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REINFORCEMENT LEARNING CONTROL OF SPACE ROBOT WITH ELASTIC BASE,ELASTIC JOINTS AND FLEXIBLE LINKS CAPTURING NON-COOPERATIVE SPACECRAFT

Abstract

With the development of space, Space robots becoming more and more widely used. Therefore, the space robot system has been widely concerned by researchers from all over the world. With the increase of spacecraft in orbits, many spacecraft become defunct spacecraft due to fuel, mechanical fault, etc. In order to achieve the maintenance and clearance of the defunct spacecraft, the space robot's ability to capture the target becomes the key technology. Considering the space manipulator usually has light weight and long arm, and the joints are often driven by flexible harmonics. However, the space manipulator is usually installed on elastic guide rail, so the system is affected by multiple elasticity. It is a great challenge to use multiple flexible space robot to capturing the non-cooperative spacecraft with high speed and rotation characteristics. A reinforcement learning stabilized motion control strategy was proposed for the motion and vibration control of a non-cooperative spacecraft captured in orbit by a space robot with multiple elastic elements. First of all, the dynamic models of the multiple flexible space robot system and the target spacecraft system before capture are derived by using the Lagrange approach and Newton-Euler method. After that, based on the law of conservation of momentum, the constraints of kinematics and the law of force transfer, the integrated dynamic model of the combined system is derived. By applying singular perturbation theory, the system is decomposed into a slow subsystem which represents the rigid motion and a fast subsystem which represents the flexible links, elastic joints and elastic base vibration. For the slow subsystem, a reinforcement learning based control scheme is proposed to realize the rigid desired trajectory tracking. For the fast subsystem, the linear quadratic optimal control method is adopted to suppress the vibrations of flexible links, elastic joints and elastic base simultaneously. The simulation results show that the proposed control scheme can realize the combined system stabilization control, and finally achieve active vibration control and stability control of the trajectory.