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PREDICTIVE CONTROL OF RABINOVICH SYSTEM

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Abstract. The chaos control problem of continuous time Rabinovich chaotic system is addressed. An instantaneous control input has been designed using predictive control principle to guarantee the convergence of the chaotic trajectory towards an unstable equilibrium point. Numerical simulations are presented to verify all the theoretical analyses. Computational and analytical results are in excellent agreement.

Keywords. Chaos, chaotic system, rabinovich system, predictive control, chaos control

1 Introduction

Chaos control is one of the major research topic in non linear control systems. Control of chaos refers to the process wherein a tiny perturbation is applied to a chaotic system, in order to realize a desirable behaviour. The first method of control known as OGY method was introduced by Ott, Grebogi and Yorke in 1990 [1]. The main idea was to wait for the natural passage of the chaotic orbit close to the desired periodic behaviour, and then applying a carefully chosen small perturbation, to stabilize such periodic dynamics. Since then the topic has been investigated extensively by many researchers. It has emerged as a new and a very attractive area of research. In this direction many theories and methodologies have been developed, such as time delay feedback method [2], adaptive control method [3, 4], sliding mode control method [5, 6], occasional proportional feedback method [7], impulsive control method [8], backstepping method [9], passive feedback control method [10], higher order method [11], generalized control by non linear high order approach [12], predictive control method [13, 14].

Recently, predictive control method for controlling continuous chaotic systems has been proposed [14]. Predictive control methods may be considered as a kind of adaptive control strategy [15, 16]. The control approach is based on gain feedback configurations. In this method, amplified versions of the difference between future predicted state of uncontrolled chaotic system and the current state is fed back as control input. The stability condition is guaranteed in the same way as in the original OGY method. The predictive control has been applied to the stabilization of various chaotic systems [17, 18, 19, 20, 21] and for the synchronization of chaotic satellite systems [22]. The stabilization and synchronization of the chaotic systems have been achieved with great satisfactory performances.

In 1978, Rabinovich differential system was introduced by Pikovski, Rabinovich and Trakhtengerts [23]. This continuous time chaotic system bears a resemblance with the well known Lorenz chaotic system in some properties. The bifurcation diagram and dynamical behaviour of this system has been explored in [24, 25]. From Rabinovich system a new 4-D hyperchaotic system was constructed in 2010 [26]. The control of Rabinovich system was first reported in [27] by using controller based on passive control technique. Later in [28], the control of the system was proposed using sliding mode controller in which control input is required for each state variable.

Motivated by the above chaos control studies, in this paper, we have investigated the control of the continuous time Rabinovich system by using predictive control method. The advantage of using a predictive controller as an alternative is apparent in the simplicity of configuration and implementation of the control design. The layout of the paper is as follows. Firstly a brief description of predictive control principle is given in Section 2. Then in Section 3 Rabinovich system is described briefly and the controller is designed to stabilize the system using predictive control principle. To verify the theoretical results, numerical simulations have been performed in Section 4 and an excellent agreement between the theoretical and numerical results have been achieved. Finally, concluding remarks are given in Section 5.

2 Predictive control principle

Consider an n-dimensional and non linear chaotic system described by

$$\dot{x}(t) = f(x(t)) \tag{1}$$

where $x \in R^n$ is the state vector and we assume that f is differentiable. Our aim is to design a feedback controller $u(t)$ which when added to the dynamical system

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