Time delay feedback control of chaos in a hyper chaotic finance system

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Abstract

In this paper, complex behavior of a four dimensional continuous autonomous hyperchaotic finance system is investigated. Also, this paper discusses the control of four dimensional continuous autonomous hyperchaotic finance system by using time delay feedback control technique. Based on the property of the time delay feedback control, the controller is designed and this controller is added to hyperchaotic finance system for achieving the control of the system. As a result, the control of four dimensional continuous autonomous hyperchaotic finance system is realized. To confirm the validity of the proposed method, numerical simulations are presented graphically.

Keywords: Hyper chaotic finance system, chaos control, time delay feedback control

1. INTRODUCTION

Chaos has been extensively interesting study area for many scientists, after Lorenz found the first attractor in 1963 (Lorenz, 1963). After Lorenz, many chaotic systems were introduced such as Liu system (Liu et al., 2004), Chen system (Chen, Ueta, 1999), Chua system (L.O. Chua et al., 1986), Rössler system (Rössler, 1976), Rabinovich system (Pikovski, Rabinovich et al., 1978) and Rikitake system (Rikitake, 1958). Chaos control has received increasingly attentions from researchers, since OGY (Ott et al., 1990) method has been proposed. Many control methods have been proposed for the control of chaotic systems such as adaptive control (Wu CW et al., 1996, Y. Hong et al., 2001), sliding mode control (Konishi et al., 1998; Ablay, 2009), linear feedback control (Yassen, 2005), and passive control (Lin, 1995; Qi, 2004; S. Emiroğlu, 2010)

Juan Ding (J. Ding et al., 2009) have reported a dynamic model of 4D chaotic finance system, composed of three first-order differential equations with state feedback. The state equations of 4D chaotic finance system are written below Eq 1.

$$\begin{aligned} \dot{x} &= -a(x+y)+w \\ \dot{y} &= -y-axz \\ \dot{z} &= b+axy \\ \dot{w} &= -cxz-dw \end{aligned} \tag{1}$$

where a; b are the parameters of the system (1), and c is constant(where c=0.2), and d is the control parameter.

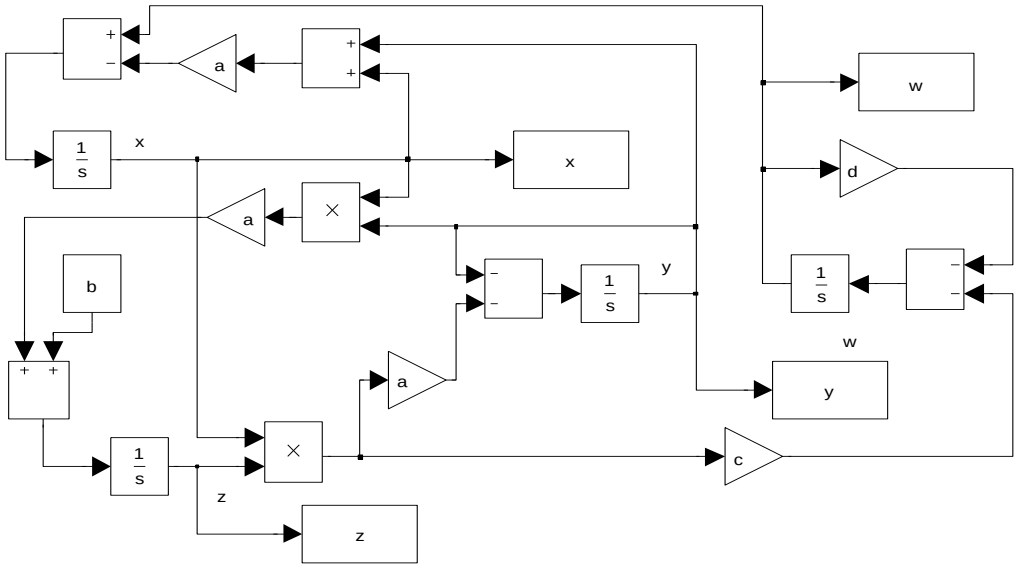

Figure 20 Matlab-Simulink model of hyper chaotic system

Using Matlab model of system (Figure 1), when parameters a = 3, b = 15, c = 0.2 and d= 0.12, chaotic time series and phase portraits of system are obtained as shown in Figure 2 and Figure 3 respectively.

