Mobile satellite antenna azimuth control system

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Abstract. In this paper, the control system of the mobile satellite antenna azimuth is studied, and the control scheme of the Smith fuzzy PID controller is proposed. The Smith - fuzzy PID controller has the characteristics of adaptive parameter adjustment, and has better adaptability to the change of the controlled object model and the external interference. Through the Simulink simulation analysis, it is proved that the Smith fuzzy PID controller has better control effect than the classical PID controller.

Introduction

With the need of modern life, mobile satellite antenna is becoming a popular development direction. How to realize the automatic of the satellite antenna is a hot research field. In the control system of mobile satellite antenna, the traditional PID controller plays a huge role in the field of civil, military and industrial production, but it also has a lot of limitations. The fuzzy PID controller is a new control strategy in recent years. It has good control effect on complex control system and high precision servo system. The Smith fuzzy PID controller based on the fuzzy PID can better eliminate the delay in the system, and achieve a more rapid adjustment effect.

Design of mobile satellite antenna controller

The mobile satellite antenna control system is a complex controlled object with large inertia and time varying uncertainty. It is difficult to be controlled accurately by conventional PID control. If the fuzzy controller and PID controller are combined together, it can be a good solution to the above problem.

Fuzzy PID controller design

By adopting the method of PID parameter fuzzy setting, adjusting the PID parameters according to the different state of the carrier and operation condition, the system adapts to the change of the parameters of the controlled object. The principle is shown in Figure 1.

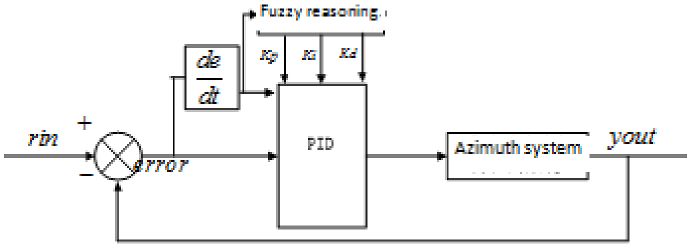

Fig.1 Block diagram of fuzzy PID control

Basic principle of Smith fuzzy PID controller

The combination of Smith predictor and fuzzy PID control system can effectively reduce the strict requirements of the Smith predictor for the controlled object model. The establishment of the Smith fuzzy PID controller is shown in Figure 2.

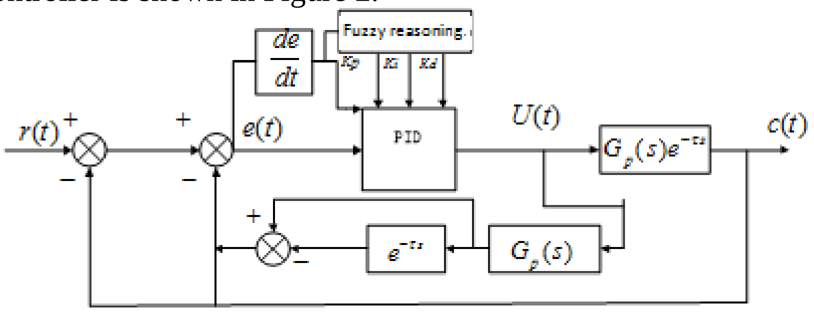

Fig.2 Smith fuzzy PID controller block diagram

Simulation of mobile satellite antenna control system

Simulation of the traditional PID controller

In Simulink, the PID control system block diagram is set up as shown in Figure 3.

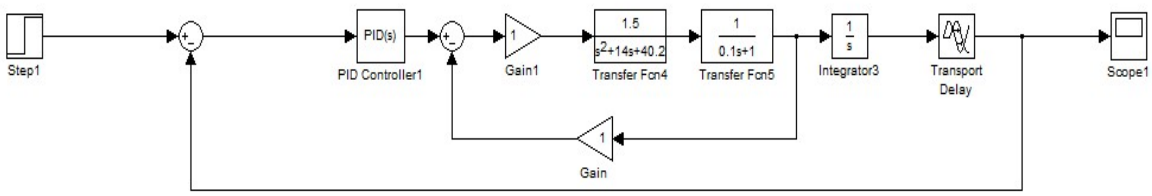

Fig.3 PID control system simulation

The PID parameters are determined by using the critical ratio method. The best simulation curve can be made when K_p=22, K_i=0.01, K_d=9 .However, the traditional PID controller can not achieve the specific requirements of the mobile satellite antenna azimuth control system when controlling the nonlinear time varying system and the large time delay model.

