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INTEGRAL SLIDING MODE NEURAL NETWORK CONTROL AND ACTIVE VIBRATION SUPPRESSION OF A SPACE ROBOT WITH ELASTIC BASE AND TWO FLEXIBLE ARMS

Abstract

Space robot is a complex, nonlinear and strong coupling dynamic system. It can instead of astronauts to perform a variety of space tasks on orbit, such as space processing, space manufacturing, space assembling, space repairing and space science experiment. So, it has received extensive attention. In order to expand the working range of the space robot on space station, it is installed on the mobile base which can move along the guide rails assembled by truss. The space robot will arouse the elastic vibration of guide rail inevitably in the operation process. The coupling of the rigid motion and the flexible vibration, and the coupling of the elastic of the base and the vibration of the two flexible arms will greatly increase the difficulty of the dynamic analysis and control. The trajectory tracking and vibration suppression of elastic base and two flexible arms for a free-floating space robot system with all flexible arms and elastic base is discussed. First of all, the elastic connection between the base and the arm is considered as a linear spring and two flexible arms are regarded as Euler-Bernoulli beam. Using the Lagrange equation of the second kind, momentum conservation principle and the assumed mode method, dynamics model of the space robot system with all flexible arms and elastic base is derived. Secondly, using singular perturbation theory of two kinds of time scale, a slow-subsystem describing the rigid motion and a fast-subsystem corresponding to vibration of base elastic and two flexible arms are obtained. For the slow-subsystem, neural network is used to approximate the two uncertainties in the dynamic model of the space robot. The integral term of proportional integral (PI) sliding mode control makes initial state of the system falls on the sliding surface, which can offset the unknown disturbance at the beginning of control and eliminate the chattering of controller output, so the robustness of the control law is enhanced. The PI sliding mode neural network controller is designed to improve the tracking performance of the rigid point-to-point movement. For the fast-subsystem, an optimal linear quadratic regulator controller is adopted to damps out the vibration of the two flexible links and base elastic, which guarantees the stability and tracking accuracy of the system. Finally, computer simulation results show the effectiveness of the compound control method.