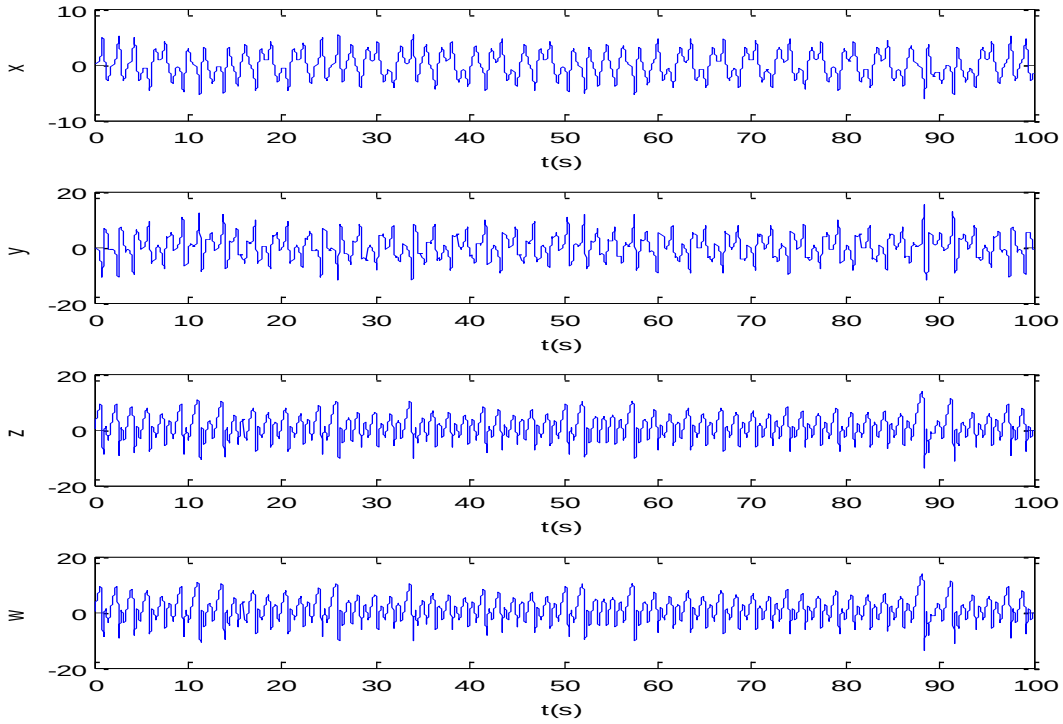

Figure 2 Time series of system

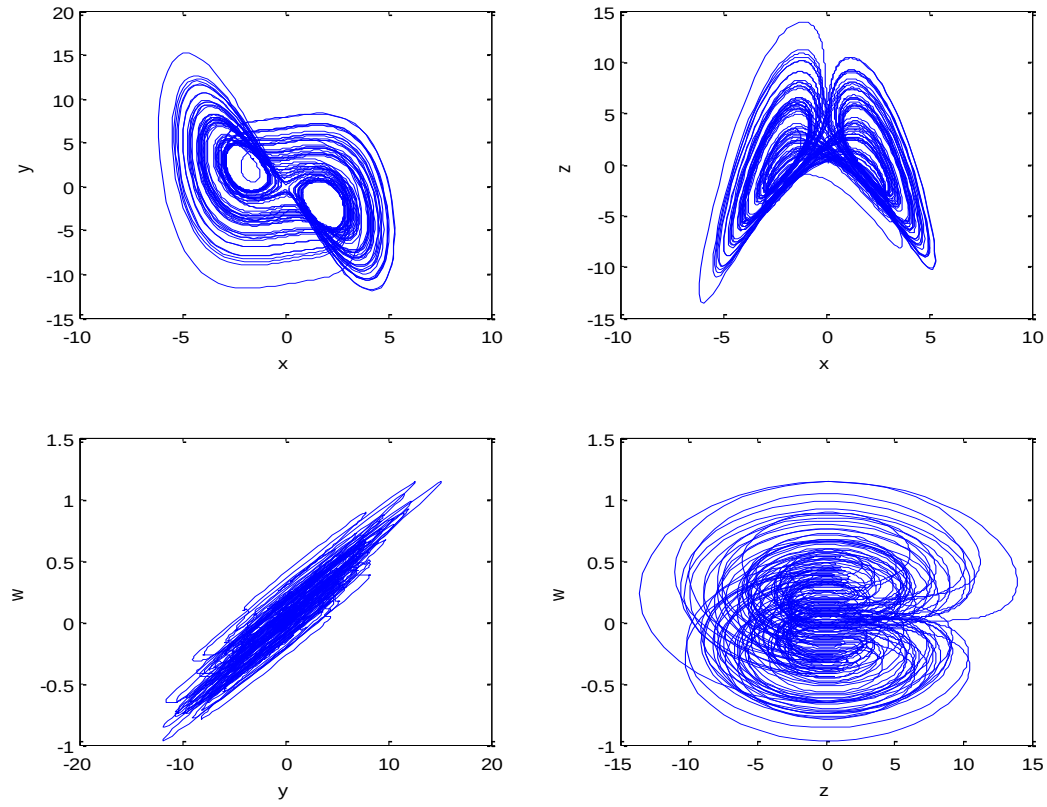

Figure 3 Phase portraits of system

2. CHAOS CONTROL OF HYPER CHAOTIC FINANCE SYSTEM

Pyragas (Pyragas, 1992) showed that chaotic behavior could be controlled by applying delayed feedback control method. The control of chaotic finance system (2) is achieved using time delay feedback control theory. The controlled model given by

$$\begin{aligned} \dot{x} &= -a(x+y)+w \\ \dot{y} &= -y-axz \\ \dot{z} &= b+axy+u \\ \dot{w} &= -cxz-dw \end{aligned} \tag{2}$$

The controller u(t) is designed based on time delay feedback control as in Eq.

$$u(t) = K[z(t) - z(t-\tau)] \tag{3}$$

u(t) obtained that the difference between current value of system variable z(t) and its τ seconds previous multiplied by constant K, where K is feedback gain.

The structure of the Simulink model for the controlled chaotic finance system using delayed feedback control method is given in Figure 4.

