Design of Industrial Automation Robot Control System Based on Fuzzy PID System

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Abstract: At this stage, the degree of automation of industrial robots is very high, and it is an indispensable important productivity in modern industry. Traditional industrial robots have difficult control systems to meet modern industrial production requirements. Based on this, based on the motion analysis of the robot, the servo system based on fuzzy PID algorithm is deeply studied, and the industrial automation robot control system based on fuzzy PID control is designed.

1. Research background

1.1 Literature review

Based on the line of sight method, Sun Xiaoyan analyzed the underwater robot control model and proposed a new path tracking control method for underwater robots. Based on the fuzzy control method, a new fuzzy PID controller for underwater robot tracking control is designed. Finally, based on the above research, experiments and simulations of the designed path tracking controller were carried out, and the results showed that the above controllers were robust (Sun, 2015). Bai Jing and other scholars have designed a fuzzy PID control algorithm to improve the system performance and control accuracy of multi-axis motion controller. Moreover, the application of this algorithm significantly improves the dynamic performance and steady-state performance of the four-degree-of-freedom palletizing robot's private service system, and the system control effect is significantly improved (Bai et al, 2016). Li Xianyu and other scholars proposed a wheel acceleration control algorithm by modeling wheeled robots. Moreover, the fuzzy rule table and the membership degree relationship are designed. Finally, the simulation experiment proves that the fuzzy PID self-tuning algorithm is better than the conventional PID algorithm (Li et al, 2016). Zhan Xiaohui and other scholars have deeply analyzed the shortcomings of existing slag-adding robots, and developed a robot that can detect and feedback slag thickness in time. In this process, they constructed a fuzzy inference engine and realized fuzzy PID control of the electromechanical system, and the experimental simulation effect was good (Zhan et al, 2019).

1.2 Research purposes

At present, science and technology continue to develop, and robots have gradually become popular and widely used in industrial production. Since the last century, the design, development and application of industrial automation robots have been greatly developed. Modern industrial production has gradually combined with intelligent robots, greatly improving the efficiency and quality of industrial production. With the continuous expansion of industrial robot applications, industrial automation has further improved the performance requirements of robots, and traditional robots can no longer fully meet the production requirements of modern industry. Based on this, this paper takes the kinematics analysis of industrial automation robot as the starting point, studies the servo system based on fuzzy PID algorithm, and designs the industrial automation robot control system, in order to provide a valuable reference for the development of industrial automation robot.

2. Kinematics analysis of industrial automation robot

From the perspective of the components, the robot is divided into seven modules. These seven

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modules are software systems, processors, controllers, sensors, drivers, end effectors, and robotic bodies (Hao et al, 2018). Among them, the robot body is the most basic part of industrial robots; the end effector is the most important execution part of industrial robots. In this paper, the kinematics analysis of robots is mainly carried out from three aspects: attitude description, position description, transformation mapping of coordinate system and vector transformation operator.

Location description. The robot is recorded as the point P, and the position of the point P in a certain coordinate system is represented by ${}^{A}P$. This particular coordinate system is represented by $\{A\}$, and it can be considered that the position of the point P in the coordinate system is equivalent to a vector. In other words, the position of point P in the coordinate system can be represented by three ordered numbers. The elements of this vector can be represented by X, Y, and Z, respectively.

Description of the gesture. In the above analysis, the position of the robot is determined by the above coordinate system. Assuming that the robot has enough joint manipulators, the robot can change in any posture with the body and finger positions remaining the same. In order to more accurately describe the attitude of the robot, it is necessary to give a fixed coordinate system on the robot while giving a positional expression relative to the reference coordinate system.

The transformation map of the coordinate system and the transformation operator of the vector. For the robot designed in this paper, there are six degrees of freedom, and the coordinate origins at each joint do not coincide and have different postures. If the pose and relative position between the two joints are converted, the position description is made in the absolute coordinate system. Then, the first thing to do is to rotate or transform the coordinate system where each joint is located so that it is in the same coordinate system when the pose is described. Moreover, the mathematical description of the relative coordinate system is the same as the mathematical description of the new vector obtained after translational rotation, rotation, and translation.

