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ROBUST ADAPTIVE COMPOSITE CONTROL AND ACTIVE VIBRATION SUPPRESSION OF FREE-FLOATING SPACE FLEXIBLE MANIPULATOR WITH PARAMETER UNCERTAINTIES IN WORKSPACE

Abstract

Space robot systems have been suggested for a number of important missions in space. It has been proposed to construct future space station, or to repair and serve satellites in earth orbit. As a result, the control of space robot systems has received increased attention. The use of light-weight flexible links in space robot systems is necessary when the weight of robots is a main concern to prevent unnecessary energy consumption and thereby extend the orbit life. However, flexural effects are inherent in light-weight slender manipulator, increasing the complexity in the system model and thus the controller design becomes a challenging problem for engineers to design a tracking controller for space flexible manipulator with inherent uncertainty. And most robust control and nonlinear control schemes of the terrestrial manipulators can't be directly applied on the space flexible manipulator. From then on, some control laws are improved and used to control the space flexible manipulator. According to the previous researches, there are a few studies focus on the adaptive and robust control of space robot system with uncertain parameters. However, all the researches largely aim at space rigid robot system. And for flexible manipulator, the most researches are considering the terrestrial flexible manipulator or the certain space flexible manipulator. It is necessary to study the robust control and active vibration control for space flexible manipulator with uncertain parameters. In order to farthest reduce the fuel consumption of the system, space flexible manipulators are generally designed that the attitude and position of the base are not controlled. However, the motion of free-floating base will disturb communication devices mounted on the base. Since communication devices are more sensitive to the change of base's attitude than to that of base's position, it's important to study space flexible manipulator with attitude-controlled base. In this paper, the dynamic equations of the system are developed by using the Lagrangian assumed modes methods, it is verified that the dynamic equation can be linearly dependent on a group of inertial system parameters. With the augmentation approach, we demonstrate that the augmented generalized Jacobian matrix can also be linearly represented by the selected group of system parameters. Based on the results and under the assumption of two-time scale, singular perturbation model of the space flexible manipulator system is obtained. The fast subsystem controller will damp out the vibration of the flexible link using optimal Linear Quadratic Regulator (LQR) method. The slow subsystem robust adaptive composite controller dominates the trajectory tracking in workspace. Finally, the numerical simulation is carried out, which confirms the controller proposed is feasible and effective.