

Design and Simulation of Construction Machinery System Based on Fuzzy Pid Control

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Abstract: in the Continuous Process of China's Modernization, Construction Machinery Has Always Played an Important Role. One of the Effective Measures to Improve the Technical Performance of Construction Machinery is to Increase the Utilization of Computer Technology and Control Technology. with the Characteristics of High Stability, Simple Operation and Strong Reliability, Pid Technology is Widely Used in the Current Construction Machinery Control System. However, Due to the Lack of on-Line Parameter Setting Function of Conventional Pid Controller, When the System Error is Large, the Control Effect is Not Good. in View of This, This Paper Uses the Fuzzy Pid Control Program to Simulate, and Compares with the Conventional Pid, and Finds That the Fuzzy Pid Control Has Stronger Fault Tolerance and More Stable Control Performance.

1. Introduction

1.1 Literature Review

The theory of PID control technology has been put forward for nearly a hundred years. It is easy to master, simple in structure and no need to create accurate mathematical model. It has been widely used in all walks of life. Han Pei et al. Take the two-dimensional servo turntable system as the research object, in the MATLAB environment, designed the fuzzy PID controller, and compared it with the conventional PID controller (Han et al, 2012). Xiao Yanjun and others analyzed the characteristics of the controlled object of roots power machine, established the scientific model of the control system, added the fuzzy control algorithm, and proposed the use of fuzzy adaptive PID control algorithm, which can eliminate the interference of steam and achieve good control effect (Xiao et al, 2018). Zhang Guodong and Qi Ruimin analyzed the shortcomings of traditional control system of BLDCM, such as low precision and poor stability. Based on MATLAB, a fuzzy PID control system of BLDCM was designed and a mathematical model was established. In terms of stability, steady-state accuracy and rapidity, it compares and analyzes the differences between fuzzy PID control system and traditional PID control system (Zhang and Qi, 2018). Sun Yuhan and others analyzed the design principle of the fuzzy PID controller, simulated the second-order system control with Matlab / Simulink, and proposed that the fuzzy PID control technology can effectively improve the dynamic performance of the control system (Sun et al, 2015). Wang Xiaowei and Zhang Lixiang analyzed the problem that a large amount of electric energy was wasted due to the constant belt speed of the belt conveyor in the coal preparation plant. The radial basis function neural network was used to create the network model, and the high precision and strong adaptability of fuzzy PID was proposed to achieve good energy saving effect (Wang and Zhang, 2015).

1.2 Purpose of Research

One of the ways to improve the technical performance of construction machinery is to use modern electronic technology, sensor technology, control technology and computer technology to complete its intelligent control and automatic control. PID technology is widely used in engineering control because of its simplicity, high reliability and good stability. However, the conventional PID controller does not have the function of on-line parameter adjustment. When the system error changes greatly, it is difficult to automatically adjust the control, which hinders the further

improvement of the control effect. For the remote service system and intelligent subproject of a specific project, the common PID algorithm is usually used to control the mechanical trajectory. Because the construction machinery operation is easy to be affected by uncertain factors, it can not complete the automatic adjustment of online parameters, which limits its scope of application and control ability. Therefore, in order to solve these problems and analyze the preliminary work of the project, it is of great significance to design and simulate the construction machinery system on the basis of fuzzy PID control.

2. Theoretical Overview

PID control is a common feedback loop in industrial control application, which is mainly composed of P (proportional unit), I (integral unit) and D (differential unit). Among them, except for special cases, the integral control unit can stably eliminate errors, while the proportional unit is the basis for controlling the entire operating system. The differential unit can control the response speed of the inertial system and the weakening trend of the adjustment in the operation practice (Xu and Lu, 2014). PID control has the characteristics of simple structure and principle, convenient operation and adjustment, reliable operation and strong adaptability. But compared with other operating systems, it has the disadvantages of intermittent accuracy, poor interference ability and so on. Therefore, on the basis of PID control, relevant personnel use fuzzy logic and carry out real-time optimization according to the parameter data accumulated by PID under fuzzy rules, so as to overcome the shortcoming that traditional PID parameters can not adjust the PID parameter data in real time, and then study the short name of fuzzy adaptive PID control (fuzzy PID control). Fuzzy PID is mainly composed of determining fuzzy rules (Fig. 1), structure fuzziness, solution fuzziness and other structural parts. In the data analysis and parameter arrangement, fuzzy adaptive PID control can be based on the original algorithm, through the input error rate of change EC and error E, and use fuzzy rules to infer parameters, find the corresponding matrix and analyze. According to the analysis results, it can meet the requirements of EC and E in different stages for automatic adjustment of PID parameters (Luo et al, 2013).

