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LINEAR STATE FEEDBACK CONTROL FOR DISTURBED MOTION AND VIBRATION OF THE COMBINATION SYSTEM AFTER FLEXIBLE-BASE FLEXIBLE-LINK AND FLEXIBLE-JOINT SPACE ROBOT CAPTURING SATELLITE

Abstract

After the flexible space robot captures the target satellite, the dynamic model of the composite system consists of the motion coupling between the manipulator and the base, and the rigid flexible coupling between the flexible base, flexible joint, flexible link elastic deformation and the rigid motion of the combined system. It's a complex multibody system. The impact analyses of the flexible space robot capturing a target and stability control problem in the post-impact process were discussed in the paper. The elastic deformations of flexible base and joints of the flexible space robot was approximately described by using linear spring and torsion spring respectively. The flexible links were regarded as Euler-Bernoulli simply supported beams and analyzed by using the assumed mode method. The dynamical models of the space robot and satellite are separately derived from the second Lagrange equation and Newton-Euler equation. The impact effect of space robot capturing satellite is calculated based on kinematics and impact force transmission relationship. Under the influence of collision force, the combination system after capturing satellite is unstable. In order to realize the stabilization control of the unstable combination system, the dynamic model is established, and the singular perturbation theory is used to decompose it into a slowly subsystem including the rigid motion of the base, the joints and the flexible vibration of the links, and a fast subsystem including the flexible vibration of the base and the joints. For the slow subsystem, using the floating base attitude controller and the manipulator joint hinge controller, and according to the feedback base attitude angle and the manipulator joint angle, a linear feedback control algorithm is designed to realize the stabilization control of the base attitude and the manipulator joint angle of the combination system. In order to suppress the flexible vibrations of the links of the slow subsystem, a hybrid trajectory reflecting the flexible vibration of the links and the rigid motion of the system is constructed by using virtual force conception, and compound controller on virtual force conception is proposed to ensure the accurate tracking of the trajectory of the base and joints, while actively suppressing the flexible vibrations of the links. For the fast subsystem, the linear quadratic optimal control algorithm is used to suppress the flexible vibration of the base and joints. Finally, the effectiveness of the proposed control algorithm is verified by numerical simulations.