THE SYNCHRONIZATION FOR TWO FIVE-DIMENSIONAL CHAOTIC SYSTEMS

SINCRONIZAREA A DOUA SISTEME HAOTICE CINCI-DIMENSIONALE

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Abstract. *Chaos control in chaotic systems has attracted much interest in recent years and there has been considerable progress in generalizing the concept of synchronization to include the case of coupled chaotic systems, especially from technicaland economical reasons. Different types of synchronization have been documented in the literature. In order to formulate the chaos control of the chaotic systems, in this work the synchronization of two chaotic five-dimensional systems using an adaptive feedback method of synchronization is presented. The transient time until synchronization depends on initial conditions of the two systems and the control strength.*
Key words: *five-dimensional nonlinear system, chaos control*

Rezumat. *Controlul haosului in sistemele haotice a atras mare interes in ultimii ani si a existat un considerabil progres in generalizarea conceptului de sincronizare pentru a include sistemele haotice cuplate, in speciat din motive tehnice si economice. In literatura au fost documentate diferite metode de sincronizare. Pentru a realiza controlul haosului în sistemele haotice, în această lucrare sincronizăm două sisteme cinci-dimensionale, folosind o metodă de feedback.Timpul după care se obține sincronizarea depinde de condițiile initiale ale celor doua sisteme si de intensitatea controler-ului.*
Cuvinte cheie: *sistem haotic cinci-dimesional, controlul haosului*

INTRODUCTION

Over the last decade, there has been considerable progress in generalizing the concept of synchronization to include the case of coupled chaotic systems, especially from technical and economical reasons. A chaotic system has complex dynamical behaviors that possess some special features, such as excessive sensitivity to initial conditions, fractal properties of the motion in the phase space, and so on. When the complete synchronization is achieved, the states of both systems become practically identical, while their dynamics in time remains chaotic. Different types of synchronization phenomena have been found in a variety of chaotic systems, such as complete synchronization, lag synchronization, phase synchronization and generalized synchronization. Many examples of synchronization have been documented in the literature, but currently theoretical understanding of the phenomena lags behind experimental studies (Grosu, 1997),

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(Grosu et al, 2008), (Hu et al, 2008), (Lerescu et al, 2004), (Lerescu et al, 2006), (Oancea, 2009). In order to formulate the chaos control of two chaotic systems, in this work the synchronization of two five-dimensional chaotic systems using an adptive feedback method of synchronization is presented.

THEORY

The five-dimensional chaotic system found by Mahmoud and coworkers is (Mahmoud et al, 2007), (Hu et al, 2008):

$$\begin{aligned}
\dot{x}_1 &= ax_1 - x_5x_3 \\
\dot{x}_2 &= ax_2 - x_5x_4 \\
\dot{x}_3 &= -bx_3 + x_5x_1 \\
\dot{x}_4 &= -bx_4 + x_5x_2 \\
\dot{x}_5 &= -cx_5 + x_1x_3 + x_2x_4
\end{aligned} \tag{1}$$

This system has a chaotic behavior for:

a=9.5, b=19 and c=3 (2)

Figure 1 shows that the attractor projected onto ,x_1x_2 space for the chaotic system (1) with values from (2)

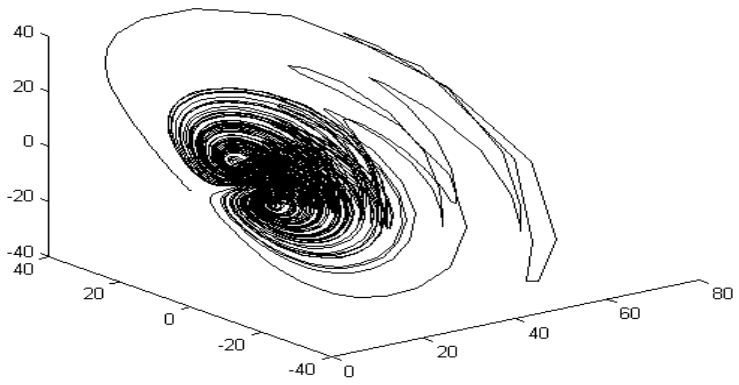

Fig. 1– Phase portrait of (x_5, x_1, x_2,) for system (1)

To synchronize two chaotic systems we used a simple method for chaos synchronization proposed by Guo and coworkers (Guo W., et al, 2009) and used by Oancea (Oancea S., 2009).

