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Author: Dr. Limin Xie
Fuzhou University, China, lucy_min@163.com

Prof. Li Chen
Fuzhou University, China, Chnle@fzu.edu.cn

SINGULAR PERTURBATION AND FUZZY VARIABLE STRUCTURE SLIDING MODE CONTROL OF SPACE ROBOT SYSTEM WITH FLEXIBLE JOINT IN INERTIAL SPACE

Abstract

In the practical application of the space robot, the joints of the space robot are usually flexible, that is, the connection of the actuator and the manipulator is elastic in the joint. In this case, the rotational angle of the manipulator is not equal with that of the actuator's rotor directly. We call this joint as "flexible joint". Because of the flexible joint, the space robot will vibrate in the high-precision and high-speed process. So considering the flexible joint in the dynamic modeling and controller designing of the space robot system is very important and necessary. And the control for the system should achieve both trajectory tracking and vibration suppression. In this paper, we discuss the dynamics modeling and control problem of the space robot system with flexible joint in inertial space based on singular perturbation method. Firstly, because of the system's special structure, in addition of the kinetic energy of the manipulators, we need calculate the kinetic energy and the potential energy of the flexible joint, which are not considered in the space robot system without the flexible joint. Then we use the linear momentum conservation, the angular momentum conservation and the Lagrange equation to establish the dynamic equations and the generalized Jacobi matrix of the system. Based on the singular perturbation method, the system is divided into two sub-systems: the slow sub-system and the fast sub-system. A fuzzy variable structure sliding mode compound controller is designed for the slow sub-system. The variable structure sliding mode controller is designed to achieve the asymptotic tracking of the system. And the fuzzy controller is used to overcome the chattering of the variable structure sliding mode controller. While a velocity feedback control term is designed for the fast sub-system to suppress the elastic vibration caused by the flexible joint. The simulation results show that the system has good tracking performance and good stability. That demonstrates the feasibility and efficiency of the proposed control method.