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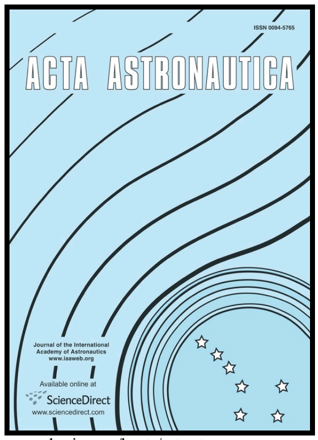

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Robust Trajectory Tracking Control of a Dual-arm Space Robot Actuated by Control Moment Gyroscopes

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Abstract

It is a new design concept to employ control moment gyroscopes (CMGs) as reactionless actuators for space robots. Such actuation has several noticeable advantages such as weak dynamical coupling and low power consumption over traditional joint motor actuation. This paper presents a robust control law for a CMG-actuated space robot in presence of system uncertainties and closed-chain constraints. The control objective is to make the manipulation variables to track the desired trajectories, and reduce the possibility of CMG saturation simultaneously. A reduced-order dynamical equation in terms of independent motion variables is derived using Kane's equations. Desired trajectories of the independent motion variables are derived by minimum-norm trajectory planning algorithm, and an adaptive sliding mode controller with improved adaptation laws is proposed to drive the independent motion variables tracking the desired trajectories. Uniformly ultimate boundedness of the closed loop system is proven using Lyapunov method. The redundancy of the full-order actual control torques is utilized to generate a null torque vector which reduces the possibility of CMG angular momentum saturation while producing no effect on the reduced-order control input. Simulation results demonstrate the effectiveness of the proposed algorithms and the advantage of weak dynamical coupling of the CMG-actuated system.

KeyWords: Space Robot; Tracking Control; Control Moment Gyroscopes; Motion Constraint; Parameter Uncertainty

1. Introduction

Control moment gyroscopes (CMGs) are an efficient means of providing large and precise torques without expending propellant. Thus, CMGs have been successfully employed as attitude control actuators on large space