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DYNAMIC SURFACE CONTROL AND VIBRATION SUPPRESSION OF DOUBLE-FLEXIBLE-ARM SPACE ROBOT WITH DEAD-ZONE AND EXTERNAL DISTURBANCE

Abstract

Space robots instead of astronauts execute space activities can reduce the risk and cost, so many scholars have carried out its research. The flexible space robot has attracted more and more attention and extensive research due to its light weight, long arm and heavy load. There is the interaction between the rigid motion and the arm's flexible vibration, and also coupling between the flexible vibrations of each arm. Therefore, such strong nonlinear coupling control problem not only focus on trajectory tracking, but also consider the suppression of flexible arm. It is worth mentioning that the two joint hinges in a space robot are driven by motors, so there is a joint torque output dead-zone. The dead-zone is used to describe the insensitivity of the system to small signals, and it is a nonlinear function. When the signal enters the dead-zone, there will be a considerable loss, resulting the deviation of the system control. Therefore, the influence of dead-zone must be taken into account in the study of space robot high-precision control. The trajectory tracking and flexible vibration suppression of a free-floating double-flexible-arm space robot system with joint torque output dead-zone and external disturbance are discussed. First of all, the two flexible arms are regarded as Euler-Bernoulli beams, and the dynamic model of the system is derived from the second equations of Lagrange, the principle of momentum conservation and the assumed mode method. Secondly, based on the two time-scale assumptions of singular perturbation theory, the system is decomposed into a slow-subsystem that represents rigid motion and a fast-subsystem that describes two arms flexible vibration. For the slow-subsystem, an adaptive dynamic surface controller based on Gaussian fuzzy basis function is designed for the existence of dead-zone. The application of dynamic surface is adopted to avoid the computational expansion caused by back stepping method and to simply the calculation. The fuzzy logic function is utilize to approximate the kinetic uncertainties including the dead-zone error and external disturbance. An adaptive law is applied to adjust the Gaussian basis weight matrix, which improves the desired trajectory tracking performance of rigid motion. For the fast-subsystems, the linear quadratic optimal control is used to suppress the vibration of the two flexible arms to ensure the stability and tracking accuracy of the system. Finally, computer simulations verify the effectiveness of this composite control approach.