Comparison of simulation results

The establishment of the fuzzy PID controller control system as shown in Figure 4.

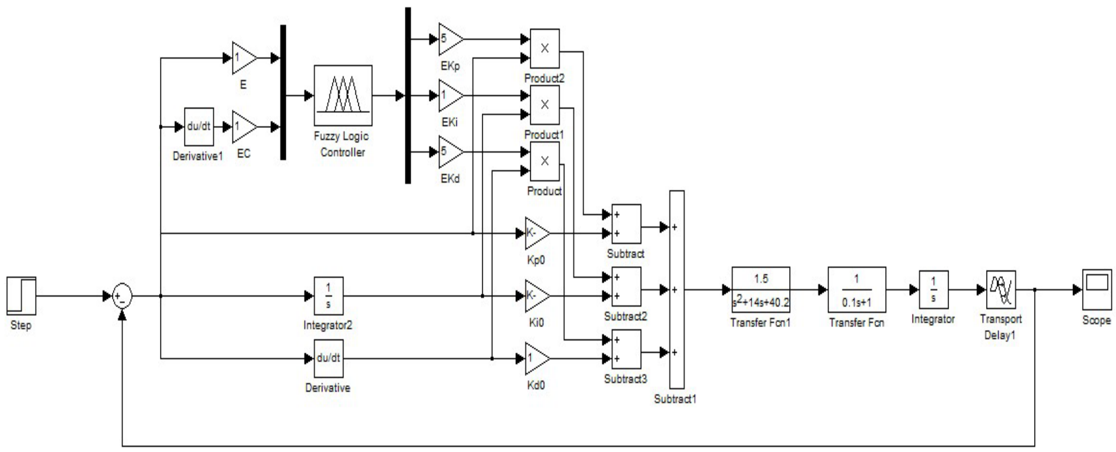

Fig.4 Control system simulation diagram with fuzzy PID controller

A step signal is given, and the resulting control curves are drawn together with the control curves obtained by using the PID controller, as shown in Figure 5.

Can be seen from figure 5, the rise time of the fuzzy PID controller is obviously shorter than that of the ordinary PID controller, and the overshoot is reduced by 2.2%, the shock was significantly reduced, and the time of stabilization was shorter.

In order to further reduce the effect of system delay, the Smith fuzzy PID controller is built on the basis of the fuzzy PID controller. Compensation of the time delay in the system by using the Smith predictor . According to the design of the Smith - fuzzy PID control system structure diagram, a control system simulation model is established, which is shown in Figure 6.

