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Original article

Generalized chaos control and synchronization by nonlinear high-order approach

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Abstract

This paper investigates the generalized control and synchronization of chaotic dynamical systems. First, we show that it is possible to stabilize the unstable periodic orbits (UPOs) when we use a high-order derivation of the OGY control that is known as one of useful methods for controlling chaotic systems. Then we examine synchronization of identical chaotic systems coupled in a master/slave manner. A rigorous criterion based on the transverse stability is presented which, if satisfied, guarantees that synchronization is asymptotically stable. The Rössler attractor and Chen system are used as examples to demonstrate the effectiveness of the developed approach and the improvement over some existing results.

Keywords: Chaotic systems; High-order control; Synchronization; Transverse stability

1. Introduction

Nowadays, chaos control and synchronization are important topics in the nonlinear control systems. Chaos control can be understood as the use of small perturbations to stabilize unstable periodic orbits (UPOs) embedded in chaotic systems via small control input. This concept was first initiated by Ott, Grebogi and Yorke known as OGY method [31]. However, the OGY method requires exact calculation of the UPO, which is often very hard in experiment. An alternative control method was proposed by Pyragas which states that, chaotic system can be stabilized by a feedback perturbation proportional to the difference between the present and the delayed state of the system [34]. However, it has been shown that the Pyragas method also has a limitation related to the odd number property [28,44]. Numerous research efforts are dedicated to overcome some limitations of these original methods. In fact, some improvements concerning the OGY method are reported in [2,7,12,19,35]. Based on the Pyragas method, several methods avoiding the odd number property are given in [1,17,20]. Boccaletti et al. [5] give a survey of the most relevant control methods. Recent progresses in controlling chaos can be found in [41,42]. On the other hand, since Fujisaka and Yamada's 1983 paper on synchronized motion in coupled chaotic systems [13], many researchers have discussed the stability of this type of motion. Up to now, different methods and techniques are investigated on synchronization of chaotic systems. Here, we just mention the Pecora–Carroll synchronization [33], complete synchronization [47], phase and lag synchronizations [36,37], generalized synchronization [18,22,46], partial synchronization [49], predictive synchronization [39], and

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