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DYNAMIC SINGULAR MODELING, ROBUST FUZZY SLIDING CONTROL AND FLEXIBLE VIBRATION ACTIVE SUPPRESSION FOR FREE-FLOATING SPACE ROBOT WITH FLEXIBLE JOINT AND FLEXIBLE MANIPULATOR

Abstract

Nowadays, most of the researches on the space robot system are based on the assumption of that the system is a multiple rigid body systems. But in the space's actual applications, the joint between the manipulator and the rotor is flexible. And the flexible manipulator has been more widely used for reducing the system's quality. So, the space robot system is a rigid-flexible coupling system actually. The flexibility of the space robot's structure can reduce the system's weight, reduce the energy consumption, and reduce the damage to the space robot. But the flexible deformation and vibration will influence system's control accuracy and stability. As the space robot technology developing, the coupling effect between the large displacement's rigid motion and the small displacement's flexible motion of the flexible manipulator and flexible joint can not be ignored. But because of the free-floating space robot system's nonlinear and strong coupling, the research on the space robot system with flexible joint and flexible manipulator is still very rare. Based on the above discussion, in this paper, the impacts both of the flexible manipulator and the flexible joints on free-floating space robot system are considered. The dynamics modeling, motion control and flexible vibration suppression problem of free-floating space robot with flexible manipulator and flexible joints are discussed. Firstly, the flexible joint is simplified as a "rotor-torsional spring system". According to system's momentum conservation, angular momentum conservation and Lagrange-Assumed mode method, the dynamic equations of the system are established. Then, based on singular perturbation method, the system is decomposed into a slow subsystem and two fast subsystems. Where, the slow subsystem represents the rigid-joint and rigid-link system's rigid motion, the fast 1 subsystem represented the system's flexible vibration caused by flexible-joint, and the fast 1 subsystem represented the system's flexible vibration caused by flexible-link. Then three control methods are proposed for these three subsystems: For the slow subsystem, a saturation robust fuzzy sliding controller is proposed to compensate the influences of the uncertain parameters, rotation angles' errors and the external disturbance, and thus realize the asymptotic tracking of the system desired trajectory; for the fast 1 subsystem, a velocity difference feedback controller is used to suppress the flexible vibration caused by flexible-joint; for the fast 2 subsystem, a linear quadric regulator is used to suppress the flexible vibration caused by flexible-link. Finally, the simulation results prove the controller's efficiency.