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PASSIVE FINITE-DIMENSIONAL REPETITIVE CONTROL BASED ON SINGULAR PERTURBATION METHOD OF FREE-FLOATING SPACE ROBOTIC MANIPULATORS SYSTEM WITH TWO FLEXIBLE JOINTS

Abstract

With the deepening of space exploration, free-floating space robotic manipulators will replace astronauts to deal with more and more repetitive tasks. Tracking periodic reference signals and attenuating periodic disturbances is an important topic in the control of space robotic manipulators. For most space robot systems, there is no absolutely rigid connection between the robot arm and the drive motor that drives its motion at the joints, it is essential to consider the flexibility of the joints. Furthermore, considering the flexibility of the two joints than the single joint, the modeling is more complex and performing tasks closer to the actual work. In this paper, passive finite-dimensional repetitive control based on singular perturbation method of free-floating space robotic manipulators system with two flexible joints is discussed. Firstly, According to the Spone's hypothesis, the flexible joint is simplified as a linear torsion spring without inertia. Then, considering momentum conservation method and the Second Lagrange method, the dynamic model of the system is established. Secondly, according to the singular perturbation method, the system is decomposed into two independent subsystems: a slow subsystem which represents the system's rigid part and a fast subsystem which represents the system's flexible part. For the slow subsystem, passive finite-dimensional repetitive control is designed not only to track the periodic reference trajectory, but also to restrain periodic perturbations. The passive finite dimensional repetitive controller is based on the passivity-based design and has a structure of a parallel connection of linear oscillators and one integrator. The tight stability conditions of the repetitive controller based on the internal model are avoided, and the convergence speed is improved. The passive connection between the controller and the nonlinear mechanical system provides the same stability condition as the exact feed-forward compensation for the robot manipulators. For the fast subsystem, a velocity difference feedback control method is used to stabilize the elastic vibrations caused by the flexible joints, and guarantee the system's stability. Finally, the simulation results show the effectiveness of the passive finite-dimensional repetitive control based on singular perturbation method of free-floating space robotic manipulators system with two flexible joints.