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RAPID TRANSPORTATION OF FLEXIBLE ASSEMBLY CELL BASED ON NON-SINGULAR TERMINAL SLIDING MODE CONTROL WITH PRE-DEFINED TIME REACHING LAW

Abstract

On-orbit service technology mainly includes fuel filling, module replacement, on-orbit maintenance, on-orbit assembly, etc. For the reason that it can greatly improve the performance and service life of spacecraft, and reduce its launch and operation costs, the technology of on-orbit service has already become a boom in the domain of astronautics. However, traditional on-orbit service technology is difficult to apply to increasingly complex space missions, such as on-orbit assembly of large space structures. Multi-robot system, with its strong flexibility and robustness, can successfully complete a variety of complex tasks, including on-orbit assembly task, which has attracted great attentions in recent years. This paper focuses on the transportation of the assembly cell, and studies how to safely and quickly transport the assembly cell to the desired position by the space transportation robot. In the process of transportation, the vibration of the assembly cell has a non-ignorable impact on the movement of the transportation robot, so it is necessary to establish a rigid-flexible coupling dynamic model of the system. The traditional floating coordinate method, which has the advantage of simple calculation, is often used to solve the rigid-flexible coupling dynamic modeling problem, but it cannot accurately describe the dynamic stiffening phenomenon. To improve the accuracy of the rigid-flexible coupling dynamic model, the geometric nonlinearity of structural deformation is considered in the process of dynamic modeling and analysis. Based on this model, the fixed-time controller is designed using non-singular terminal sliding mode control (NTSMC) method. In order to improve the control performance of the sliding mode controller, a new and more general pre-defined time (PdT) reaching law is proposed in this paper. Comparing with the traditional sliding mode reaching law, the proposed reaching law can effectively solve chattering problem, and make the system state converge to the sliding mode surface in pre-defined time. At the same time, considering the uncertainty of the model and the external disturbance, a uniformly convergent observer is proposed to enhance the robustness of the control system, which can accurately estimate the disturbance in a fixed time. Due to more accurate modeling and more general pre-defined time reaching law design, the proposed controller can complete the transportation task of the assembly cell more accurately, quickly and safely.