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Research Article

Terminal Sliding Mode Control with Adaptive Feedback Control in a Class of Chaotic Systems

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This paper analyzes semifinite time stability for a general chaotic system. By cooperating methods terminal sliding mode (TSM) with adaptive feedback control (AFC), a controller based on the two methods is derived to achieve semifinite time stability. The theoretical analysis employs the theories of linear matrix inequalities and Lyapunov functional method. Finally, numerical simulation is given to illustrate the derived theoretical results.

1. Introduction

Chaos phenomenon can be found in many physics and engineering systems in practice. However, to improve the system's performance, it is often desirable to avoid chaos, and various methods are proposed. Due to different emphases, controllers have different merits and drawbacks. For example, TSM establishes terminal sliding mode surface to couple system variables and control them to reach equilibrium points. Its control is effective, but it can only control system states coupled in the sliding mode surface; readers are referred to [1–7] for more detailed information. As for impulse control [8–16], they add impulse effects to continuous differential equation and, by constructing comparison system, establish relationships between parameters of system and impulse. Their controllers are effective, but design processes of their controllers are too much complex. For adaptive feedback control as in [17–21], similar to TSM, they have unified the format with different parameters. AFC has a wide range of applications in various fields, but its dynamic is not as good as the first two.

For the system's structure constructed in this paper, we design controllers from methods TSM and AFC, both of which have unified formats. If TSM is used only, we should design several TSM surfaces. If AFC is used only, its controller is very simple and flexible, but it can only achieve asymptotical stability. Combining their merits and drawbacks, a cooperative controller is proposed in the paper. TSM method finite-timely controls system states, which are coupled in TSM surface, as in [4–7]. Simple AFC is introduced as a supplementary control into the remaining states of the system, controlling system states which are outside TSM surface and making them asymptotically stable [18, 20], and, finally, the overall system tends to be semifinite-time stable [5].

This design scheme can control main elements of system finite-time stability, firstly, then use AFC method to ensure that other dimensions are asymptotically stable, and finally realize the overall system's semifinite time stability. Compared with TSM only, this design can greatly reduce the control input and simplify the design process of controller; compared with AFC only, it has obvious advantages in time sequence.

The rest of the paper is organized as follows. In Section 2, a general chaotic system model and some preliminaries are presented. In Section 3, we will show theoretical analysis, establish several sufficient conditions for SFTS, and formulate controller. In Section 4, numerical simulation is presented to verify the validity of theoretical results. Finally, the conclusions are drawn in Section 5.