<i>U</i>	<i>EC</i>						
	NB	NM	NS	ZO	PS	PM	PB
NB	PB	PB	PB	PB	PM	ZO	ZO
NM	PB	PB	PB	PM	PM	ZO	ZO
NS	PB	PM	PM	PS	ZO	NS	NM
<i>E</i> ZO	PM	PM	PS	ZO	NS	NM	NM
PS	PS	PS	ZO	NM	NM	NM	NB
PM	ZO	ZO	ZO	NM	NB	NB	NB
PB	ZO	NS	NB	NB	NB	NB	NB

Fig.1 Fuzzy Rule Table

For example: using FIS window to create a mamdani fuzzy controller, which contains three outputs (KP, Ki, KD) and two inputs (E, EC). The input (E, EC) domain value is set to (- 6,6), the output (KP, Ki, KD) fuzzy logic is set to (- 3,3), and the language values in the domain are divided into negative large (NB), negative medium (nm), negative small (NS), zero value (Zo), positive small (PS), positive medium (PM) and positive large (PB), so that all input and output variables are trinf, and then build Fuzzy model adaptive PID simulation model and get the simulation results.

In non special cases, the data can be made statistics according to the simulation results. In the three-stage linear system control, the method of stable boundary is used to sort out the parameters. In the aspect of overshoot, the traditional PID control is larger than the fuzzy PID control, but the steady-state error exists in the fuzzy PID control. Therefore, the fuzzy PID control uses the dynamic characteristics from the fuzzy set and the concept description to make the control decision according to the fuzzy logic of the fuzzy adaptive PID, which can solve the complex control

problems in the traditional PID system and adapt to the operating environment dynamically.

3. Design and Simulation Based on Fuzzy Pid Controller

3.1 Fuzzy Pid Control Rules

The factors that affect the fuzzy PID control system mainly include overshoot, stability, steady-state accuracy and response speed. KP in PID parameters is the proportional adjustment coefficient, which can reflect the system response speed, error reduction and accuracy adjustment. When the KP value changes, the regulation accuracy will decrease, which will slow down the response speed of the system, resulting in a longer regulation time and a worse dynamic and static characteristics of the system. When the KP value increases, the response speed of the system becomes faster and the regulation accuracy increases, but it is easy to exceed the regulation or the system is unstable. Ki is an integral regulation system, which can eliminate the steady-state error of the system. When ki is small, it is difficult to eliminate the static error of the system, which affects the accuracy adjustment of the system. When ki is large, the speed of error elimination will be increased, but the integral saturation phenomenon will appear when ki is too large, resulting in the response larger than the regulation degree. KD is the differential adjustment coefficient, whose main function is to predict the deviation direction and correct it in advance. When KD is large, it will lead to response braking in advance, regulation time is longer, and anti-interference performance is reduced.

3.2 Pid Controller

The following is mainly based on a channel control system as the research formation. PID controller is selected to open the gate smoothly. When the gate reaches the final opening value for the first time, the fuzzy controller is used to fine tune and shorten the adjustment time. Therefore, the conversion between fuzzy controller and PID controller is determined by the time threshold set in advance. The PID controller is divided into differential, proportional and integral parts, which are added to the P + PR controller. The relationship between the differential control function and the input conversion rate is as follows:

$$G_d = K_d \cdot (d(YT - YF) / dt)$$

In the formula, Gd represents the gate opening; YT and YF represent the target water level and actual water level respectively; KP represents the proportion coefficient.

