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Stabilization of Arbitrary Unstable Periodic Orbits of Nonlinear Systems

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Abstract. A new algorithm for stabilization of unstable periodic orbits (UPOs) is proposed. It is based on the open-plus-closed-loop (OPCL) master-slave synchronization method [15]. The algorithm can be applied to continuous systems and delay systems, as well as discrete systems and slowly nonstationary discrete systems. Numerical results are given for Lorenz, Rossler, Mackay-Glass, Ikeda and nonstationary logistic systems. Any UPO of a low or high-dimensional system can be robustly stabilized. Also, the algorithm offers a periodic driving in order to obtain a periodic behavior of a desired period. The method is general and easy to use.
Keywords. chaos, synchronization, unstable periodic orbits, stabilization of UPOs, delay systems
AMS (MOS) subject classification:

1 Introduction

Chaotic systems have the distinguishing feature of sensitivity to initial conditions, and from this, they have undesirable unpredictability in engineering applications. On the other hand, biological systems are highly nonlinear multivariable systems, which are regulated by mechanisms that are poorly understood. Chaotic attractors contain, theoretically, an infinite number of UPOs. Stabilizing UPOs usually means to control a chaotic system in some way. So, a controlled chaotic system can have a lot of opportunities in terms of predictable periodic behaviors, and so they could be more useful than a nonchaotic one. Hence, a reliable, general, and robust algorithm for stabilization of arbitrary UPOs is important and useful. For example, robust periodicity of biological systems could be achieved based on such an algorithm.

Ott, Grebogi and Yorke [23] (the OGY method) stabilized a previously determined UPO of a discrete system by very small changes of a suitable parameter. Another good methid in chaos control was suggested by Pyragas [24], to stabilize a UPO of a continuous system with an additive delayed feedback that does not require a reference signal. OGY and Pyragas' methods, along with other variants, have enriched the methodologies of control