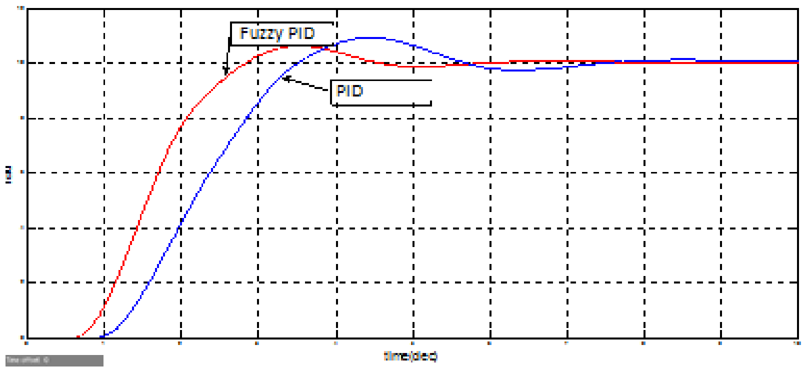

Fig.5 Simulation results of fuzzy PID controller

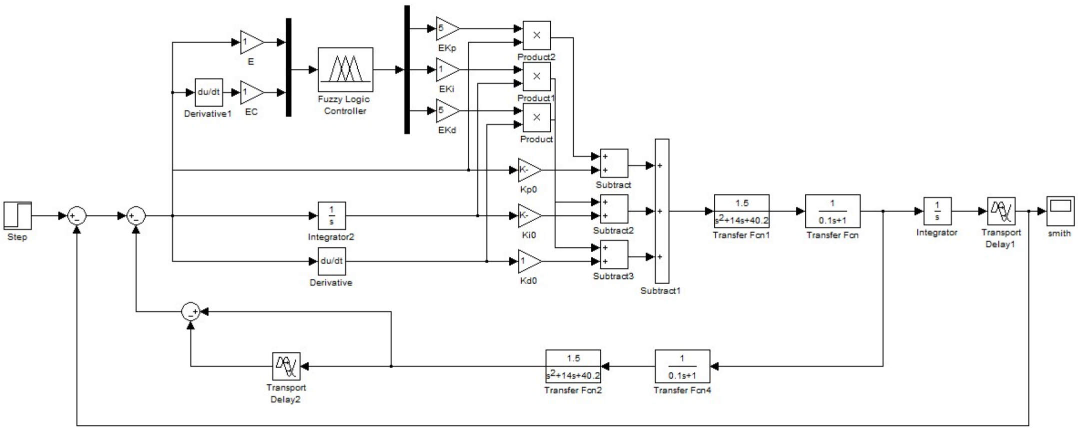

Fig.6 Smith fuzzy PID control system simulation block diagram

Give the system a step signal, and draw two kinds of control curves before and after the addition of the Smith predictor, as shown in figure 7.

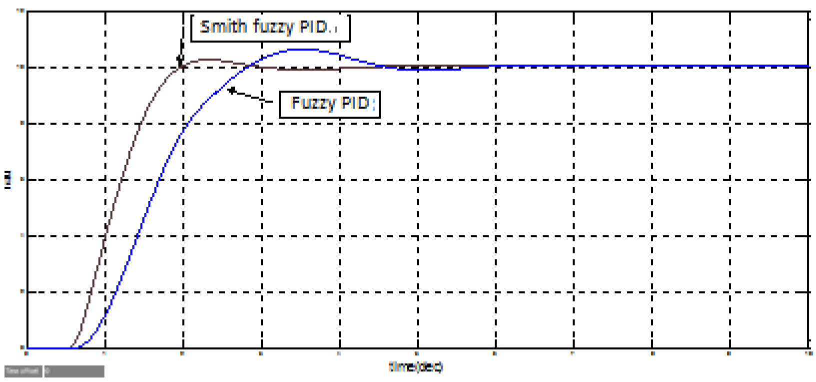

Fig.7 Simulation results of Smith fuzzy PID controller

	Peak time (s)	Overshoot (%)	Rise time (s)	Adjustment time (s)
Traditional PID	4.26	8.62	3.48	5.35
Fuzzy PID	3.5	6.4	2.82	3.92
Smith-fuzzy PID	2.4	4.85	1.83	1.78

Table1 Comparative analysis of traditional PID, fuzzy PID and Smith fuzzy PID control curves

We can get the contrast data in table1 by using the M function. Through the data shown in the table1, we can see that the control effect of the Smith fuzzy PID controller is more obvious than that of the traditional PID for the mobile satellite antenna azimuth control system. It has a good compensation effect for the time delay of the system. Regulation time can also meet the requirements of the system.

Smith fuzzy PID controller with disturbance

When the vehicle equipped with on-board satellite will have a large vibration when the road surface is rough, the servo control system of the antenna has formed a challenge. The system is robust to the disturbance of vibration, and is a key indicator to evaluate a system.

Before the control object, 20% of the perturbation is introduced, the duration is 6S to 8s, observe the response curve of the Smith fuzzy PID control system, and compare it with the traditional PID control system, as shown in Figure 8.

