

Simulation Realization of Sliding Mode Control for Second Order System with M Language

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Abstract. Aiming at a class of two order systems with single input and non minimum phase, a sliding mode control method is used to design the controller. And the problem of using Matlab software M language programming is studied. Finally, the simulation results show that the design of the controller and the programming is reasonable.

Introduction

In 1950s , the Soviet Union scholars put forward the sliding mode variable structure control, which originated from the relay control. The main difference between it and the conventional control method is that the control of the discontinuity. This control method has experienced 50 years of development, and gradually formed a relatively independent branch, becoming a common design method of automatic control system. The difference between this control method and other control methods lies in that the structure of the system is not fixed. It uses a special kind of control mode, forcing the state of the system to slide down to the desired point along the trajectory of the sliding surface. Sliding mode control has good control performance for nonlinear system, and can be applied to multi input and multi output system. When the system is in the sliding model, the model error and parameter changes of controlled object as well as external interference are not very sensitive. What's more, the physical realization is relatively simple and easy so as to provide a better solution for the control of complex industrial. The main obstacle of this method in the practical application is that when the state trajectories reach the sliding surface which is determined by the mode, it is difficult to move strictly along the reserved sliding mode to the equilibrium point, but slide back and forth across the both sides closer to it, resulting in buffeting.

Model Description

The research object of this paper , that is the controlled object, is selected as the following two order system model:

$$\dot{x}_1 = 5x_1 + 4x_2 \quad (1)$$

$$\dot{x}_2 = 7x_2 - 9x_1 + u \quad (2)$$

By designing the control law u to realize the control goal of the state tracking, that is to achieve $x_i \rightarrow x_i^d$, in which x_i^d is the expected value.

Controller Design

Define error variables as:

$$e = x_1 - x_1^d \quad (3)$$

The sliding mode surface is selected as the:

$$s = \dot{e} + 10e \quad (4)$$

The theoretical deduction is as follows:

If $s = 0$, then

$$\dot{e} = -10e \quad (5)$$

Known as

$$v = \frac{1}{2}s^2 \quad (6)$$

Then

$$\dot{v} \leq 0 \quad (7)$$

there must be $v \rightarrow 0, s \rightarrow 0$.

Taking the derivative of v , obtained:

$$\dot{v} = s\dot{s} \quad (8)$$

Taking the derivative of $e = x_1 - 1$, obtained:

$$\dot{e} = \dot{x}_1 = 5x_1 + 4x_2 \quad (9)$$

By the synovial surface $s = \dot{e} + 10e$, obtained:

$$\dot{s} = \ddot{e} + 10\dot{e} \quad (10)$$

in which,

$$\ddot{e} = \dot{x}_1 = 5(5x_1 + 4x_2) + 4(7x_2 - 9x_1 + u) \quad (11)$$

$$\dot{s} = 5(5x_1 + 4x_2) + 4(7x_2 - 9x_1) + 4u + 10(5x_1 + 4x_2) \quad (12)$$

We make the control

$$u = \frac{1}{4}[-\delta - 5s] \quad (13)$$

So,

$$\delta = 5(5x_1 + 4x_2) + 4(7x_2 - 9x_1) + 10(5x_1 + 4x_2) \quad (14)$$

Simulation Program

We design the time interval is 0.001s, the simulation time is 10s, the initial value is 0 and the expected value is 1. Then we make $x \rightarrow x^d$ through the program design and design the control quantity u to control the rudder deflection δ . The simulation program is as follows:

```
dt=0.001;tf=10;
xd=0;x1=0;x2=1;
u=0;
for i=1:tf/dt
t=i*dt;
dx1=5*x1+4*x2;
dx2=7*x2-9*x1+u;
e=x1-1;
de=5*x1+4*x2;
s=de+10*e;
delta=5*(5*x1+4*x2)+4*(7*x2-9*x1)+0*u+10*(5*x1+4*x2);
u=1/4*(-delta-5*s);
x1=x1+dx1*dt;x2=x2+dx2*dt;
sp(i)=s;
ep(i)=e;
tp(i)=t;
x1p(i)=x1;
end
figure(1)
plot(tp,sp);
figure(2)
plot(tp,ep);
```

```
figure(3)
plot(tp,x1p);
```

Simulation Result and Analysis

The simulation results which are obtained from the basic principle analysis realized by the above controller design and simulation program are as follows:

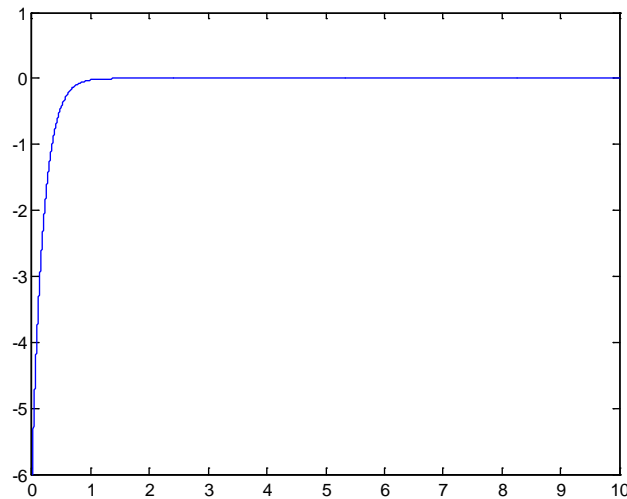


Fig. 1 PID control simulation

From the figure above, we can see that the design of sliding mode controller can make the reaching condition satisfied, thereby reaching the sliding surface in finite time. And in the process of reaching rapid, the system has small buffeting. Simulation through the MATLAB shows that adding the sliding mode in the control system can have a certain effect in reducing the oscillation for the rapid stability of the system.

Conclusions

In this paper, we study the design of the sliding mode controller for A class of two order linear systems with single input and non minimum phase. In particular, the chattering problem of sliding mode control is reduced by using the proportional terms instead of the traditional shear. Finally, the Matlab software M language is used to study the problem of its program implementation, and the corresponding analysis is carried out from the simulation results.

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