

Adaptive control effect analysis with parameters not totally identified

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Abstract: In view of the fact that the parameters can not be fully identified, which is frequently occurred in real adaptive parameter identification, this paper makes a deep analysis and studies the effect of the adaptive control law on the situation that parameter is not fully identified. In order to simplify the problem, this paper selects a class of first order systems with unknown parameters, the controller design and numerical simulation analysis are carried out by using the method of non adaptive control and adaptive control method, the results show that the adaptive control can replace the integral control, which can eliminate the steady-state error of the system.

1. Introduction

In 1980s, the development of differential geometry theory of nonlinear feedback control systems has stimulated the research interest of adaptive control for nonlinear systems. Although nonlinear differential geometry theory has many advantages, it is not long before people realize that it also has some disadvantages^[1-5]. One of them is that it can not deal with the unknown parameters in the system, which makes the emergence of the first class of adaptive nonlinear control strategy^[6-9]. After 30 years of development, adaptive control has made great progress both in theory and in application. But this year's research shows that the difficulty of parameter identification is often greater than the stability control of the system. This article is based on the above reasons, we want to reveal the role of adaptive control in the case that the system parameters can not be fully identified. This situation is very easy to happen in the practical application, so although the research of this paper is aimed at a kind of simple first order system, the result is very inspiring.

2. Problem description

One order system can be written as:

$$\dot{x} = a_1 x + a_2 \sin x + u \quad (\text{Eq.1})$$

where a is unknown constant parameter, the goal is designing a controller such that the system state x can trace the expected value x^d .

3. Design controller without adaptive control

First, define a error variable as $z_1 = x_1 - x_1^d$, then

$$\dot{z}_1 = \dot{x}_1 - \dot{x}_1^d = a_1 x + a_2 \sin x + u \quad (\text{Eq.2})$$

Design state feedback control law without using adaptive method as:

$$u = -\sum_{i=1}^n k_i f_i(z_1) \quad (\text{Eq.3})$$

choose $n = 5$,

$$f_1(z_1) = z_1, f_2(z_1) = z_1^3, f_3(z_1) = z_1^{1/3} \quad (\text{Eq.4})$$

$$f_4(z_1) = \frac{z_1}{|z_1| + \varepsilon}, \varepsilon = 0.2, \quad (\text{Eq.5})$$

$$f_5(z_1) = \frac{1 - e^{-\tau z_1}}{1 + e^{-\tau z_1}}, \tau = 0.5 \quad (\text{Eq.6})$$

where $f_3(z_1)$ is Terminal attractor, and $f_5(z_1)$ is Sigmoid function, $f_4(z_1)$ and $f_5(z_1)$ are both bounded, Obviously, $f_i(z_1)$ satisfies $z_1 f_i(z_1) \geq 0$, then

$$\dot{z}_1 = a_1 x + a_2 \sin x - \sum_{i=1}^n k_i f_i(z_1) \quad (\text{Eq.7})$$

Choose a Lyapunov function as

$$V = \frac{1}{2} z_1^2 \quad (\text{Eq.8})$$

Solve its derivative as

$$\dot{V} = z_1 \dot{z}_1 \quad (\text{Eq.9})$$

And it can be simplified as

$$\dot{V} = z_1 a_1 x + z_1 a_2 \sin x - \sum_{i=1}^n k_i z_1 f_i(z_1) \quad (\text{Eq.10})$$

If $|a_1 x + a_2 \sin x| \leq M_a$, then $|z_1| \leq M_b$, or

$$\dot{V} \leq 0 \quad (\text{Eq.11})$$

So according to Lyapunov theory we get $z_1 \rightarrow 0$.

4. Numerical simulation

Choose unknown parameter $a_1 = 3, a_2 = 5$, initial state $x_1(0) = -1$, expected state $x_1^d = 1$, use Simulink in Matlab, write program without improved integral adaptive identification controller, the program can be written as:

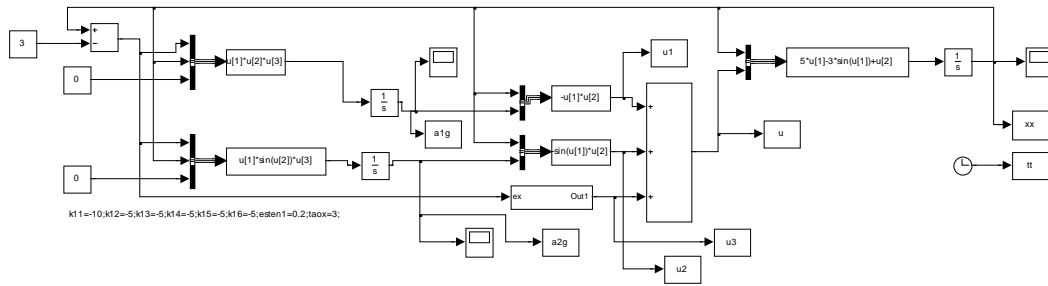


Fig.1 Program without improved integral

Choose $k_1 = 5$, $k_{s1} = \Gamma_a = 1$, the simulation results are as follows:

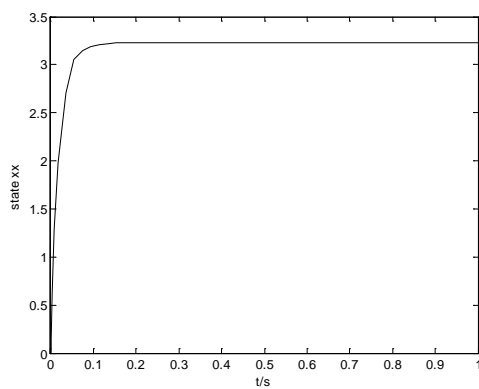


Fig.2 State x

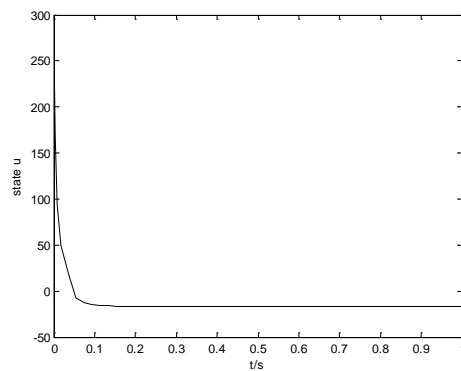


Fig.3 Control u

From the above simulation result, we can find that the system has steady state error, so a kind of integral adaptive control law can be adopt to reduce steady state error. Then the program can be revised as:

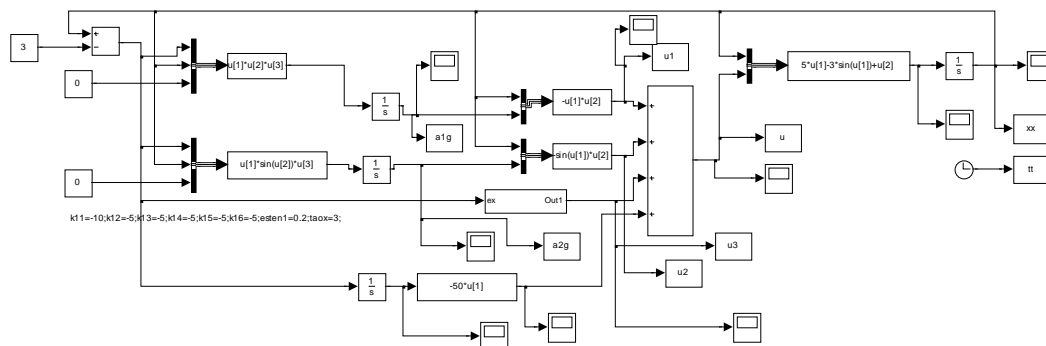


Fig.4 Program with adaptive item

Choose $k_2 = 1$, the simulation results are as follows:

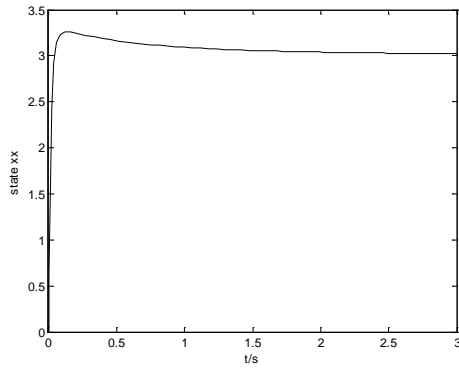


Fig.5 state x

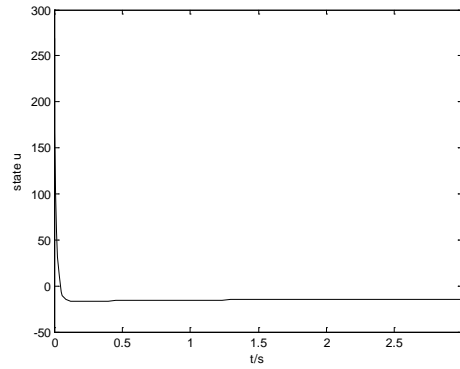


Fig.6 state x1

The unknown parameter can be identified. If the system don't use integral control, that is $k_{s1} = 0$, the simulation results are as follows:

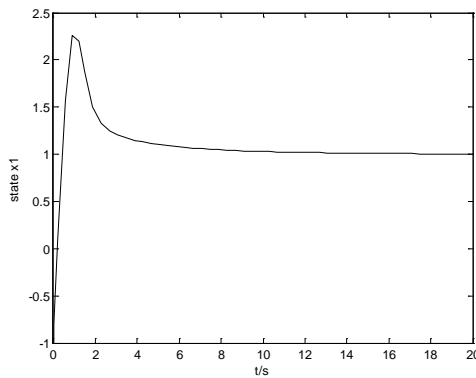


Fig.7 State x

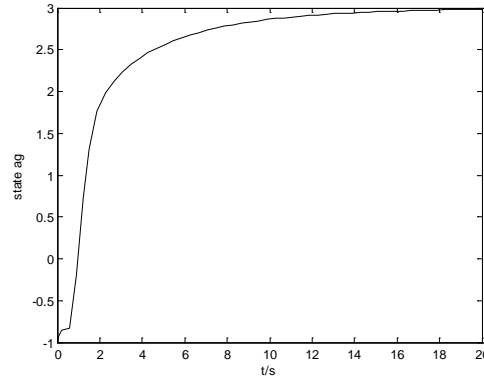


Fig.8 Control u

According to above simulation result, we can make a conclusion that the adaptive item can reduce the steady state error.

5. Conclusion

In this paper, the theory of adaptive control and non adaptive control for a class of simple systems with unknown parameters is analyzed, and the simulation results are compared and analyzed. The simulation results show that the adaptive control law can effectively eliminate the error of the system when the parameters are not accurately identified, and the adaptive control law can play the role of integral control.

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