# Adaptive Control And Single Parameter Identification Of One Order System

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**Abstract.** In order to achieve adaptive control and single parameter identification of one order system, an ordinary adaptive control method is used in this paper. Based on Terminal attractor and Sigmoid function, an adaptive control law is designed, and the result of parameter identification is analyzed. In the end, a conclusion can be made that theoretical analysis is correct and parameter identification method is effective by numerical simulation.

## Introduction

As the demand for control performance increases, the problem of time-variance parameters of controlled system is more and more important[1-4]. A lot of parameter identification method is proposed by specialists and representatives from China and abroad[5-7]. The single parameter identification is a kind of simple situation but it is still has some result that can be found when we research on it[8-11]. The classical parameter identification method is least square method[1], Kalman filtering method, adaptive. The method modern parameter identification method is neural network method[2], genetic algorithm method[3] and particle swarm optimization. But calculating amount of these method is large, instantaneity and astringency can't meet the demands of the control system. Based on Terminal attractor and Sigmoid function, an adaptive identification controller is proposed in this paper.

## Problem Description

One order system can be written as：

$$\dot{x} = ax + u \qquad \text{(Eq.1)}$$

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

## Design Adaptive Identification Controller

An ordinary adaptive control method is used as follows, define a error variable as $z_1 = x_1 - x_1^d$, then

$$\dot{z}_1 = \dot{x}_1 - \dot{x}_1^d = ax + u \qquad \text{(Eq.2)}$$

Design state feedback control law as:

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

where $n = 5$ ,

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

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

 

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

where $f_3(z_1)$ is Terminal attractor, and $f_5(z_1)$ is Sigmoid function, $f_4(z_1)$ and $f_5(z_1)$ both have boundedness, Obviously, $f_i(z_1)$ meet $z_1 f_i(z_1)\geq 0$, then

$$\dot{z}_1=\tilde{a}x-\sum_{i=1}^{n}k_i f_i(z_1) \qquad \text{(Eq.7)}$$

where the error variable $\tilde{a}$ can be defined as:

$$\tilde{a}=a-\hat{a}, \qquad \text{(Eq.8)}$$

design regulating law:

$$\dot{\hat{a}}=\Gamma z_1 x \qquad \text{(Eq.9)}$$

where $\hat{a}$ is unknown estimated parameter value, choose initial value $\hat{a}(0)=0$, then

$$\dot{\tilde{a}}=-\dot{\hat{a}} \qquad \text{(Eq.10)}$$

choose Lyapunov function:

$$V=\frac{1}{2}z_1^2+\frac{1}{2\Gamma}\tilde{a}^2 \qquad \text{(Eq.11)}$$

then

$$\dot{V}=z_1\dot{z}_1+\frac{1}{\Gamma}\tilde{a}\dot{\tilde{a}} \qquad \text{(Eq.12)}$$

then

$$\dot{V}=z_1\tilde{a}x-\sum_{i=1}^{n}k_i z_1 f_i(z_1)-\frac{1}{\Gamma}\tilde{a}\Gamma z_1 x=-\sum_{i=1}^{n}k_i z_1 f_i(z_1)\leq 0 \qquad \text{(Eq.13)}$$

So $z_1\to 0$.

## Parameter Identification Result Analysis

When $z_1\to 0$, where $u=-\hat{a}x$, then

$$\dot{z}_1=ax-\hat{a}x=\tilde{a}x \qquad \text{(Eq.14)}$$

So when $z_1\to 0$, where $\dot{z}_1\to 0$, $\dot{z}_1=ax-\hat{a}x=\tilde{a}x=0$, then $\dot{z}_1=ax-\hat{a}x=\tilde{a}x=0$, when $x\neq 0$, where $\tilde{a}\to 0$.

## Numerical Simulation

Choose $a=5$, $x_1^d=2$, program can be written as follows:

```
clc;clear;a=5;x1d=2;ag=0;x=0;u=0;tf=15;dt=0.001;
for i=1:tf/dt
    t=i*dt;     dx=a*x+u;     x=x+dx*dt;
    k1=5;k2=0.2;k3=1;k4=1;k5=1;esten=0.2;tao=0.5;
    z1=x-x1d;     f1=z1; f2=z1^3; f3=z1^(1/3);f4=z1/(abs(z1)+esten);
    f5=(1-exp(-tao*z1))/(1+exp(-tao*z1));
    ta=30;     dag=ta*x*z1;     ag=ag+dag*dt;
    u=-ag*x-k1*f1-k2*f2-k3*f3-k4*f4-k5*f5;
    tp(i)=t;xp(i)=x;agp(i)=ag;
end
figure(1);plot(tp,xp);xlabel('t/s');ylabel('state x');
figure(2);plot(tp,agp);xlabel('t/s');ylabel('state ag');
```

