IAF ASTRODYNAMICS SYMPOSIUM (C1)
Attitude Dynamics (2) (4)

Author: Dr. Mingming Wang
National Key Laboratory of Aerospace Flight Dynamics,Northwestern Polytechnical University, China, mwang@nwpu.edu.cn

Prof. Jianjun LUO
National Key Laboratory of Aerospace Flight Dynamics,Northwestern Polytechnical University,Xi'an,, China, jjluo@nwpu.edu.cn
Prof. Yuan Jianping
National Key Laboratory of Aerospace Flight Dynamics,Northwestern Polytechnical University,Xi'an, China, jyuan@nwpu.edu.cn
Prof. Ulrich Walter
Technische Universität München, Germany, walter@tum.de
Mr. Xinyuan Lu
National Key Laboratory of Aerospace Flight Dynamics,Northwestern Polytechnical University,Xi'an, China, xinyuanlu0410@163.com

BASE ATTITUDE STABILIZATION OF SPACE ROBOT WITH GUARANTEED PRESCRIBED PERFORMANCE

Abstract

In light of the space robots currently planned by worldwide space agencies, an increase in the number and the capacity of robot applied in space missions will be a foregone conclusion in the coming future to fulfill the increasing demands of satellite maintenance, on-orbit assembly and space debris removal etc. Not like the fixed base manipulator on ground, space robot exhibits some special characteristics due to the dynamic coupling effect between the space manipulators and the spacecraft (base). It is significant to maintain the base attitude in order to keep the orientation of pointing instruments and scanning devices, especially when the space manipulator executes operations. Accordingly, particular attitude control techniques have to be developed to cope with the dynamic coupling issue of space robot.

When the space manipulator is kinematically redundant, base attitude can be regulated by using the redundancy of the space manipulator in its reaction null-space. Nevertheless, zero reaction can only be achieved with specific robot paths and it inevitably restricts the workspace of a robotics manipulator. Therefore, active control of space robotic base is requisite. In practice, it is difficult to determine the inertia parameters of the space robotic system and the magnitude of reaction forces and torques, when the configuration of the space robot changes. The uncertain dynamic parameters and unknown external disturbance to the base enhance the difficulty of attitude controller design.

In this paper, a robust prescribed performance control (PPC) scheme has been proposed for the base attitude stabilization of space robot, especially when the dynamic coupling effect between manipulator and base is taken into account. The multi-body dynamics of space robot is introduced, the reaction forces and torques of space robotic operation to the base was obtained and treated as external disturbance. To ensure a high fidelity transient and steady-state tracking performance for base attitude regulation, robust PPC strategy was derived, where the system output is guaranteed to converge to a predefined arbitrarily small residue set with a prespecified rate and overshoot. The stability of the proposed control strategy was also analyzed based on Lyapnov function. This study has been implemented for a 7 degree-of-freedom

(DOF) kinematically redundant manipulator mounted on a 6 DOF spacecraft. When the manipulator tracks a predefined trajectory to perform space tasks, the base attitude can be regulated with guaranteed prescribed performance. Simulation results demonstrate the feasibility and effectiveness of the proposed control scheme.