved when performing the set task. Therefore, it is necessary to choose a high-precision, well-positioned motor [7].

3.3. **The overall structure of the robot**

Most of today's industrial robots are mechanical arms with six degrees of freedom, which are not only complex in structure, but also occupy a large space, and their working range is basically within a limited circle around a fixed point. The Cartesian coordinate robot has a compact structure, it is easy to control, and it can complete a wide range of work according to requirements. Cartesian coordinate robots are divided into: two degrees of freedom, three degrees of freedom, four degrees of freedom and so on.

The two-degree-of-freedom Cartesian coordinate robot has only two freedoms in the horizontal direction. The working range is in a limited plane, so it is also called a plane Cartesian coordinate system robot, which has a simple structure and low manufacturing cost. However, due to the limited degree of freedom, it can only complete simple tasks, such as: two-dimensional plane printer, plane drawing and plane metal welding and other simple tasks.

A four-degree-of-freedom Cartesian coordinate robot has one more degree of freedom compared to a three-degree Cartesian coordinate robot. Many four-degree-of-freedom robots have one more plane rotation motion than three-degree-of-freedom robots, the linear motor drives the worktable to rotate. Although the difference is only one degree of freedom, there is a lot of difference in performance. The Cartesian coordinate robot can reach any point in the space as long as it has three degrees of freedom, but with one more degree of freedom, the Cartesian coordinate robot can quickly specify the position. The purpose of this is to directly improve the work efficiency of the robot.

The three-degree-of-freedom Cartesian coordinate robot has many uses and wide applications. Therefore, the three-degree-of-freedom robot is most commonly used in the industry. There are many structural forms of the three-degree-of-freedom Cartesian coordinate robot. According to the structure, it is divided into gantry type, wall hanging type and cantilever type [8].
4. The research of robot motion control

4.1. Control system hardware selection
The system hardware is mainly divided into two parts: one part is called the upper computer, which refers to the "brain" industrial computer of the entire system. The industrial computer is used as the computing processing center to process received information and send instructions. Moreover, the industrial computer must coordinate the operation of the entire equipment, which can make the system orderly and efficient. The other part refers to the motion control card of the lower computer. The function of the motion control card is to receive the instruction information from the upper computer, and then control the motion of the actuator mechanism [9].

4.2. Classical control method
The typical application of classical control theory in practice is the PID controller. The controller includes three parts: proportional unit, integral unit and differential unit. Because of its simple structure, strong robustness and adaptability, PID controller is easy to adjust, so far it is still the most widely used controller among industrial controllers. The adjustment performance of the PID controller is determined by the three parameters of Kp, Ti and TD. The PID controller is most used in linear systems. Technicians will not change after adjusting the three parameters to appropriate values according to the actual tasks of the control system. In the process of chip cutting, the PID controller needs to calculate the deviation between the expected position of the knife and the actual position of the knife [10]. By combining the deviation according to the linear combination of proportional, integral and differential, it can complete the task of optimizing the trajectory of chip cutting.

5. Conclusion
At present, vision-guided Cartesian coordinate robot trajectory planning is a hot research direction. With the development and advancement of computer visualization technology, the research will continue to break through the difficulties and deadlocks. Of course, there are still many problems, which need our continuous efforts to solve them.

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