Design of auto disturbance rejection control system for pneumatic manipulator based on PLC Technology

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Abstract. Aiming at the coupling effect between joints of two degree of freedom pneumatic mechanism in reciprocating motion, and the reciprocating motion problem caused by the imprecision and jitter of dynamic model in high-speed motion, an auto disturbance rejection control system of Pneumatic Manipulator Based on PLC technology is designed, and the parameter model of flexible joint manipulator system is established, and the cubic spline interpolation is optimized by PLC technology, The effective control mode of operation space is realized. The correctness and stability of the active disturbance rejection control system of Pneumatic Manipulator Based on PLC technology are verified by simulation experiment.

1. Introduction

The control strategy of omega-3 manipulator is studied by using traditional algorithm. Based on the coupling variable structure control strategy of mechanical joints, an active disturbance rejection control system of Pneumatic Manipulator Based on PLC technology is proposed[1]. Considering the uncertainty and disturbance of the system model and the influence of the fast motion speed on the tracking accuracy, the position tracking error is reduced. In order to solve the problem of trajectory tracking accuracy caused by uncertain parameters of two degree of freedom planar translational manipulator, the influence of PLC adaptive synchronous control strategy on trajectory tracking accuracy of pneumatic manipulator and accurate identification of dynamic characteristics of high acceleration system are adopted to optimize the control strategy of pneumatic manipulator[2-3]. Due to the high speed, fast response and large overshoot of the system, it is necessary to improve the traditional control strategy to solve the contradiction between fast response and overshoot.

2. Active disturbance rejection control system for pneumatic manipulator

2.1. hardware configuration of active disturbance rejection control system for manipulator

The hardware configuration of active disturbance rejection control system of manipulator mainly includes three aspects: key control circuit, global PID disturbance rejection controller and multi joint disturbance rejection controller[4]. The core control circuit of the system is tension acquisition and controller acquisition. Taking STM32 single chip microcomputer as the core, the tension acquisition experimental circuit is set. When STM32 MCU starts to work on the hardware execution equipment, it filters and amplifies the anti-interference differential signal of the file scanning manipulator, and then
uses LM324 operational amplifier chip to convert the differential signal into single ended signal. The rated supply voltage range of STM32 single chip is 1.0 ~ 15 V, and that of LM324 operational amplifier is 0 ~ 3.3 v. The resistance loss of the whole sub circuit is not negative[5]. Its acquisition sub circuit takes ad8476 clock chip as the core, and uses tension collector sub circuit to intercept and convert single ended signal[6]. The basic structure of the key control circuit is as follows.

![System control circuit structure diagram](image1)

**Fig. 1** system control circuit structure diagram

The control circuit board of the lower computer is composed of AT89C51 single chip microcomputer, servo input and output interface circuit and level conversion circuit. The server is responsible for communicating with the upper computer controller, processing the control instructions sent, so as to obtain the corresponding pulse signal and complete the remote control operation[7-8]. The hardware structure block diagram of pneumatic manipulator control system is shown in Fig. 2. The main panel includes motor and driver, DSP28335 main panel, servo motor, absolute encoder decoding circuit, etc.

![Hardware structure block diagram of control system](image2)

**Fig. 2** hardware structure block diagram of control system

The main control chip DSP28335 is responsible for the calculation of the control quantity of the manipulator and the acquisition of the motor current signal, mainly including program storage, data storage, DAC conversion of output control quantity, ADC converter motor torque detection, JTAG interface, etc[9-10]. The control algorithm of DSP28335 is designed, the optimal trajectory is planned, and the location look-up table is given. Its function is to convert the voltage signal output from 3 V + 3 V to 0-3 V, which is convenient for DSP to sample at a / D port.

### 2.2. Realization of active disturbance rejection control for manipulator

According to the design standard, ensure that the whole mechanical transmission system works normally on the machine tool, and the measurement deviation between the gear and the center wheelbase is 0.1-0.2 mm. Therefore, in order to reduce the error caused by various mechanical parts, it is necessary to realize the accurate positioning of the equipment. The specific steps are as follows: set the transmission ratio of the servo mechanical driver to make the pulse match the precise position of
the operation. The length of the manipulator is $l$, the distance between the gear and the central axis is $t$, and the allowable rotation error of the whole machine is:

$$\alpha = \frac{t}{T(\tau + \theta')}$$  \hspace{1cm} (1)$$

The feedback control must be used to overcome the influence between the machines and achieve accurate positioning. Through the combination of sensor and response time, the pulse vector $f_0$ is used to determine the motor running speed as shown below.

$$V = \frac{T \times f_0}{s + \alpha}$$  \hspace{1cm} (2)$$

In the process of self reaching precise positioning, the combination of sensor and response time is used to determine the motor operation. The details are as follows.

