Hybrid projective synchronization and control of the Baier–Sahle hyperchaotic flow in arbitrary dimensions with unknown parameters

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Abstract

The problem of hybrid projective synchronization (HPS) strategies and control for the Baier–Sahle hyperchaotic flow in arbitrary dimensions with unknown parameters is considered. Based on the Lasalle invariance principle and adaptive control method, adaptive controllers and parameters update laws are given for the HPS between two identical hyper-chaotic systems with fully unknown parameters. Using this method, the Baier–Sahle hyperchaotic flow in arbitrary dimensions is controlled to the unsteady equilibrium points. The Baier–Sahle hyperchaotic flow is a useful choice for this analysis, since it is a standard model of hyperchaos, yet it is simple enough to be analytically tractable. In particular, the Baier–Sahle hyperchaotic flow has been proposed as an \( N \) dimensional nonlinear system model giving the maximal number of positive Lyapunov exponents (\( N - 2 \)). Both a rigorous theoretical analysis and direct numerical simulations are provided to demonstrate the control of hyperchaos in this model. The results suggest that the methods used here can be applied to more complicated models from which hyperchaos arises.

1. Introduction

Chaos synchronization and chaos control, have been developed and studied extensively in the last few years. Chaos control is an effective method for both chaos utilization and elimination. Chaos synchronization means making two systems oscillate in a synchronized manner, and it has become a very important goal and a subject of much on-going research due to its important applications in secret communication. For the reason that chaos is very sensitive to its initial condition, chaos control and chaos synchronization were once believed to be impossible until the 1990s when Ott et al. developed the OGY method [1] to suppress chaos, Pecora and Carroll [2] introduced a method to synchronize two identical chaotic systems with different initial conditions. Since then, chaos control and chaos synchronization have attracted a great deal of attention from various fields during the last two decades. Research efforts have been devoted to the chaos control and chaos synchronization problems in many physical systems [3–7]. Simultaneously, many types of synchronization phenomena have been discovered, such as complete synchronization, phase synchronization, anti-synchronization, generalized synchronization, projective synchronization and hybrid projective synchronization (HPS) [8,9]. Among all kinds of synchronization schemes,