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Adaptive attitude tracking control for hypersonic reentry vehicles via sliding mode-based coupling effect-triggered approach

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Abstract

This paper proposed a coupling effect-triggered control approach for hypersonic reentry vehicles attitude tracking system based on the adaptive sliding mode techniques. A coupling effect indicator (CEI), which is established based on the Lyapunov stability theory, is obtained to demonstrate whether a coupling harms or benefits the system. In consequence, the coupling effect-triggered control driven by the CEI is developed to cancel the harmful couplings while keeping the beneficial couplings. Meanwhile, the robustness of the proposed method is enhanced by the adaptive sliding mode approach even when the boundary of the disturbance is unknown. To avoid the non-differentiable terms in the controller design, the command filtered scheme is introduced and the bounded stability of the closed-loop system is guaranteed. This technique outperforms the existing controllers which do not consider the coupling effect in the transient response. Finally, application to the hypersonic vehicle system is presented to demonstrate the validity of the proposed control scheme.

Keywords:
Tracking control, coupling effect-triggered approach, adaptive sliding mode, hypersonic reentry vehicles

1. Introduction

Hypersonic reenrty vehicle (HRV) control is one of the more widely researched applacation areas, largely because of its importance in both military and civil fields [1, 2]. Compared with the traditional flight vehicles, HRV has special advantages such as high-speed transportation, near space accessibility and affordable cost [3, 4]. Hypersonic flight usually covers a large flight envelope during which the environmental and aerodynamic characteristics undergo huge variations, so there are several critical problems making precise control of the HRV attitude system quite challenging, such as the heavy uncertainties and coupling issues [5, 6].

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