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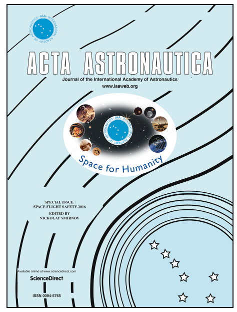

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Learning-based adaptive prescribed performance control of postcapture space robot-target combination without inertia identifications

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Abstract

In this paper, a novel learning-based adaptive attitude takeover control method is investigated for the postcapture space robot-target combination with guaranteed prescribed performance in the presence of unknown inertial properties and external disturbance. First, a new static prescribed performance controller is developed to guarantee that all the involved attitude tracking errors are uniformly ultimately bounded by quantitatively characterizing the transient and steady-state performance of the combination. Then, a learning-based supplementary adaptive strategy based on adaptive dynamic programming is introduced to improve the tracking performance of static controller in terms of robustness and adaptiveness only utilizing the input/output data of the combination. Compared with the existing works, the prominent advantage is that the unknown inertial properties are not required to identify in the development of learning-based adaptive control law, which dramatically decreases the complexity and difficulty of the relevant controller design. Moreover, the transient and steady-state performance is guaranteed a priori by designer-specialized performance functions without resorting to repeated regulations of the controller parameters. Finally, the three groups of illustrative examples are employed to verify the effectiveness of the proposed control method.

Keywords: Prescribed performance; Spacecraft; Adaptive dynamic programming; Nonlinear control; Space robot

1. Introduction

Recently, on-orbit capture technologies have attracted extensive attention owing to its intriguing and potential military, civil and commercial applications in the future space missions including on-orbit maintenance, on-orbit assembly, service life extension, space debris removal and so on [1, 2]. For example, Projects FREND [3] and SMART-OLEV [4] were launched to supply the on-orbit spacecraft with propulsion, navigation and guidance services to extend its lifetime.

In order to capture the space target (can be inactive satellites, space debris, etc.), space robot (or manipulator) equipped with flexible capture devices, as a promising way, is widely used in many space missions and experiments [5–7], and many corresponding researches are reported in the existing works. Flores-Abad and Ma investigated an optimal control strategy to control the space manipulator to reach the determined motion state by predicting the future capture time in [8]. The relevant research was further explored when the space robot captured a tumbling target with consideration of uncertainties in [9]. Toglia *et al.* proposed some different design strategies to grasp the space object with consideration of minimizing the vibrations of the end-effector of space manipulator in [10]. Xu *et al.* only utilized the manipulator motion to berth the target and re-orientate the base at the same time in [11]. Moreover, impact dynamics and robust control of a flexible dual-arm space robot were studied in the presence of the effect of payload

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