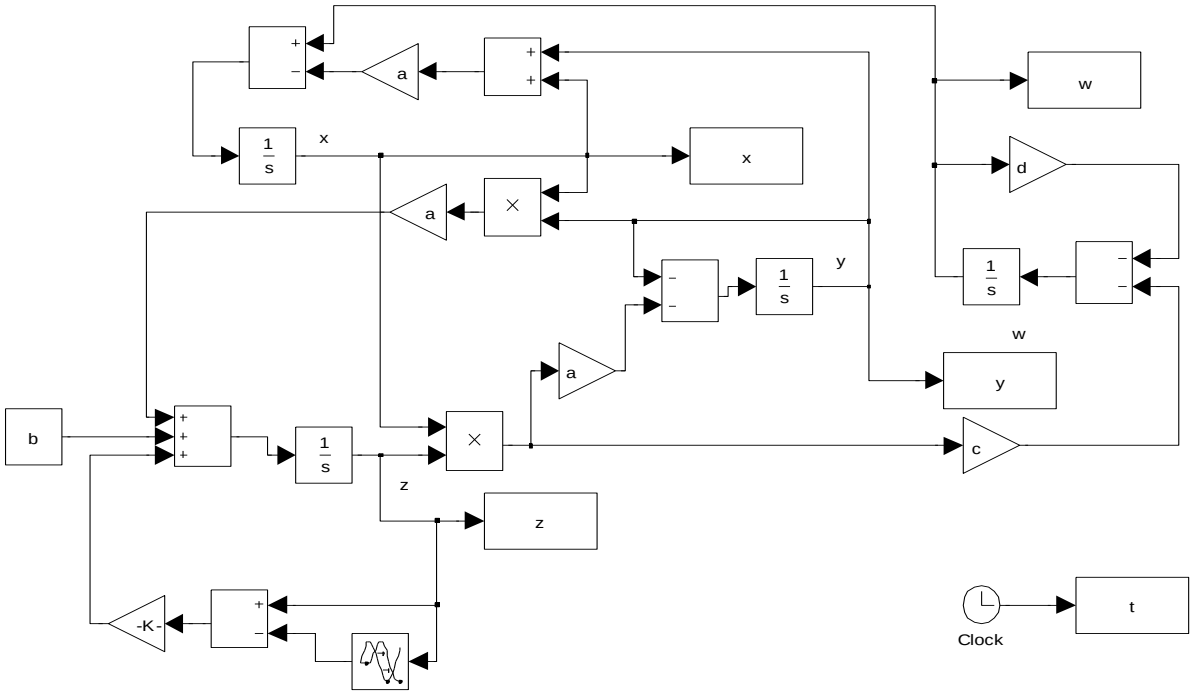

Figure 4 Matlab-Simulink model of controlled hyper chaotic system with time delay controller

Time series of system and controlled system are shown in Figure 5. After the controller is activated at t=20s, the system converges to zero equilibrium point as shown in Figure 5.

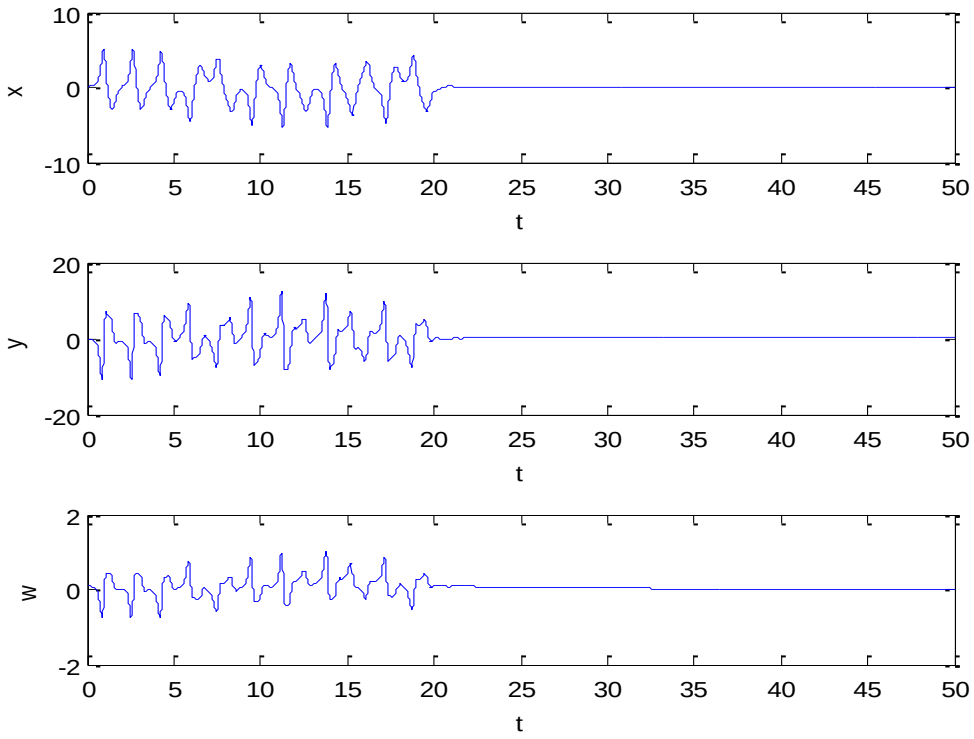

Figure 4 Time series of controlled hyper chaotic finance system when controller is activated at t=20s

3. CONCLUSION

The delay feedback control has been used to control chaos in hyper chaotic finance system. By using the time delay feedback theory, controller is proposed to realize the global asymptotical stability of the finance system. Also, the controller provides that the controlled system converge to zero equilibrium. As shown in Figure 4, the controlled system converges to zero equilibrium.

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