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Indirect Adaptive Control for Attitude Tracking of Spacecraft with Unknown Reaction Wheel Friction

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Abstract—This paper examines attitude tracking problem with unknown friction torque of reaction wheels and external disturbances. A robust adaptive controller with parameter update law is proposed and analyzed. An indirect (nonregressor-based) approach to dealing with the effects of unknown friction torque and external disturbances is explored. This is done by not focusing on friction torque and external disturbances themselves, but on their bound, which allows the core information on friction torque and external disturbances to be extracted and used for control design. It is shown that the proposed controller guarantees not only stability of the resulting closed-loop system but also transient performance. Numerical simulations are presented to show the effectiveness of the proposed attitude tracking approach.

Keyword: attitude tracking, attitude control, adaptive control, friction torque, reaction wheel

I. Introduction

Advanced space missions demand accurate attitude maneuver, tracking and pointing capabilities for attitude control system of spacecraft. Because of its small weight and high control accuracy, reaction wheel is often used as actuator for spacecraft attitude control system. The effect of friction torque of reaction wheel severely limits attitude control accuracy. Although there are rich results on attitude control in the literature, such as adaptive control [1]-[3], optimal control [4][5], sliding mode control [6]-[8], and iterative learning control [9], *etc.*, there are few papers that have explicitly dealt with the effect of friction torque of reaction wheel.

One method to deal with the effect of reaction wheel friction torque in practice is to add a prior friction torque versus speed of reaction wheel to control torque command in a feedforward way. But it is difficult to measure

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