And the simulation results are as follows:

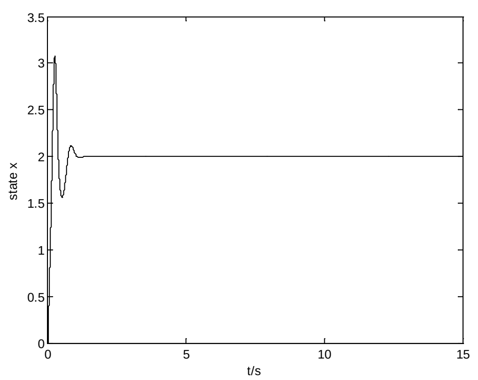


Fig.1 state x

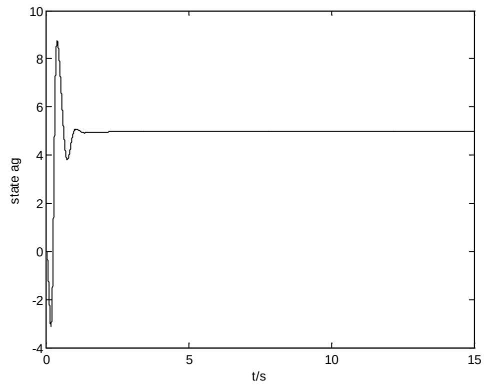


Fig.2 state a

From the simulation results, we can know that the unknown estimated parameter value is close to the actual value, and system state is also close to the expected value, these show that the method in this paper is effective and parameter identification result analysis is correct. But when control gain is not matched with identification gain, parameter identification will cost much time, so the program can be written as:

```
clc;clear;a=5;x1d=2;ag=0;x=0;u=0;tf=150;dt=0.001;
for i=1:tf/dt
    t=i*dt;     dx=a*x+u;     x=x+dx*dt;
    k1=5;k2=0.2;k3=1;k4=1;k5=1;esten=0.2;tao=0.5;
        k1=5;k2=5;k3=5;k4=5;k5=5;
    z1=x-x1d;     f1=z1; f2=z1^3; f3=z1^(1/3);f4=z1/(abs(z1)+esten);
    f5=(1-exp(-tao*z1))/(1+exp(-tao*z1));
    ta=0.1;     dag=ta*x*z1;     ag=ag+dag*dt;
    u=-ag*x-k1*f1-k2*f2-k3*f3-k4*f4-k5*f5;
    tp(i)=t;xp(i)=x;agp(i)=ag;
end
figure(1);plot(tp,xp,'k');xlabel('t/s');ylabel('state x');
figure(2);plot(tp,agp,'k');xlabel('t/s');ylabel('state ag');
```

And the simulation results are as follows:

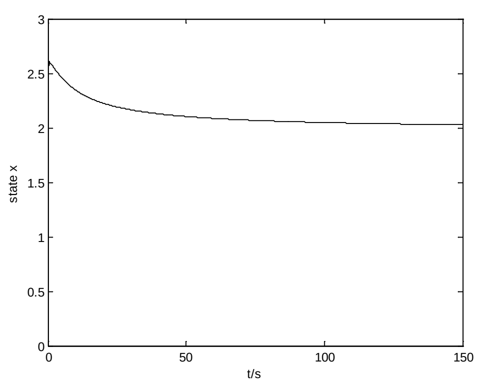


Fig.3 state x

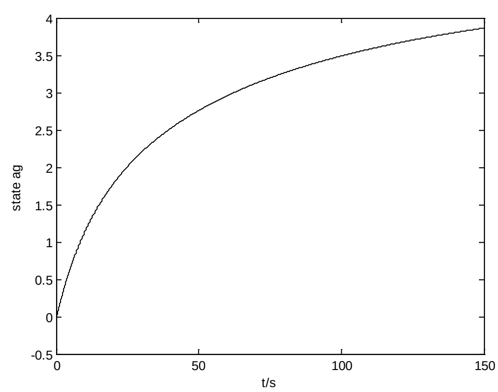


Fig.4 state ag

## Conclusion

By analysing theory and the simulation results, we can make a conclusion that the method of combining Terminal and Sigmoid function in this paper is effective to parameter identification. When the control gain is matched with identification gain, unknown parameter identification can success easily. But when the control gain is not matched with identification gain, the result is not ideal.

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