It can be seen from the above formula that the differential control function is proportional to the input conversion rate. Before the error of differential function increases, an obvious correction signal will appear. If another coefficient is added to differential control, it will become a more sensitive controller.

3.3 Design and Simulation of Fuzzy Controller

The fuzzy editor can manage some advanced system attributes, such as system output and input variable names and quantities. Fuzzy inference rules can edit rule list and define system behavior. The fuzzy observer is a graphic display based on MATLAB, which can show the effect of rules and how the change of independent shape affects the result. The output characteristic surface graph can be generated by the fuzzy observer and show how any input changes an output result. The process of building an effective fuzzy system is complex. It needs to modify the parameters repeatedly according to the simulation results and requirements, so that the function can present the fuzzy rules effectively. Because there are many membership functions, the function can only be determined by comparison and trial calculation for many times, which is affected by the designer's knowledge and rich design experience to a certain extent. When designing the fuzzy controller, we must focus on the value of time threshold. The parameters of PID controller, fuzzy inference system and time threshold affect each other. When the matching degree is high, the control effect is better.

4. Simulation Experiment and Result Analysis

In the process of fuzzy PID simulation experiment, it is found that the fuzzy logic toolbox of MATLAB provides the connection function for smulink. When users carry out fuzzy logic work, they first create a fuzzy reasoning system, then add logic reasoning to smulink simulation environment, and finally analyze the results (as shown in Figure 2). In addition, it has been proved that there should be a corresponding fuzzy logic control system in smulink, that is, fuzzy logic block, which copies the fuzzy logic module to the smulink simulation framework system established by the user. In this process, the consistency of the name should be consistent with the name of the fuzzy reasoning system established by the user in the MATLAB workspace.

The simulation results of the fuzzy PID control system are compared with those of the P + PR controller. The results are shown in Figure 2. From the output curve of fuzzy PID and common PID control, it can be concluded that in response speed, they are basically the same, while in overshoot and stability time, fuzzy PID adaptive control is better than traditional PID control. This shows that the fuzzy PID control based on the traditional PID control realizes the upgrading of the original system's comprehensive function and improves the feasibility of PID control. In addition, the system delay is removed from the curve change and the control curve is observed. It is found that even in the state of system delay, fuzzy PID control has more functional advantages in engineering control.

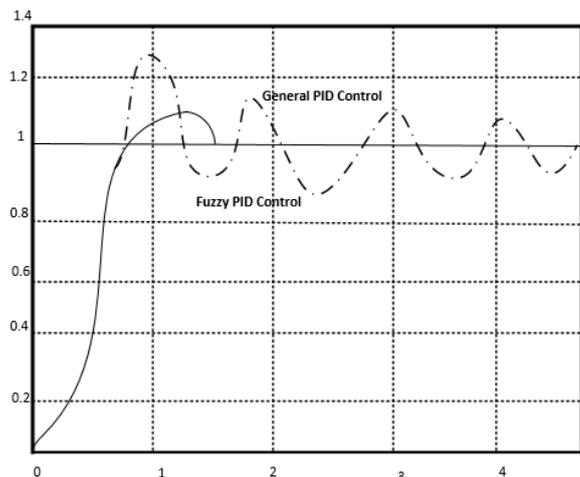


Fig.2 Comparison between General Pid and Fuzzy Pid

5. Conclusion

In this paper, the theory of general PID control and fuzzy PID control are summarized firstly. It is pointed out that PID control is a common feedback loop in the application of industrial control. It is mainly composed of three parts: P (proportional unit), I (integral unit) and D (differential unit). A kind of fuzzy controller is designed by using matlab fuzzy logic module toolbox and simulated by Simulink. Three parameters K_P , K_I and K_D of fuzzy PID control can be obtained by inputting E and EC. The results show that the fuzzy PID control improves the overall performance of the system and has the function of data dynamic tracking and monitoring. These data obtained under the fuzzy PID control system point out the shortcomings of the common PID control in the design of the construction machinery system, at the same time, it also lays a good foundation for the next improvement of the fuzzy PID control.

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