3. Research on servo system based on fuzzy pid algorithm

At present, PID control technology has gradually matured and is widely used in various fields as a system control method (Chen et al, 2016). Among them, the PID control mode is also applied to the control system of the servo motor. In actual use, manual adjustments are still needed according to the actual situation. Although the adaptability of the PID controller itself is very good, its control effect is still affected by three different parameters. These three control parameters have a very close relationship. When the parameter selection is more suitable, the control effect of the PID controller is generally ideal. But the reality is that most control systems have greater dynamics, with more external and internal changes. In other words, the PID control mode is not suitable for nonlinear, time-varying systems. Therefore, this paper introduces a fuzzy PID control system for the actual situation of PID control, and combines the traditional PID controller with the characteristics of fast self-adjustment of fuzzy PID to construct a new PID controller to better realize the control function.

The traditional PID control algorithm has a linear control process, and its output value and input value together make the control deviation of the PID control system. Among the existing control methods such as proportional control, integral control, and differential control, the easiest to implement is proportional control. However, in a specific control system, if proportional control is used alone, the system will have a steady-state error. The integral control just eliminates this steady-state error. The inertia of the system causes a delay in the error variation, which in turn produces a vibration phenomenon, and the role of differential control is to eliminate this phenomenon.

Similar to traditional PID control, fuzzy control also needs to establish a corresponding fuzzy controller. The specific control process begins with the upper computer reading the value of the controlled quantity, then comparing the input quantity with the read value to obtain the error and using it as the output quantity. In order to implement fuzzy control, it is also necessary to blur the obtained output, and then use the obtained vector set to represent the amount of blur.

Conventional PID controllers are difficult to apply to time-varying, non-linear control systems. Fuzzy control is difficult to eliminate the static error of the system. Combining these two methods, namely fuzzy PID control, enables real-time online control of PID parameters and maintains good control effects. Therefore, the fuzzy PID control system not only has the advantages of strong stability and easy to use, but also has the advantages of high precision, strong adaptability and great flexibility.

4. Industrial automation robot control system design

4.1 Control scheme selection

The industrial automation robot control system designed in this paper uses PC as the open platform and adopts modular design method for system development. At present, there are four main control modes at home and abroad, namely single PC control mode, PC+PC control mode, PC+ multi-controller control mode and PC+DSP motion control card mode. In this paper, four control modes are studied in depth and compared. Finally, in the above four control modes, the PC+DSP motion control card mode has the advantages of high speed, good compatibility, integration, etc. The control mode is better than the other mode. Moreover, the PC+DSP motion control card mode is the main development trend of the future robot control mode. Therefore, this paper finally chooses to use PC+DSP motion control card mode for industrial automation robot control system design.

4.2 System overall structural design

The control system designed in this paper mainly has two schemes for the assignment of control tasks. The first is to complete human-computer interaction on the PC side, and the motion control card controls and calculates the interpolation algorithm of the core. This solution greatly reduces the real-time performance requirements of the PC. PCs can run in common operating systems, and human-computer interaction interfaces can also be developed in a more relaxed environment. The disadvantage of this scheme is that the interpolation algorithm of the motion control card is performed in real time, so the workload is heavy, and the complexity of the overall system becomes high. In general, this structurally designed system is primarily used on experimental machines.

The second option is that the system's interpolation algorithm and core control are all operated on an industrial PC. The main task of the motion control card is to complete the exchange of analog signals or actual pulses with a given digital quantity. Compared with the first scheme described above, this scheme simplifies the system hardware design work. Moreover, the openness of the system is relatively high. As long as the software platform for exchange is mature, it can be easily implanted into other control systems. Therefore, through the actual comparison, this paper finally decided to adopt the second system structure design.

4.3 Control system electrical design

According to the different electrical configuration, the circuit design of the control system can be divided into three parts, namely the servo connection circuit, the internal circuit of the servo system and the peripheral circuit. Among them, the research focus of the electrical design in the design of the control system lies in the design of the servo connection circuit, which mainly includes the servo communication circuit, the wiring diagram of the driver and the controller, and the power supply circuit. The main circuit is contacted by the five terminals of the driver and connected to the reactor. The servo driver's power supply voltage selection range is 12-24V. The motion controller is primarily connected to the drive via six ports. Finally, in order to ensure the smooth operation of industrial automation robots, it is necessary to connect the various servo drives to realize their communication and data transmission.

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