If the chaotic system (master) is:

$\dot{x} = f(x)$ where $x = (x_1, x_2, ...x_n) \in R_n$;

$f(x) = (f_1(x), f_2(x).....f_n(x)) : R^n \to R^n$

then the slave system is: $\dot{y} = f(y) + z(y - x)$

where the functions $\dot{z}_i = -\lambda_i (y_i - x_i)^2$ and λ_i are positive constants

RESULTS AND DISCUSSION

The slave system for the system (1) is:

$$\begin{aligned}
\dot{y}_1 &= 9.5y_1 - y_5y_3 + z_1(y_1 - x_1) \\
\dot{y}_2 &= 9.5y_2 - y_5y_4 + z_2(y_2 - x_2) \\
\dot{y}_3 &= -19y_3 + y_5y_1 + z_3(y_3 - x_3) \\
\dot{y}_4 &= -19y_4 + y_5y_2 + z_3(y_4 - x_4) \\
\dot{y}_5 &= -3y_5 + y_1y_3 + y_2y_4 + z_5(y_5 - x_5)
\end{aligned} \tag{3}$$

The control strength is of the form:

$$\begin{aligned}
\dot{z}_1 &= -(y_1 - x_1)^2 \\
\dot{z}_2 &= -(y_2 - x_2)^2 \\
\dot{z}_3 &= -(y_3 - x_3)^2 \\
\dot{z}_4 &= -(y_4 - x_4)^2 \\
\dot{z}_5 &= -(y_5 - x_5)^2
\end{aligned} \tag{4}$$

Fig.2 shows the syncronization of the two chaotic five-dimensional systems.

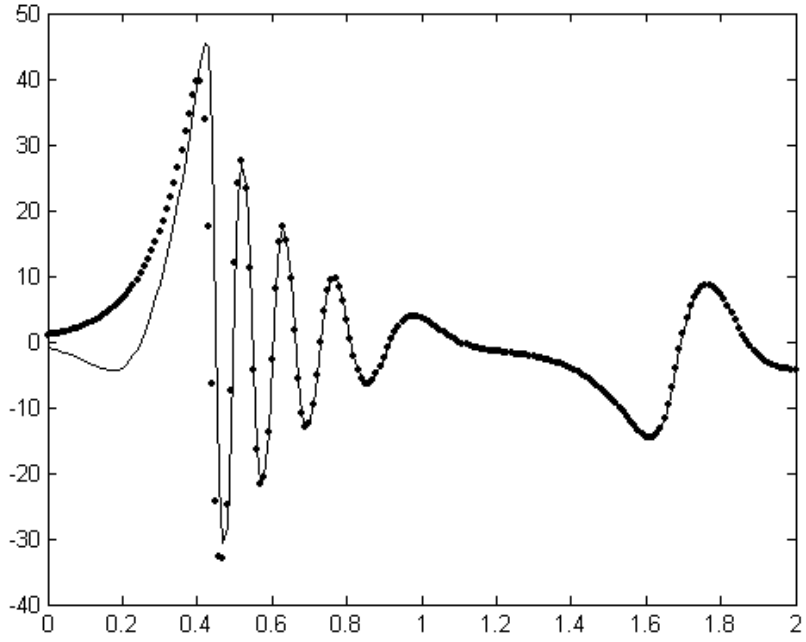

Fig. 2 – The synchronization of the two chaotic systems

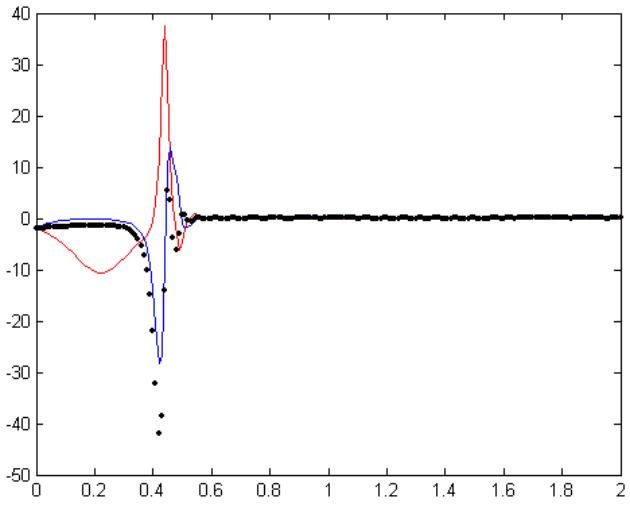

Fig. 3 – Synchronization errors between master and slave

CONCLUSIONS

In order to formulate the chaos control, the synchronization of two five-dimensional systems is presented in this work. The transient time until synchronization depends on initial conditions of two systems and the control strength.

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