As shown in the figure, it can be seen that when the manipulator control system is initially started, it is necessary to set the parameters of loading and unloading of the device, check whether all mechanisms are in place, whether the power supply has been powered on, and the secret language of each operation room. Once the effect is ignored, the manipulator control system alarm indicator lights up, and the manipulator control system automatically cuts off the power supply and stops running. Through serial communication subroutine and motor speed control subroutine, the working state of servo driver in all directions of manipulator can be realized. The chart shows the process design that can control the system.
3. Analysis of experimental results

The experimental platform of manipulator control system is established, and its effectiveness is verified by experiments, and the experimental results are analyzed combined with the simulation results in previous chapters. The system uses sgmah-08ala4c motor as driving circuit, Sichuan e-ii as driving circuit, tsn21domokawa absolute 17 bit photoelectric encoder as joint position feedback encoder, and seedudec28335 development board of CUHK as the main control chip to verify the control algorithm of the system. In addition, the initial position of a given manipulator joint is 0, that is, day = 0, norm = 0. At the same time, the maximum output electromagnetic torque is 2.39 n, so 100:1 harmonic reducer is used to make the control torque output tend to saturation. The control algorithm software follows the design idea of modular programming, divides it into several independent modules according to its function, and writes independent source file program according to each module, and compiles and links throughout the whole project. It mainly includes main program, initialization program, interrupt service subroutine and operation control program. AC permanent magnet synchronous motor is a two-stage motor in a two degree of freedom manipulator. The technical parameters of its driving motor are as follows:

| Serial number | performance       | performance parameter |
|---------------|-------------------|-----------------------|
| 1             | Motor model       | SGMAMH-08A1A4C2       |
| 2             | Rated torque      | 2.39N.m               |
| 3             | Rated output power| 0.75KW                |
| 4             | Rated speed       | 3000rpm               |
| 5             | Rated angular acceleration | 84.8kW/s       |
6. Rated power change rate 35500 rad/s²
7. Rated current 4.4A
8. Instantaneous maximum torque 7.16N.m
9. Instantaneous maximum current 13.4A
10. Maximum speed 5000rap
11. Torque parameters rotor inertia 0.590N.m/A
12. Brake moment of inertia 0.14*10⁻⁶kg*m²

Use 17 lines of TS when shutting down 5668n021 encoder, namely 360 code. It is divided into 6536 values. Seed of Zhongda company is adopted. The main control DSP chip is developed by dec28335 DSP. Sgdm-08ada motor and driving mode are adopted. The photoelectric encoder decoding circuit of the robot arm joint position adopts the decoding circuit board purchased by Beijing Hekou Dingtian Technology Co., Ltd. the decoding circuit board adopts special decoding chip, FPGA memory update, and data exchange with DSP controller development board.

Fig. 5 detection structure of comparative experiment

Compared with the traditional method, it can be seen that the torque feedforward compensation algorithm based on dynamics can significantly improve the tracking accuracy of the end position and space speed of the high-speed mobile arm. However, compared with the control algorithm simulated by PLC, the tracking accuracy and spatial speed of the manipulator are significantly improved because of the independent absolute encoder installed after vibration reduction, The anti-jamming ability of the manipulator is improved and its tracking performance is improved.

4. Conclusion
The state equation is derived from the dynamic equation of pneumatic mechanism, and the nonlinearity of the system is represented by additional parameters and coupling parameters. The adaptive algorithm is used to identify the coupling parameters online, and the nonlinear controller is designed according to the active disturbance rejection control algorithm. The experimental results show that, compared with the traditional control algorithm, this algorithm can effectively reduce the joint overshoot and improve the precision of joint position tracking. The improved ADRC method solves the problems of fast response and overshoot of high-speed pneumatic arm, and improves the dynamic response of the system.

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