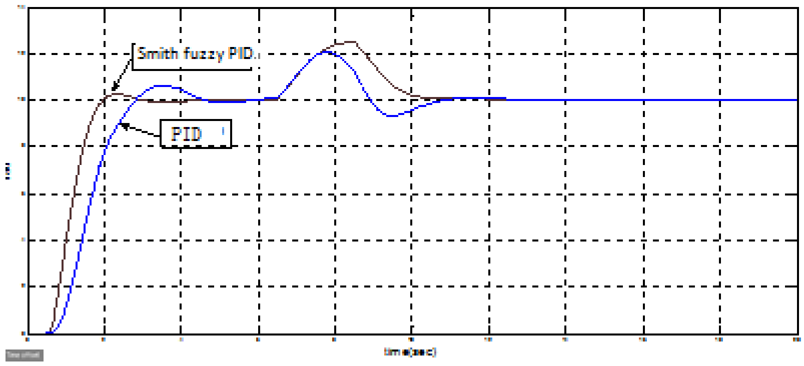

Fig.8 Comparison of two control curves under step disturbance

Can be seen from the diagram, after sixth seconds to join the 20% step disturbance, Smith - fuzzy PID can quickly control the azimuth angle, and adjust the angle back to the stable state after the disturbance disappears. However, the classical PID is not adjusted to the appropriate angle before the perturbation is gone, and the system has a shock after the disturbance is gone. Compared with the classical PID, the Smith - fuzzy PID controller shows better robustness.

When the car is driving on the highway, the road is relatively stable, and the speed is relatively high, at this time, the interference of wind speed is the main factor. When the carrier movement speed reaches a certain value, the antenna surface will be affected by the surface pressure from the air .this pressure is proportional to the speed of the carrier. Under this pressure, the torque of the servo system is changed, and the model parameters of the whole mobile satellite antenna will be changed.

The carrier is subjected to a surface pressure is F .

$$F = \rho s v \sin\theta \cos\theta \tag{1}$$

In this formula, it is assumed that the ρ, s and θ are kept constant. When the speed of the carrier is changed, the pressure of the antenna surface is equivalent to the moment of inertia of the servo motor. So the servo motor transfer function has changed, and the transfer function can be expressed as (2).

$$G(s) = \frac{2.5}{0.2s^3 + 4s^2 + 23.84s + 44.2} \quad (2)$$

The simulation results are shown in Figure 9.

As can be seen from the picture, the classic PID at this time produced a violent shock, the amount reached 25%. And Smith fuzzy PID for the system model of the change, the amount of excess capacity remained at around 11%, showing a better adaptive performance. In the control of the Smith fuzzy PID controller, the mobile satellite antenna azimuth control system has stronger robustness to the strong wind.

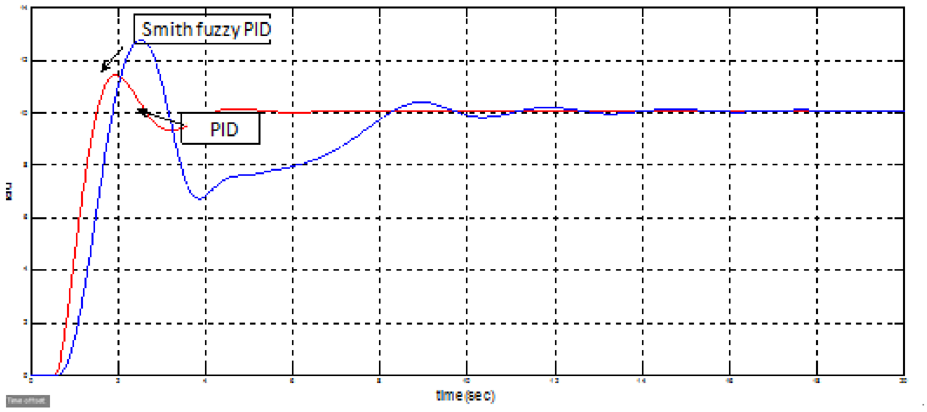

Fig.9 Comparison of two controllers under wind disturbance

Conclusions

In this paper, the performance index and robustness under interference of the two aspects of the Smith - fuzzy PID and the classic PID were compared. which shows that the nonlinear time delay system of the position angle control system of the mobile satellite is very good. And because the parameters of the controller can be adjusted according to the change of the controlled object transfer function, it can be used to solve the problem of the mobile satellite antenna azimuth control system.

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